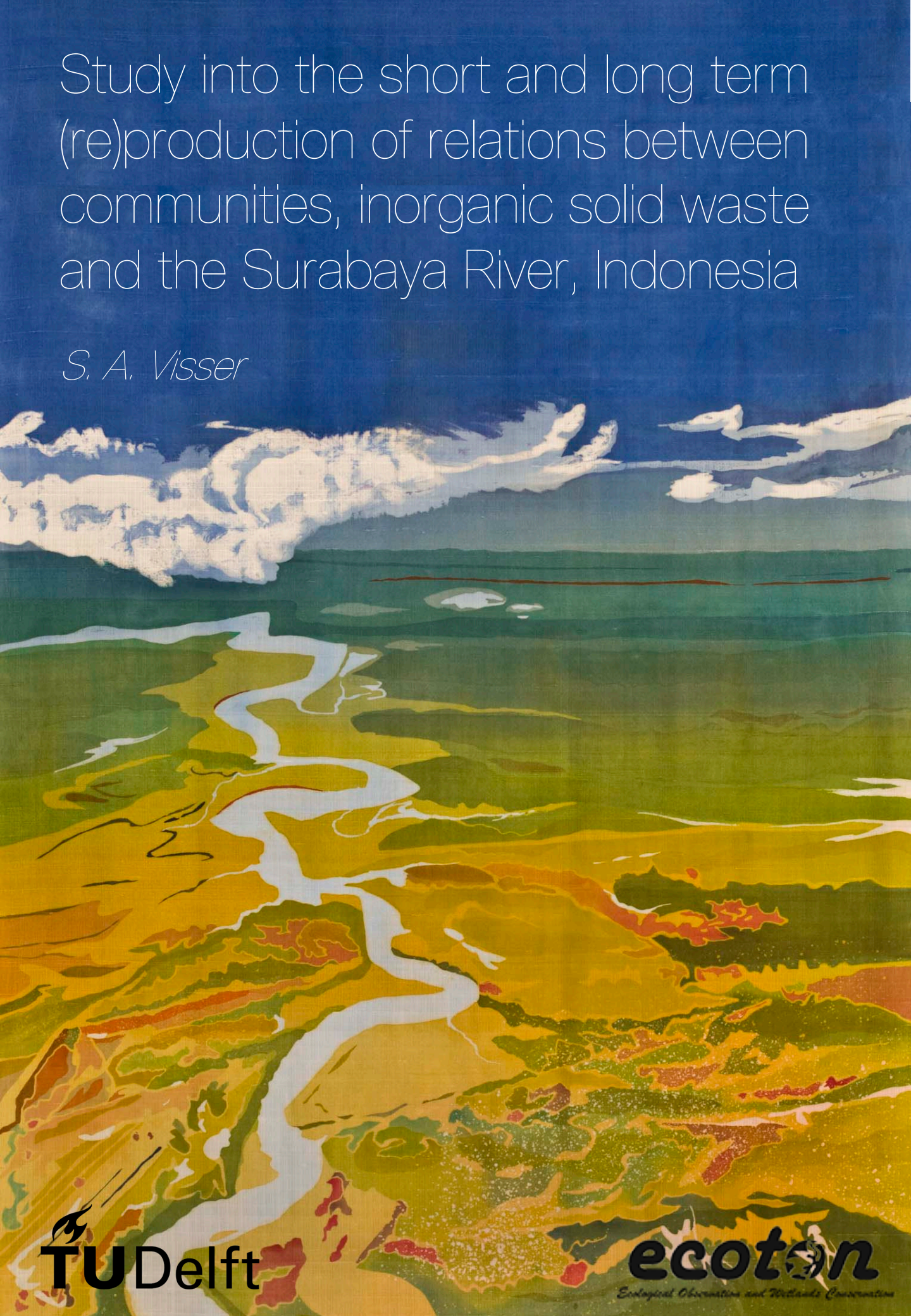
Study into the short and long term (re)production of relations between communities, inorganic solid waste and the Surabaya River, Indonesia

S. A. Visser



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Ecological Observation and Wetlands Conservation

Study into the short and long term (re)production of relations between communities, inorganic solid waste and the Surabaya River, Indonesia

by

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Master thesis MSc Water Management

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Abstract

In Indonesia, river pollution due to inorganic solid waste has become an enormous issue. This article explores the (re)production of relations between communities, river and inorganic solid waste in the Surabaya River Basin. It does so by analysing activities based on interviews, observations and measurements. It tries to explain the current situation in the Surabaya River Basin and shows how 'river water' and 'waste' shape ontologies. Furthermore, how these two nonhuman actors act differently (or the same) in different ontologies. The definition used in this study for an ontology is "a construction of how concepts of reality are constructed". Several analyses are used. Firstly, statistics are used to support narratives where deemed necessary. In addition, QGIS is used to visualise data. Lastly, a flow diagram is made to show the flow of waste into the Surabaya River. Existence of multiple ontologies in the Surabaya River Basin is described. It is found that both reproduction of actions is present (on the short term) as well as production of different actions, which becomes more visible in the long term. For example, waste burning every afternoon is a reoccurring action. However, the reduction of single-use plastics is an evolved state. The riverbank is an important location in the relations and could serve as a suitable location for such actions. Lack of information, communication and facilities are identified to be the most important issues. In general, people are optimistic and motivated concerning the environment. However there are some people not engaged. This causes a divide and together with social control leads to tensions in the community. Recommendations include, among others, setting up an information sharing platform between institutions and community members and making use of the cultural resources to work towards a common goal. Including the multiple ontologies in decision-making processes could lead to inclusive and sustainable river management and waste management.

Keywords: *River pollution; Surabaya River; Domestic inorganic solid waste; Community; Ontology*

1. Introduction

In the last decades, river pollution has become an enormous issue to most of the rivers on Java Island due to population growth and economic development. This pollution leads to water quality degradation and results from human activities such as domestic, industry, agriculture, solid waste and waste water [Jennerjahn et al., 2013]. In addition, less environmental awareness, ineffective institutional arrangements and incomplete regulations contribute to this problem [Jasa Tirta I Public Corporation]. Prior focus of projects in the area were mostly on water quantity, but water quality is at least as important.

The Brantas River Basin, with a length of 320 km, is the largest river in the East Java Province, with a basin area of 11,800 km^2 (figure 1). The Brantas River functions as the most important source of water supply in the East Java Province, where in 2003 approximately 15.5 million people rely on this water source [Jasa Tirta I Public Coorporation, 2005]. The downstream branch of the Brantas River that flows through Surabaya, named the Surabaya River, is of most importance to industries and drinking water companies.

Various governmental organisations are concerned with the water management in the Surabaya River Basin. The responsibilities of PJT consist of

water allocation and water infrastructure O&M. Furthermore they provide technical advice to BBWS on water usage and assist the government in protecting and making water resources safe. BBWS manages the water resources in the Brantas Basin and makes policies about water quantity and quality. Public works is responsible for land use management in the catchment area and therefore for land use of the riverbanks and floodplains. The EPA is responsible for policies, implementation and guidance, researching and innovating in environmental management. Another responsibility of EPA is the water quality of the Brantas River, where PJT feels responsible for the Surabaya River water quality, however is not. PDAM uses water from the Surabaya River and is responsible for providing (and distributing) good water quality to its customers. When EPA fails to control good water quality in the Brantas River, where the Surabaya River is a branch in the downstream area, this impacts the industries and drinking water company in the Surabaya River Basin. In turn, PJT cannot provide good raw water quality to PDAM and industries. PDAM then might not be able to treat the water properly to supply good water quality to its customers. Information on water resources can be found in appendix A.

In Indonesia, water quality has been classified in four classes (Government regulation no. 82/2001), where class I is water that can be used as drinking water, class II represents water used for recreation, class III water is used for fresh fish preservation and for irrigation and class IV can be used for irrigation (or other purposes requiring similar quality) [Darmayanti and Koudstaal, 2016]. In 2009 Javanese river water quality was classified with class III-IV status, due to the high pollution levels [Wibowo, 0] [Fulazzaky, 2009]. This is due to a combination of untreated domestic sewage, solid waste disposal and effluents from industries [ADB, 2016]. Furthermore, plastics from packaging disrupts the ecosystem, especially when broken down into microplastics.

Additionally Indonesia has become one of the largest waste importing countries of the world since China has stopped importing [Greeners, 2019]. Population growth, rapid urbanisation and economic development, which have spurred consumption in goods and services, has led to an increase in volume

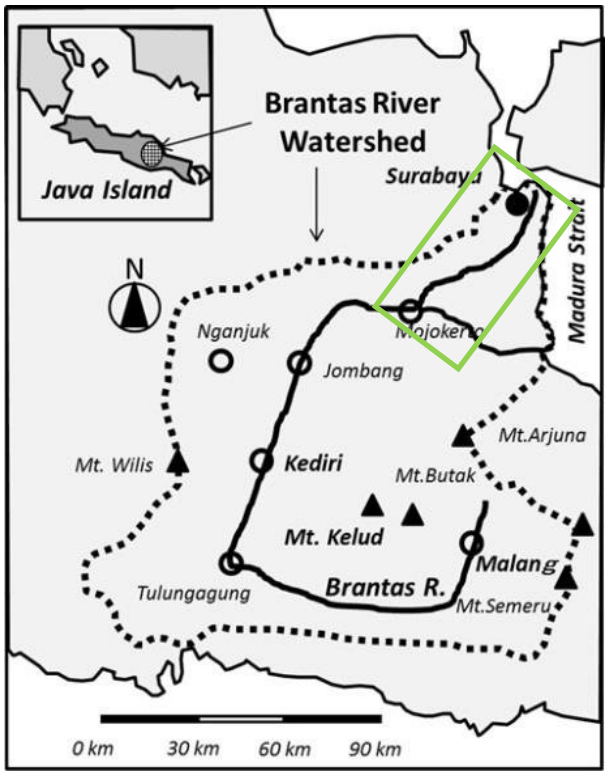

Figure 1: *Map of the Brantas River Basin [Yoshino et al., 2017]. The study area, the Surabaya River Basin, is indicated by the green box.*

of waste as well. In 2015, Indonesia's Environment and Forestry Ministry waste management director Sudirman said that the waste problem in the country has reached a "state of emergency" [Jong, 2015].

Thereby, Indonesia's rivers are the second-largest contributors of plastic waste to the oceans in the world, with an estimated 1.3 million tonnes of plastic waste annually [Rakhmat and Tarahita, 2017]. Public Works and EPA share responsibilities and activities in the waste management system. Public Works is responsible for setting up and supporting operation and management of waste facilities and EPA is responsible for transportation from waste collecting centres to the landfill. More information on waste management can be found in appendix A.

Therefore, there is a need to look at improved waste management and river basin management regarding water quality in Indonesia. This study focused on the Surabaya River the downstream

branch of the Brantas River that flows north through Surabaya, in East Java. Over a period of two months during the dry season a cross-sectional study was carried out for studying the interactions between communities, inorganic solid waste and river pollution in the Surabaya River Basin. On a long time scale, two months is just one event. The 'current state' is produced along the way, it is the result from all actions before. However, on a time scale of people's actions, two months is quite a long time step and offers information on several states that have been produced along the way. Do these actions happen all the time, or is this just a snapshot in time? To assess this, several activities were carried out. Actions were analysed based on interviews, observations and measurements. This study investigated how these states I observed in my fieldwork were build. What I suspected to find was that the states I think I observe, were constructed in terms of different *ontologies*.

> The definition used in this study for an ontology is "a construction of how concepts of reality are constructed".

This study presents the evidence of multiple ontologies in the Surabaya River Basin concerning river pollution and waste handling.

An ontological approach has been taken in various disciplines in science. Latour and Strum [1986] have made use of a questionnaire to approach different accounts for the origin of society. Mol [2002] argues the existence of multiple ontologies in a study discussing a patient's disease in a Dutch hospital. In the field of water management, Hirsch [2016] showed in his research that there are a multiple of "Mekong Dam ontologies". Sithirith and Gillen [2017] encouraged the study by Hirsch [2016] to further discover ontologies of the river from the local people's perspective. Furthermore, Carolan [2004] showed that multiple crises exist in a river basin and a possible way to account for that. Law [2004] argued in his book that methods do not only describe social realities but also shape them, and that multiplicity in realities is not unthinkable.

Ontologies provide more information for the stakeholders' understanding of one another and the things involved, and when provided as feedback can support for example decision making processes. This study tried to show how waste and the Surabaya River (being nonhuman agents) extend further than just their materialities, how they are used by human agents to achieve their needs. However these nonhuman agents are not passive and can therefore 'act' different, or the same, in reality than was in mind by the human agents. [Ertsen, 2016]

> Dear reader, with this article I described my study and by doing this I provided one ontology, contradicting the claim I make that multiple ontologies exist in the Surabaya River Basin. In addition, I do not master the required vocabulary to describe multiple ontologies, therefore I still used words such as system, solution, Surabaya River, waste, etc.

1.1. Research motivation

The Surabaya River is an important water source for at least 3.3 million people, who receive their (drinking) water from this river as well as many industries that support Surabaya's economic value, thereby making it an important and precious resource. Furthermore, rivers are the major source of plastics and solid waste entering the oceans, ten rivers account for 88% - 95% of plastic debris load entering the ocean [Schmidt et al., 2017]. Getting an understanding of how this type of waste is transported by the river and how it is actually experienced by the people residing along rivers can provide new insights into combating this issue.

In order to effectively understand and communicate about inorganic solid waste pollution in the Surabaya River and look for solutions to improve the situation, it is necessary to understand the connections between inorganic solid waste in the Surabaya River -being visible and something that people are dealing with on a daily basis- and the actions the community members concerning inorganic solid waste and river pollution. Looking at a very local scale into community solid waste flows and their underlying dynamics, as well as

the actions of community members regarding waste, can provide insights applicable to a larger scale. Furthermore, exploring both short and long term could provide an understanding of this (re)production of relations. This is where presenting ontologies could help to gain insights for stakeholders, for getting a better understanding of everyone's viewpoint and motivation as well as showing the barriers and opportunities at hand. This has led to the following research question for this research:

How are the relations between communities, inorganic solid waste and the Surabaya River (re)produced on the short and long term?

Following this introduction, this thesis continues with a description of the study site: the Surabaya River Basin (section 2). The subsequent section describes the methodology of this research (section 3). After that, results will be presented (section 4). Here I show that multiple ontologies exist. Following this, a discussion of the results will be provided (section 5) and conclusions are drawn (section 6). Lastly, recommendations will be given (section 7).

2. Study site

The Brantas River is divided itself into the Surabaya River and the Porong River. The start of the Surabaya River is at Mlirip Sluice (bottom left in figure 2). The Surabaya River flows through the regencies of Mojokerto, Gresik, Sidoarjo and the Greater Surabaya Metropolitan Area. After Gunung Sari Sluice (top right end of the dark blue line in figure 2) the Surbaya River is divided into the Mas River and the Wonokromo River. The Surabaya River is an important source of water for industries and the drinking water company that supplies to most of Surabaya. A more detailed description of the hydrology and morphology of the Surabaya River is provided in appendix B.

The average population density of these areas combined is almost 2,000 people/km^2. In total, three communities along the Surabaya River were studied in detail and observations, government interviews, group discussions and boat surveys provided detailed information of the actions in the Surabaya River Basin. The population in the studied communities where the household interviews took place was 5,295 in Wringinanom, 12,671 in Bambe and 8,883 in Jambangan (in 2010) [BPS, 2010]. For detailed maps and information of the communities, see appendix C and figures 12, 13 and 14. The average household size in the East Java province is 3.6 persons [BPS, 2015]. The main religion is Islam (about 80%). Most people work in factories, government offices and (small) informal business such as a *warung* (typical Indonesian restaurant or cafe) or a *toko* (shop) at their house.

Waste management is managed at community level and the studied communities had different facilities. Water management facilities also varied per community. The existing facilities per community are summarised in table 8 in appendix D.

3. Methodology

This section aims to explain the methods and materials used in this research. The overall method used to answer the research question of this study was by **constructing ontologies**. This study looked at two time scales: short term and long term. Short term means within the time frame of the fieldwork and by long term I refer to a period that stretches beyond this time of fieldwork. These two time scales provided the distinction between several (similar) states observed and succession of states.

Data was collected during a fieldwork of two months. An overview of the performed activities is presented in table 1. Figure 2 shows the study area and places local knowledge was collected, more detailed maps can be found in appendix A. Appendix E shows the interviews with households and women groups (section E.1), fishermen (section E.2), PJT (section E.3), BBWS (section E.4), EPA (section E.5), PDAM (section E.6) and Public Works (section E.7).
Several analyses were used to assess what actions have led to or were performed to produce the ontologies.

In the first place, descriptive statistics and statistical tests for relations were used to support the narrative(s). Structured, face-to-face interviews

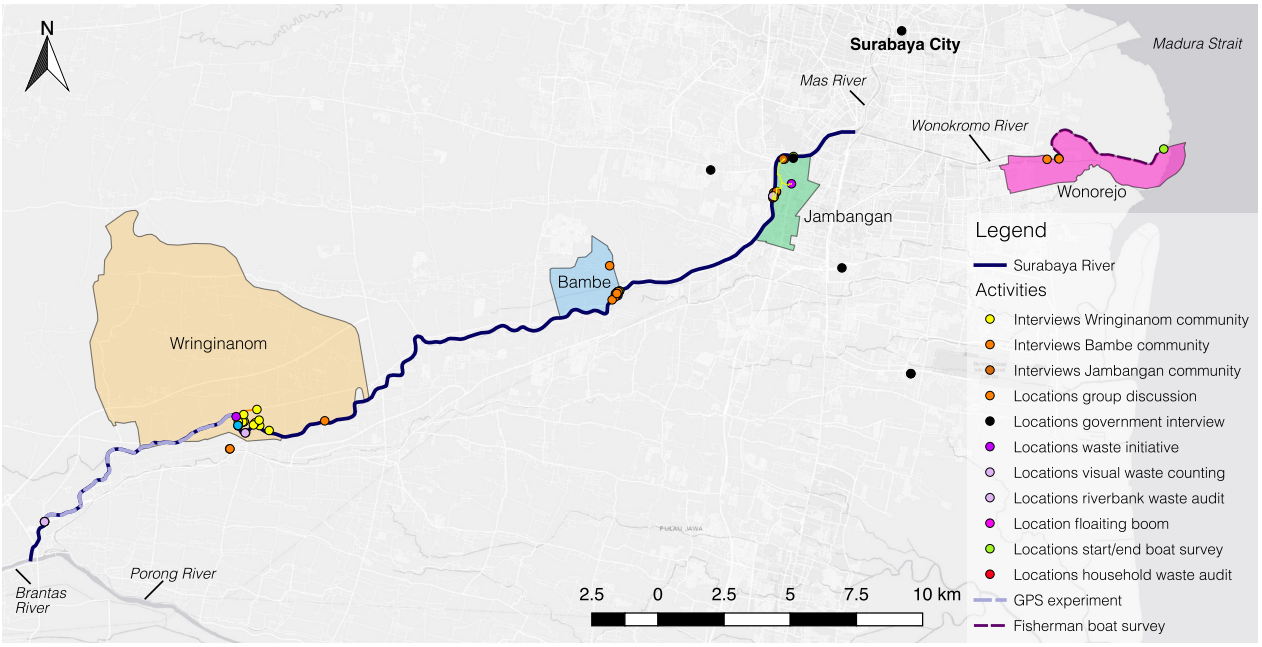

Figure 2: *The study area. The dark blue line indicates the Surabaya River and the coloured areas represent the areas where most data was collected. The coloured points represent various activities carried out during the fieldwork.*

Table 1: *Activities performed to study actions and ontologies in the Surabaya River Basin, focused on river pollution and waste handling*

Methods	**Activities**
Interviews	Structured conversational interviews with individual at households (in communities Bambe, Jambangan and Wringinanom) about a. demographics, b. water use and sources, c. waste handling, d. river and river pollution and e. environmental involvement/participation; group interview with fishermen (in community Wonorejo); group discussion with women groups (in community Penambangan, Sumengko and Wonorejo); interviews with government officials (PJT, BBWS, EPA, Public Works, PDAM); conversations with NGO Ecoton; conversations with water infrastructure operators (PDAM, PJT); conversations with waste facility centres (in Penambangan, Wringinanom, Jambangan, Gresik)
Observations	Actions of people along the river, waste activities of people around houses and near waste facilities or (if available), actions and expressions of interviews, observations from boat for quantification and categorisation of waste dump sites on riverbanks and waste in riparian vegetation (from Mlirip Sluice until Gunung Sari Sluice), observations from boat for activities and actions of people along the river, observations from boat on waste being transported by the river and interactions between solid waste in river and at water structures (from Mlirip Sluice until Gunung Sari Sluice)
Measurements	Waste audits at 10 households for a period of one week (in Wringinanom), visual waste counting of floating inorganic solid waste in the river (in Mlirip, Wringinanom and Jambangan), waste audits using a floating retention boom (in Wringinanom), waste audits on riverbanks and floodplains (in Bambe and Krembangan), GPS experiment for simulating travel path and time of solid waste item (Mlirip Sluice until Wringinanom)

at households, and group discussions and interviews were done to try to understand the actions

of community members in various communities along the Surabaya River. Purposive sampling for the group discussions and interviews was done. Discussion groups and a group for interviewing were selected based on their strong connectivity with their community and their activities in their community. Three women groups were selected from different communities along the river as well as a fishermen community downstream of the Surabaya River. Statements regarding river and river pollution, and participation in environmental projects were presented. Quotes from interviewees and community members were used to illustrate the narrative. Pictures were made of some observations, to provide a more illustrative representation of the area during the time of the fieldwork. These can be found in appendices F and G.

Three communities along the Surabaya River were selected with different water and solid waste facilities and also to include the upstream-downstream connection of a river. Within these communities the interviewees were selected based on geographical location and convenience, close to the river with some variety in distance and people being available for interviews. In total, 30 households across the three communities were interviewed using a structured interview with room for more questions, achieving a response rate of 100 percent. For the household interviews the questions concerned household waste interaction, water use, river and river pollution, and environmental involvement or participation. In addition, demographic information of the respondents was also collected. Mostly women were interviewed, this was due to availability and their responsibilities in their households. The sampling strategy used allowed to conduct the 30 household interviews as well as carrying out the other activities within the limited time span. Table 9 in appendix D shows the demographic profile of the household interviewees.

Most data collected in this study is nominal/categorical and some is ordinal. The type of data and how it is sampled determines what kind of statistical test can be performed [Gunawardana, 0]. To look for relations between variables, a (Pearson) Chi-Squared (χ^2) test, Spearman's Rank-Order Correlation Coefficient or measures of association can be used for the collected type of data. Furthermore, frequency tables can be used to describe a variable. The relations are tested for statistical significance using IBM's program SPSS (version 24-25). A grounded theory approach -where a theory is generated out of data [Bryman, 2012]- was used in this study to formulate hypotheses.

A Chi-Squared test, which indicates whether there is a statistical significant relation or not, is appropriate to use for nominal/categorical data [Gunawardana, 0]. For 2x2 tables a Continuity Correction (*Yates' correction*) is done to make the test more conservative. When there is evidence that there is a significant relation, measures of association (*Phi (ϕ)* and *Cramer's V*) can be used to see what the strength is of the relation. Hypotheses need to be formulated in such a way that the null hypothesis is that there is no correlation.

The statements in the interviews and discussions are on ordinal scale. For this type of data the Spearman Rank-Order Correlation Coefficient is appropriate to use. This correlation coefficient represents the strength and direction of a relationship between two variables (but not causality).

Because my specialisation is not in statistics, I needed some extra guidance and therefore this study has taken the following requirements from Simmons et al. [2011] into account. (1) A sample size rule was set beforehand; 10 interviews per community were conducted, and as many observations as possible in the two months of fieldwork, without evaluating them in the meantime. Moreover, (2) a sample size of at least 20 was advised because a smaller sample size is not powerful enough to detect most effects, this study had a set rule of a minimum of 30 interviews, in this way I accounted for some for detecting effects. Furthermore, (3) a list of all collected variables must be presented, as can be found in the appendices of this article (appendix E) and specifically which variables were used for which hypothesis have been summarised in table 10 in appendix H. This table shows the steps and decisions (including (points 4, 5 and 6) the experimental conditions) that were made for the statistical analysis, for not only supporting the narratives but also provide some relevant numbers. [Simmons et al., 2011]

In addition, QGIS was used to visualise maps of the studied areas and the GPS tracking of a solid waste item in the river. A buffer zone along the river which potentially contributes to solid waste inpust into the river was calculated with this program as well. The calculation of this area was done with the $area function.

Finally, a flow diagram was made to visualise the flow of waste from "sources" to the Surabaya River, and into Gunug Sari retention boom. Data used for this analysis comes from visual waste counting, riverbank waste counting and audits and floating retention boom measurements and interviews with its operators.

4. Results

A two month period of fieldwork offered the possibility of exploring the existence of several 'current states' and providing information for both short and long term (re)production of relations. This section presents the ontologies found during the research.

4.1. Origin of inorganic solid waste in the Surabaya River

A river does not only transport water, but also serves as a transportation network of other materials (such as waste), non-materials (e.g. information, ideas, collaboration, trust, morality) or humans on ships. At the end of the Surabaya River, the retention boom structure at Gunung Sari has been put into place to retain solid waste from travelling further downstream. According to PJT, it retains on average 156 m^3 of waste every week. Waste floating downstream in the Surabaya River eventually gets stopped by the retention boom. This current state of the waste could have been caused by waste accumulating downstream, or due to population growth in combination with the change in waste generation by the population, or both. A river connects agents in terms of space, but also in time (connecting past and present) [Ertsen, 2016]. Understanding the origin of this waste pollution in the Surabaya River could provide a better understanding of the system. Thereby it could help tackling the problem of solid waste items entering and being transported through the Surabaya River.

Was the 'current state' continuously (re)produced or were several states observed? During conversations and discussions, when talking about and looking at *the* problem, to some it might be a *unique present state*, to others it is a *continuously (re)produced state*. These different tensions that exist shape and enact reality. How *the* problem can be addressed therefore depends on which 'problem' you 'see'.[Carolan, 2004]

4.1.1 More people, more waste... a *continuously (re)produced state*

The average population density per km^2 in the Surabaya Metropolitan Area is 1,682 people/km^2 (in 2015). Observations and interviews showed that within an estimated 150 meter of the river it is likely for waste ending up in the river. This includes directly dumping waste into the river, but also the area where dumping leads to waste ending up in the river (e.g. at the riverbank, in drains). When we assumed a distance of 150 meter from the river (visualised in appendix C figure 15 and more in detail per community in figures 16, 17 and 18) to be the zone in which people dump their waste into the river, an area of 14.23 km^2 is responsible for contributing to solid waste problems in the river (calculated with QGIS). Population was estimated to be just below 24,000 people in the zone with an average waste generation in 2015 is 0.33 kg/capita/day. On average, municipal solid waste has a density of 116 kg/m^3 in Indonesia [Damanhuri, 2008], this means that about 480 m^3 of waste was generated by the people (residing and dumping) in the buffer zone per week. When we travel back a bit in time, around the year of 2000, the population density was 1,360 people/km^2 and waste generation was 0.22 kg/capita/day (when calculated back taking an average waste generation growth rate of 2.7% per year)[Damanhuri, 2017]. This means that about 260 m^3 of waste could have been generated back then over the period of one week. Even though some respondents were actively trying to reduce their waste generation, there is still a trend of an estimated waste generation increase of 84% in the period of 2000-2015. [Dhokhikah et al., 2015][World-

Bank, 2012][Damanhuri, 2017] This could indicate that the area could not accommodate this growth with proper facilities and infrastructure and therefore it ended up in the Surabaya River. An EPA official mentions this as a potential reason, as illustrated by the following quote:

> *"Due to a growing population and new industries priority to other facilities over community waste facilities was given"*

However, according to the employees of the waste facility in Jambangan, people in their community have reduced their waste generation almost by half over the last three years. But they still see that there are misunderstandings about waste handling in their community and surrounding communities, as expressed by the following quote:

> *"Some people think they have to pay for their service, which is not true. That is why they dump it. Other villages can also send their trash here, but they do not know that."* - Employee of waste facility in Jambangan

So, waste dumping could also be a reason waste does not reach the waste facility. Other reasons, such as more people being a member of waste banks or giving their valuable waste to scavengers for example, could also lead to a reduction of waste ending up in the waste facility.

4.1.2 Waste accumulation in the system, an *evolved current state*

Waste accumulation downstream in the river as a process leading to the current state (one that is the results of all actions before) could also be the origin of the waste in the retention boom in front of Gunung Sari Sluice. This observed current state can be quite different than the states produced before, for example in wet season compared to this study during the dry season. As a member from the women group during a discussion in Sumengko mentioned:

> *"The reasoning that there is waste is because when it is raining, the water level in the river rises and the river water will flood on the floodplain, here the waste from upstream communities travels to and stays there once the water level drops again or gets transported downstream by the river."*

Interviews with retention boom operators, visual waste counting exercises (appendix I, table 14), counting river dump sites (appendix I, table 17) and collecting waste by means of a self-built retention boom at a point in the river (appendix I, figures 53, 54, 55 and 56, table 15) provided information for a waste accumulation analysis. A flow diagram was used to visualise the flow of waste from sources to the Surabaya River, and into the Gunung Sari retention boom (figure 3). The process described with the flow diagram shows how the 'current state' has been produced. The term "sources" was used to describe activities by which we can estimate the amount of waste (such as using the information from riverbank waste audits in table 16, sampling visualised in figure 16), some kind of control points (e.g. visual waste counting locations, river section information and floating retention boom). A few assumptions were needed in order to make the analysis. Assumed was that all residual waste in order to balance the amount caught in the retention boom at Gunung Sari comes from tributaries. Estimation of direct waste dumping or waste entering the river from the riverbanks is a volume of 30% of the total amount of riverbank dumpsites. Table 18 in appendix I shows the values of the flow diagram diagram.

4.2. What happens at the riverbank?

The riverbank is the physical location on land where waste and river meet, where people and the river ecosystem interact and what seems to be a location at which there is difficulty in maintaining authority by the (local) government.

The three main uses of the riverbanks along the Surabaya River are: land for agriculture, houses or waste dump sites and waste accumulation due to varying water levels. A PDAM employee says the following about it:

> *"The reason people use the water as a disposal site is because of the people's mindset. They dump their waste on no one's land, then it is not their responsibility and problem anymore"*

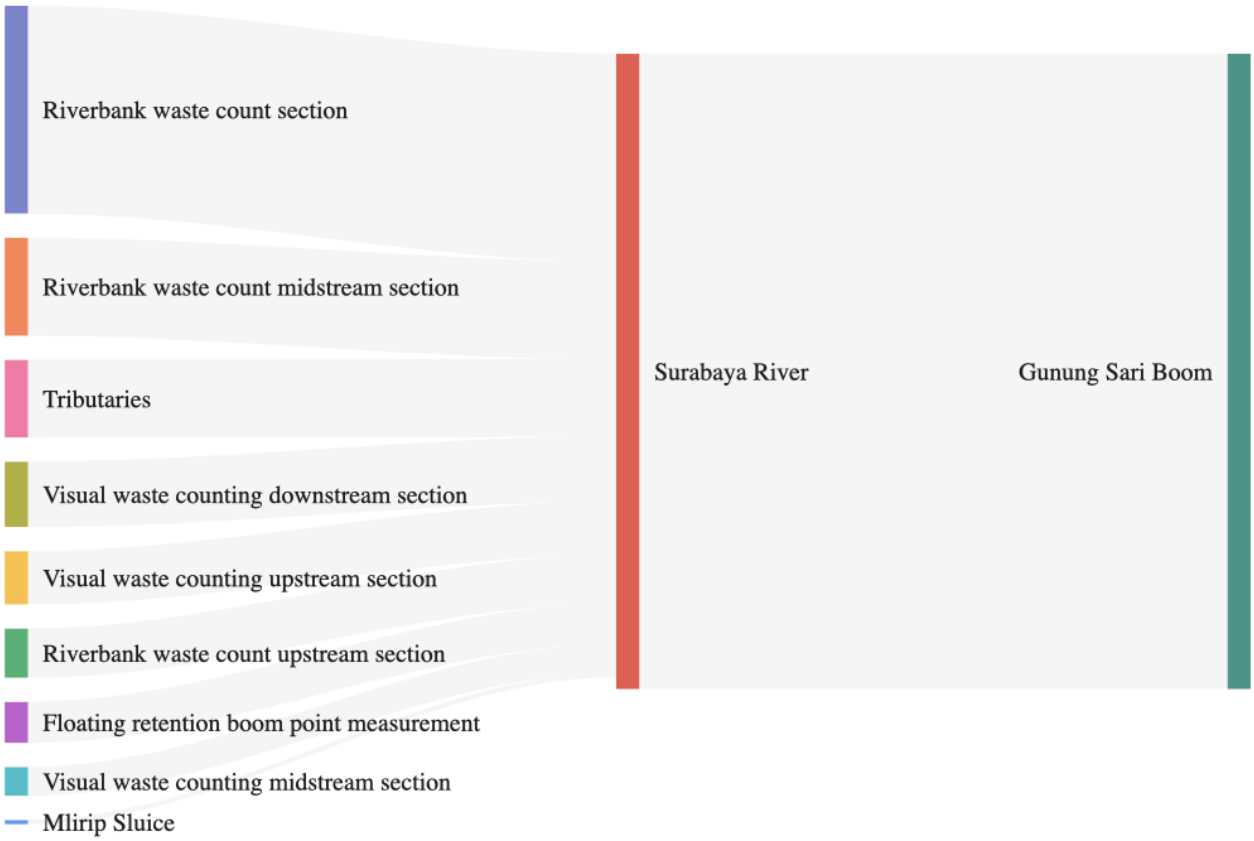

Figure 3: *Flow diagram showing "sources" (in m^3) of waste going into the Surabaya River, as estimated by interviews, waste audits and counting exercises*

It is by law forbidden to build your house within a certain distance to the river, depending whether it is an urban or rural area. However, from a historical perspective it was advantageous for people to settle near rivers, and they build their houses at the riverbank. Still, people settle near rivers in (informal) settlements, due to availability of land. Nowadays you often see newly constructed houses at the river bank, mainly because more people are moving towards (peri-)urban areas. Houses are the most common land use in the more downstream areas of the Surabaya River. In the upstream part, there is still a lot of agriculture being practised along the river. Boat surveys provided insights on riverbank land use and occurrence (pictures in appendix F, figures 19, 25 and 29) and size of riverbank dumpsites along the Surabaya River, as visualised in a graph per boat survey in figure 4, figures 21, 27 and 31. It clearly showed more riverbank dump sites going downstream, this could be explained by the more urbanised area in the downstream part of the Surabaya River. When water levels start to fluctuate, for example during the wet season, dump sites could be supplemented with floating solid waste from the river. At the same time, solid wastes from the river bank can be taken by the water and transported by the river further downstream. Not only the amount of riverbank dump sites is larger downstream, but also larger dump sites are present. This can be explained by the fact that people live closer together and thereby share these sites.

When these observations from boat surveys were combined with data from visual waste counting from land, it showed that while the riverbank dump site increased downstream, the visual waste counting provided not a similar pattern (figure 5).

Just after the sluice where a part of the Brantas River diverts into the Surabaya River, visual waste

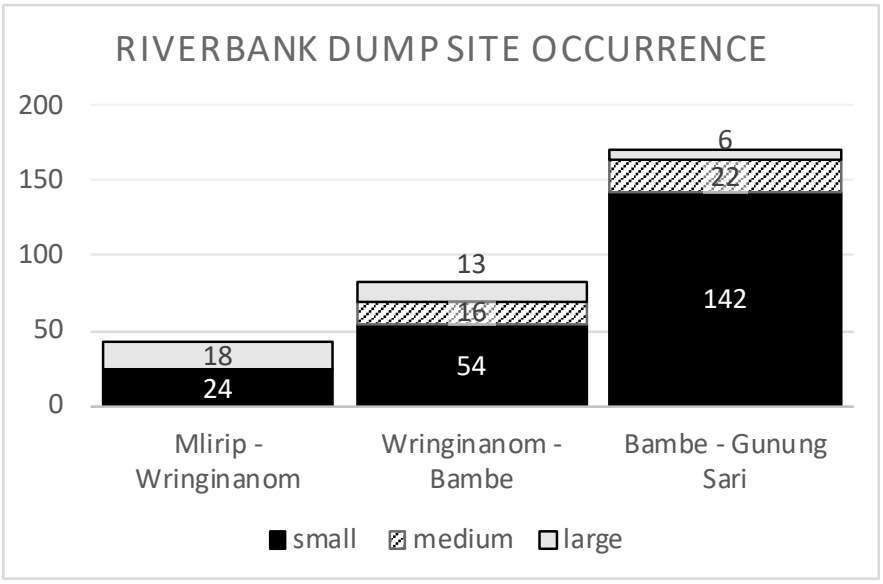

Figure 4: *Occurrence of riverbank dumpsites by size in three sections of the Surabaya River (from left to right: upstream, midstream and downstream)*

counting showed 48 waste items floating by in half an hour. This could be explained by the activities of the workers at the retention boom just upstream of the sluice, they let the waste float through when no transport is correctly scheduled, or "temporarily" dump it on the riverbank (figures 47 and 48, appendix G.2). Almost half of the amount (25 compared to 48) of the amount floating waste has been counted at more than ten kilometres downstream, while doing the counting exercise on another day but at the same time during the day. Most likely this difference can be explained by the fact that waste got stuck on the way downstream in vegetation. GPS tracking of a floating waste item (appendix F, figure 23) and also observing other floating waste items (appendix F, figures 22, 28 and 32) showed that these items can easily be caught up in the riparian vegetation during their travels downstream (appendix F, figures 20, 26 and 30; appendix G.2, figure 46). Furthermore, the river transports these items over the same meandering path (appendix F figure 24), influenced by wind. The travel time of the device for floating 10.2 km downstream is just over four hours, having an average speed of 0.67 m/s.

Most houses along the river are facing away from it. Efforts are made by several institutes and organisations (e.g. EPA, Ecoton, Unilever) to increase the appreciation of people living at the riverside regarding the presence of the river. In the community of Jambangan the houses have been turned facing the river and the riverbank has become a place where people can enjoy their surroundings. NGO Ecoton has been developing plans for ecotourism on riverbanks, thereby trying to change the land use of the riverbanks in something for preservation and at the same time attracting people to these areas for recreation. The community members interviewed also have various ideas to improve this area where community meets river. Almost all respondents of the interviews (28 out of 30) indicated that they want to join or support projects concerning waste or the river. Three mention that they want to clean up the riverbanks, six want to clean up the river and three want to do a regular cleanup in the community. One person is involved with a riparian vegetation project.

4.3. Ontologies of 'improved water quality'

Among the institutions concerned with surface water in the Brantas River Basin, prior projects were focused on water quantity but now there is a shift

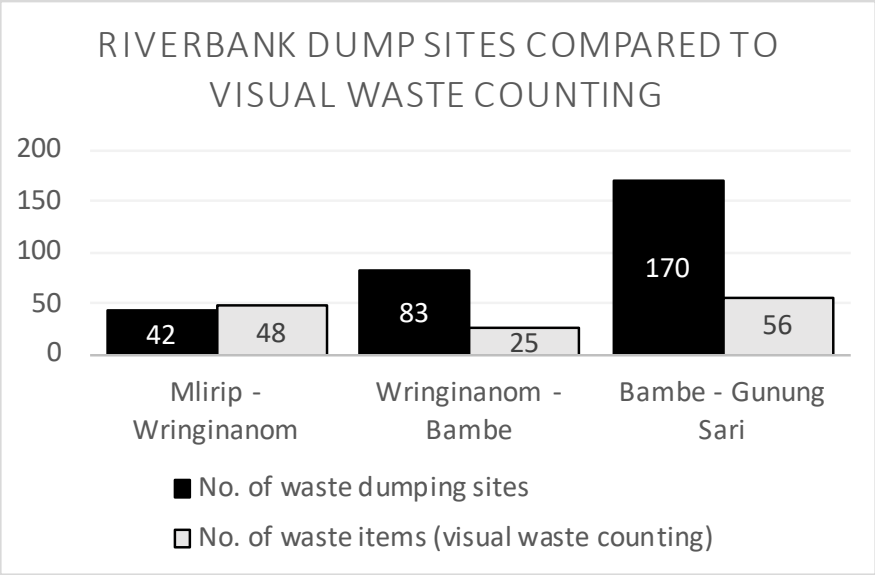

Figure 5: *Riverbank dump sites occurrence combined with visual waste counting activities at three sections of the Surabaya River (upstream, midstream and downstream)*

to improving water quality. In conversations with community members, institutions and Ecoton we were talking about "improved water quality" in the Surabaya River. But what is this "improved water quality"? Following the reasoning of Carolan [2004], that partly depends on the *doing* of ontology. So, for a fisherman this is where there are plenty of fish and no inorganic solid waste getting caught up in their boat's propellers (or fish nets), for fish ponds these are the conditions in which fish populations thrive. Over time the amount of fish has decreased, the fishermen blame it on the increase of inorganic solid waste in the river and the illegal releasing of effluent by industries.

NGO Ecoton carries out research and advises the institutions on sustainable integrated water resource management. For Ecoton 'improved water quality' is when fish habitats are present and wetland restoration is done.

'Improved water quality' for engineers are values or indications of certain water quality tests, the EPA engineers rates the water quality using the Water Quality Index for example.

For PDAM it is their raw product; the "cleaner" the water the better, because this will decrease treatment costs.

For communities along the Surabaya River this might be that there is no smell of dead fish and solid waste floating around, or that they can swim in the river again. A long time ago they used the river for swimming, washing, washing clothes, fishing and as a toilet. Nowadays, fishing has become a leisure activity, because they do not catch anything anymore. People mostly use the river for transport from one side to the other by *tembangan* (a traditional boat), some people are swimming and washing (appendix F, figures 33 and 34), some people are fishing or looking for worms to sell to fishermen (appendix F, figure 35), two persons were seen using the river as a toilet (appendix F, figure 36) and one person was caught in the act of throwing waste directly into the river. Many from the interviewees hope that one day they can swim and enjoy the river again. People have different visions on this, illustrated by the following quotes.

> *"We are very optimistic. We expect that in about 50 years with good activities, the river water quality will be better."* - Women's group discussion Penambangan

> *"It needs a lot of effort and continuously working together. I am pessimistic, but we have to be optimistic for the next generation."* - Interviewee from Jambangan

> *"I am more concerned about floodings than water pollution"* - Interviewee from Jambangan

Looking at domestic water use, interviewees did not use their in-house groundwater well or piped water system as drinking water source because they indicate that the water is contaminated (i.e. strange smell, colour, turbid). They buy plastic containers or bottles instead. They said that they do not trust the water from the sources and that it is more convenient to use plastic bottles.

Governmental institutions strive to improve the river water quality as well, in terms of taking responsibilities and performing activities. The responsibilities of the governmental institutions studied can be found in appendix A. Looking at activities done by these institutions, BBWS and PJT both monitor water quantity and quality on a monthly basis (PJT uses their laboratory for it), while EPA also measures water quality (also monthly). PJT, EPA and BBWS together perform patrol activities. PJT also does the O&M of water infrastructure and has social responsibility programs. EPA fines the industry when water quality is compromised (happens sporadically). Activities by PDAM consist of renewal of water distribution pipes (continuous activity throughout the year), running pilot projects on providing drinking water and not only household water. In public spaces, they provide good drinking water and refill stations in public spaces. In addition, they have a conservation and reforestation project in an area upstream. In terms of collaborating with communities, BBWS promotes community development in water resource management and also has a river school program for communities along the river. PDAM works together with universities to launch their pilot projects on drinking water. EPA encourages communities to engage in river protection practices.

Industries and agriculture might have another vision on this. These stakeholders were left out of this study.

In addition the concern of "good" water quality is also linked with water *quantity*.

Through communication via an early warning system, water pollution could be diluted in the Surabaya River. Especially during the dry season, more water will be directed into the Surabaya River. This means that less water will flow through the Porong River (the other river in which the Brantas River flows into), and thereby less water for the large agricultural areas adjacent to this river.

This is a decision of supporting many industries and drinking water for millions of people weight over the needs of the large agricultural areas along the Porong River. Hence, it is linked with the upstream area. It influences the river water quality and quantity of the downstream areas. Rising water levels due to change in sluice settings in both Mlirip and Gunung Sari leads to houses on floodplains being flooded. Two respondents from Bambe who are living directly next to the river indicate that they experience nuisance of washed up waste twice a year when their house gets flooded and inorganic solid waste enters their houses.

The reasoning about "proper waste handling" is analogously discussed as that of water quality and will be explored below.

4.4. Ontologies of 'proper waste handling'

Most people buy their products at the traditional market or at a *toko* and after using the products, the waste is either (not) separated and taken by some kind of collection service or people have to dispose of it themselves, in a communal container or at whatever place is convenient for them. Most of the time it is at places where there is room for waste or there is already waste lying around: in no man's land on the riverbank. Half of the respondents indicate that people in their community do not throw waste into available waste facilities. The main reasons why the respondents found the waste a concern was because the littering looks bad, followed by the concern that waste has a negative effect on human health and environment. Some indicated that waste lying around will result in waste ending up in the river. Many interviewees said that the reason the waste is not properly handled is because people do not care and facilities are not sufficient (figures 49 and 50 in appendix G.2). Almost everyone agreed that more facilities would be helpful when

asked directly. However, here are also respondents who do not see a waste problem in their community.

Figure 6 shows a graph comparing the knowledge of people regarding available use of 3R facilities -such as a waste bank (figure 39, appendix G), collection and sorting facility (figures 41 and 42, appendix G), diaper containers (figure 43, appendix G) and a floating retention boom (figure 44, appendix G)- and their actual use. All respondents in Wringinanom and Bambe indicated that in their neighbourhood people still throw waste onto the riverbanks or in the river. However, Jambangan has a fully operating waste collection service and no waste dumping into the river.
In all three communities there were respondents who are actively separating their own waste (in organic/inorganic or valuable/valueless), therefore it could be interesting to test whether this is correlated with waste dumping practices. From this, the following hypotheses was formulated:

H_0**:** {Waste separation, waste collection service} does not have a significant influence on the waste dumping actions

H_{1-2}**:** {Waste separation, waste collection service} does have a significant influence on the waste dumping actions

Table 2 shows a frequency table, as you can see most respondents (9 out of 30) separated their waste and dumped it, an equal amount (8 out of 30) either separated their waste and did not dump it or did not separate their waste and dumped it. Only few respondents (5 out of 30) did not separate their waste and did not dump it. This indicated that when people do not separate their waste it does not automatically mean that they dump their waste. In some cases, for example in Bambe, there were no waste facilities at hand except for the communal open dumping site.
A Chi-Squared test is carried out (table 11 in appendix H), the value for Chi-Squared was found to be 0.222 and a two-sided asymptotic significance of 0.638. Because the statistical significance is larger than 0.05, the null hypothesis $H_{0,1}$ is not rejected.

There is no statistical significant relation between waste separation and waste dumping activities.

Table 2: *Comparison waste dumping practices and waste separation activities*

		Waste dumping		Total
		Yes	No	
Waste separation	Yes	9	8	17
	No	8	5	13
Total		17	13	30

A member from the women group in Wonorejo provides reasons about not separating waste:

> *"We want to separate waste, but not everyone understands the reason why so we stopped separating the waste. Another reason for not separating our waste is so scavengers can get the valuables out and earn a little extra money from that."*

Other reasons given by interviewees were lack of awareness of how to properly handle waste, people do not care or that the transportation costs or member costs for a collection service are too high.**refer to appendix** Some indicated that this is their only option, because there were no waste facilities available, e.g. in Bambe. Most people in Bambe collect their waste in a waste bin or bag, but had to go to the communal dumping site (near the river) to dump their waste. So at home they properly handled it but they had no other choice but to use the communal dump site, as illustrated by the following quote of a Bambe community member:

> *"We collect our waste in a plastic bag and dump it at the communal dumping site. There is no waste system here. Some burn their waste behind their house."*

For others, it is easier to use their own dump site at the riverbank or people directly dump it into the river. Burning of waste takes place every afternoon/evening (figure 45, appendix G.2). People living in the proximity of the site experienced nuisance due to smell and smoke.

A second hypothesis is also investigated. Table 3 shows that the most respondents (13 out of 30) did not have a waste collection service and dumped their waste, an equal amount (4 out of 30) either

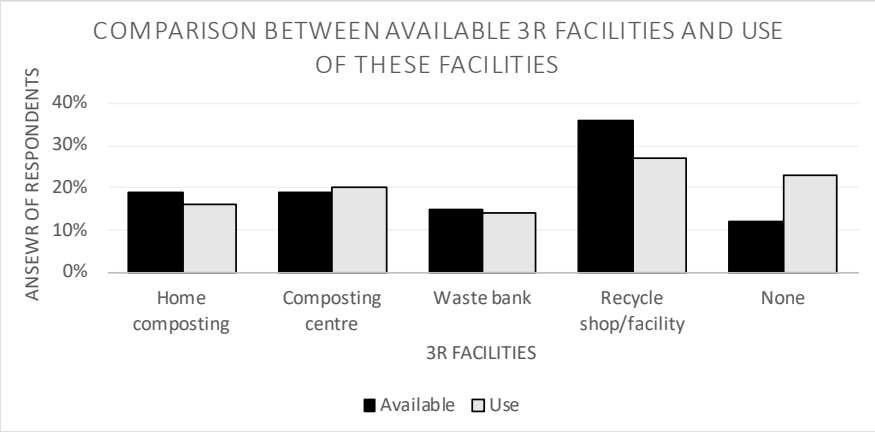

Figure 6: *Graph shows the available 3R facilities that people know of and the actual use of these facilities. With the term "none" it is indicated the lack of facilities (in black) or not using any facilities (in grey).*

had a waste collection service and still dumped their waste or did not have a waste collection service and did not dump their waste. 9 out of 30 respondents indicated that even though there was no waste collection service they did not dump their waste. This indicates that having a waste collection service does not necessarily mean that people do not dump their waste, however, whenever there is no waste collection service available, people tend to rely on easy ways of disposing of their waste (such as dumping).

Table 3: *Comparison waste dumping and available waste collection service (use)*

		Waste dumping		Total
		Yes	No	
Waste collection	Yes	4	9	13
service	No	13	4	17
Total		17	13	30

A Chi-Squared test is carried out (table 11 in appendix H), the value for Chi-Squared was found to be 6.266 and a two-sided asymptotic significance of 0.012. The significance is smaller than 0.05 (also after being corrected by Yates' correction), therefore the null hypothesis $H_{0,2}$ can be rejected.

With a certainty of 95% it can be said that waste dumping and the existence of a waste collection service are not independent. The strength of this relation can be found with *Phi* (ϕ). The value of of Phi is 0.457, meaning that there is a moderately strong relation [De Voght, 2011]. Practically this means that providing waste collection services in communities could prevent waste dumping activities.

Considering activities, local governments and communities manage waste at their level, which in turn needs to be transported to larger waste facilities. PJT have installed floating retention booms before Mlirip Sluice and before Gunung Sari Sluice ten years ago and also provides waste facilities in some villages. Public Works manages the cleaning and transportation scheduling of the boom. The Cleaning and Gardening Agency DKP, a department of Public Works, clears the boom from waste twice a week. Transporting waste from the booms to the landfills is also an activity of Public Works. PDAM maintains its own retention boom in front of their water intake by removing solid waste regularly.

Communities are included in many waste related activities of PJT, EPA and Public works. PJT campaigns at the riverbank and tries to involve students. Through socialisation and education EPA wants to provide communities with knowledge and tools, however, communities need to actively ask for this. Public Works implements 3R facilities by building, supporting and managing the facility for the first year. After this, the responsibilities and activities are passed on to the community. This transition of-

ten does not go so smoothly and results in facilities being closed over time. According to Ecoton and an government official of Public Works this is due to mismanagement in community, lack of support in the transition process or financial support. The waste facility in Jambangan however, is an example of a facility that still functions well. This is due to support of Unilever Indonesia Foundation, who started the with the clean river programme *Brantas Bersih* in 2001 and has supported the community in 3R waste management practices until 2006 after which it was declared "waste free" [DSGC, 2015]. Other activities of Public Works include connecting the community and the government and organising education and trainings. Lastly, they organise the Green and Clean Competition in Surabaya City. They mention that the main reason of many communities to participate is the money incentive and after the competition 90% of the communities return to their old habits and activities. NGO Ecoton is actively involved in advising institutions and people about proper waste management and also providing diaper containers in their neighbourhood. Furthermore, they work together with local women groups and have protests and campaigns about the diaper pollution in the Surabaya River. In addition, they encourage and help people to change their actions from using single-use plastics to more sustainable alternatives.

During their work fishermen experience nuisance from inorganic solid waste because it disturbs the propellers of the boat, it is a large by-catch or it disturbs fish lives (e.g. eat microplastics instead of food, get caught up in plastic). (appendix F, figure 38). Therefore, they try to handle their waste as properly as possible and also retrieve (valuable) waste from the river if they are not fishing, so they can sell it to the waste bank.

4.5. About environmental actions, and how these can create tensions

During this study human agents' actions were studied regarding nonhuman agents (i.e. river and waste), including interactions and practices with these nonhuman agents to see how that shapes their reality. By doing this and identifying barriers and constraints, but also opportunities, possible insights into actions for suitable solutions could be found.

Figure 7 shows the statements of E.1.4 and E.1.5 (appendix E) that were presented to the interviewees and women groups (whole household questionnaire can be found in appendix E.1). As can be seen, the answers to the first nine statements in figure 7 clearly showed that the respondents had a very positive view on the engagement of their community in environmental causes and people's actions in their neighbourhood. Moreover, most respondents found clean water sources to be very important and see what kind of actions they can (e.g. protection of water sources, community participation and waste collection from river) and cannot (e.g. throw waste in the river) do. Most of them believed that the Surabaya River can become less polluted. However, almost half of the respondents indicated that people in their neighbourhood still throw waste in the river. Still, the respondents were inconclusive whether people contribute to the solid waste problem in the river, most respondents blamed only the industries along the river to be the cause. However, when asked who is responsible for changing the current state, the large majority of the respondents (25 out of 30) said everyone (i.e. government, river basin authority, industry, communities). Two respondents said it is the government's responsibility and two respondents said it is the responsibility of both the government and industries.

Actions were studied by combining observations with questions asked during interviews. Figure 8 shows the topics of questions asked during the interviews where actions were asked. The full questions can be found in appendix E.1 (where they are numbered: E.1.2.4, E.1.5.5, E.1.5.6, E.1.5.3, E.1.4.1, E.1.2.3). Questions have been interpreted as presenting a "positive" attitude or a "negative" attitude in their actions. This was done by grouping answers of the questions in non-polluting or actively involved in environmental activities (being positive) and polluting or not being active or concerned with the environment (being negative). There was a strong willingness to participate in environmental projects among the respondents and most respondents claim that they do not throw waste in the river or pollute it in another way. Many people talked about environmental issues regularly. Waste disposal actions were almost equally split

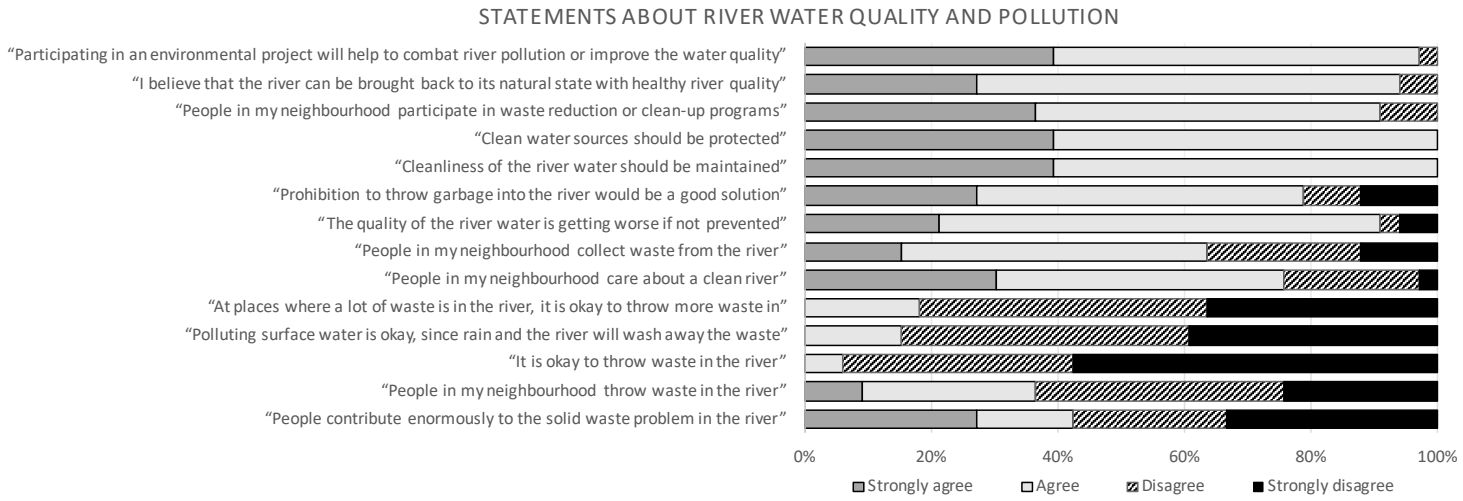

Figure 7: *Statements presented to study the view on actions of community members along the Surabaya River*

between a positive and negative attitude. This could be explained by the availability of waste facilities in communities. Community members who want to perform positive waste actions and were constrained due to a lack of available waste facilities still performed negative waste actions. Looking at waste separation practices at home, it can become more clear whether this facility constraint actually affects their actions at home. Even though some people lack facilities in their community they still separate waste and compost their organic waste and give away their valuable waste to scavenges.

The last thing that can be noticed is that information on river pollution has not resulted in change in actions of most respondents. This can be explained by the claimed uselessness of the information provided. Between institutions and stakeholders some systems are set up. EPA and Public Works try to engage communities in their activities through offering information on their websites and trying to link the government and the communities through this. PJT and PDAM have a communication system and PDAM has an early warning system with government and communities. Most of the institutions also provide information or communication opportunities in a different way. PJT provides results of monitoring and evaluation of water quantity and quality on their website. BBWS provides water data and information on their website, the same applies to EPA. PDAM organises regular meetings for users and has a campaign to use community water.

Since the statements presented in figure 7 are ordinal (four point Likert scale) data and the waste actions are on a nominal/categorical data, statistically it is difficult to compare. Converting the statements presented in figure 7 to nominal/categorical data does not seem appropriate here because it probably needs lump the data too much. So comparing the bar charts as they are presented here in figures 7 and 8, it can be seen that overall community members had an optimistic view on how their communities interact with waste and the river, but also see the things that need to change. Most of the community members' actions are in line with this. This could also be explained by the fact that all respondents except for one have said that they feel a moral obligation to participate in environmental projects regarding the river and waste. However, as some do not actually take action following their feeling of moral obligation, tensions can arise. There exists strong social control in the area, as illustrated by the following quote from a member from the women group in Wonorejo:

> *"We make a picture of people that are throwing waste into the river and report it"*

That women group coordinates the fining policy

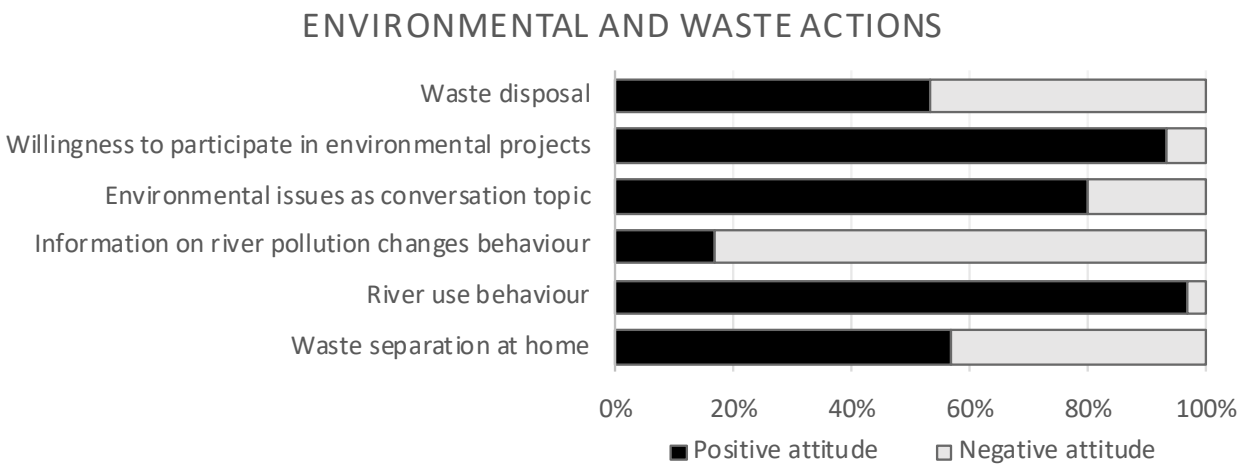

Figure 8: *Positive and negative attitude in environmental and waste actions*

of throwing waste into the river (a penalty ranging from 75,000 up to 1,500,000 rupiah, depending on amount of waste) in their neighbourhood. In Jambangan there is a team of community members that monitors waste dumping into the river and calls out the polluters so they collect their dumped waste. This social control, but also government involvement can cause conflict. Some respondents indicated that conflict due to regulations for polluters shall arise once these come to effect, this is illustrated by the following quote, as an answer to the statement about prohibition, of one of the members from the group discussion in Penambangan:

> *"This will probably lead to conflict in the community, because the people who care about the river and environment will tell the polluting people that they should not pollute. It is expected that the polluters then will become angry with the other people form the community"*

During a conversation with people working at the collecting and sorting facility in Wringinanom, they mentioned that there was some conflict when their waste facility was going from governmental supervision and operation to community supervision and operation. This concern was also expressed by the person in charge of the 3R projects by Public Works.

Now that we have looked into how the respondents say that they *see* and *think* about "the problems" and what they *say* what they *do*, it is time to deeper investigate two aspects: the familiarity versus the willingness to participate in projects (so translating the *knowledge* to *actions*) and exchanging information to changing actions (the *talking* to *actions*).

A potential relation between the familiarity with environmental projects (focusing on river pollution or waste) and the willingness to participate in these projects could provide information on whether people are motivated to join when they know about such projects. Even though participation was not directly measured, it is assumed when people say that they participate, that they were actually participating. The following hypothesis was formulated:

H_3: Familiarity with environmental projects does not have a significant influence on participation in such projects

H_4: Familiarity with environmental projects does have a significant influence on participation in such projects

Table 4 shows that overall, more than half of the respondents are familiar with any projects and more than half of the respondents are willing to participate in such project. It also shows that the most respondents (15 out of 30) who are familiar with environmental projects focused on river pollution or

waste are also willing to participate in such projects. At the same time, 10 out of 30 respondents who are not familiar with projects are also not willing to participate in these.

Table 4: *Comparison familiarity and willingness to participate in environmental project focused on river pollution or waste*

		Willingness to participate		Total
		Yes	No	
Familiarity	Yes	15	3	18
	No	2	10	12
Total		17	13	30

Looking at the (Pearson) Chi-Squared test (table 11 in appendix H), a value of 13.032 and a two-sided asymptotic significance of 0.000 is found. The significance is smaller than 0.05 (even after Yates' correction), therefore the null hypothesis H_3 can be rejected.

With a certainty of 95% it can be said that familiarity of projects and willingness to participate in these kinds of projects are not independent.

The strength of this relation can be found with *Phi* (ϕ). The value of of Phi is 0.659, meaning that there is a strong relation [De Voght, 2011]. In practice this means that providing information about projects and setting up projects in communities will most likely stimulate participation by community members and could thus lead to an acceleration of the implementation process of effective measures.

A potential relation between the information exchange on a regular basis (i.e. frequent conversations on topics such as river pollution and changing actions due to information about river pollution) and actions could be explored. The following hypothesis was formulated:

H_5**:** Regular related information exchange does not have a significant influence on the changing in waste actions

H_6**:** Regular related information exchange does have a significant influence on the changing in waste actions

Looking at table 5, it shows that overall the majority of the respondents have frequent conversations with their relatives, friends or neighbours about topics such as river pollution and waste and a slight majority had not changed their waste actions due to information that they had received.

Table 5: *Comparison environmental issues as conversation topic and change in actions due to information on river pollution*

		Change waste actions		Total
		Yes	No	
Conversation topic	Yes	7	10	17
	No	7	6	13
Total		14	16	30

A Chi-Squared test is carried out (table 11 in appendix H), the value for Chi-Squared was found to be 0.475 and a two-sided asymptotic significance of 0.491. Because the statistical significance is larger than 0.05, the null hypothesis H_5 is not rejected.

There is no statistically significant relation between waste separation and waste dumping activities.

It must be noted that most respondents have indicated that when they receive information about river pollution (at all), the information is useless, meaning that the respondents do not know how to act upon this.

4.6. Evidence of multiple ontologies

In the sections above we have studied the realities of human agents and nonhuman agents in the Surabaya River. As we see, activities show that more than one ontology might exist and that these multiple ontologies are shaped in practice. There are many ways to approach this state in terms of measurement, resulting in this multiplicity. During conversations, interviews and observations the shift between waste, river, environment and people's actions and views is constantly made. This is illustrated by the following quotes:

> *"It will be difficult since in the area upstream of the river also needs to change their polluting habits and behaviour"* - Participant in women group discussion Penambangan

> *"We have enough facilities. But still people do not throw waste in this. People are lazy!"* - Interviewee from Jambangan

> *"People do clean up the waste from the riverbank for burning, but do not clean the river from waste. They think it is useless because the other villages are still polluting the river"* - Interviewee from Bambe

Mol [2002] and Carolan [2004] argued that statements about what *is*, can make a difference and therefore are more than just words, not being only descriptive but also performative, where the *what is* is performed in a specific way. Multiple ontologies does not necessarily imply fragmentation, as explained by the quotes below.

> *"Through translation, reality shifts. But it shifts not because the materiality is itself fragmented, un-centred, and fluid.... Rather, shifts in reality occur because the object itself has shifted."* - Carolan [2004]

> *"But the ontology that comes with equating what* is *with what* is done *is not of a pluralist kind. The manyfoldedness of objects enacted does not imply their fragmentation."* - Mol [2002]

5. Discussion

Inorganic solid waste pollution in the Surabaya River has become an enormous issue. By looking at relations between communities, this inorganic solid waste and the Surabaya River and at which time scale these relations occur, I tried to provide insights for combating this solid waste pollution in the Surabaya River. Using observations, interviews and measurements as inputs for several analyses have resulted in presenting multiple ontologies. From this research forward, accounting for multiple ontologies could help for reaching inclusive waste and river basin management.

Before we continue with the discussion, a small note must be made. I want to remind the reader that this thesis has provided one ontology, while contradictory claiming that multiple ontologies exist in the Surabaya River Basin. That said, having a large amount of data and choosing which data to present in what way shapes the research and the thesis as well.

There is evidence for the origin of waste in the Surabaya River being there due to a continuously (re)produced state, but also that the 'current' state observed has been a different state that has evolved from previous states. Within the time frame of the fieldwork, both states were found. Many respondents expressed that they are making an effort to reduce their waste generation, and that this takes some time to adapt their lifestyle to. On the contrary, observations showed that the use of many types of plastic food packaging (around everything you could think of) is common practice. This includes having drinking water in plastic single-use cups. Another example is the burning of the waste every afternoon. These are short term actions that are being continuously reproduced.

Information sharing from institutions towards communities is done in such a way that it is presented on their website but there is not much effort put into the sharing to the public in other ways. However, during the study when the community members were asked whether they receive (useful) information about river pollution, a follow-up question about whether they actively look for information was not asked. So it could be that not only governmental institutions are quite passive in sharing information, but also community members are not as interested or involved as they think they are (or would like to present themselves). Or, as explained in Charriere et al. [2013], there are different views of what are good ways to share information and also what the public find important versus what the managers think that the public wants.

An available waste collection service and waste dumping suggest that when people have access to waste facilities, waste dumping could be reduced significantly. Furthermore, the comparison of knowledge of available waste facilities and actual use suggests that people have a positive attitude towards proper waste handling. On the other

hand this can be explained by Knussen et al. [2004], who performed a study on intentions to recycle household waste in Scotland found that a perceived lacking of facilities discourages people to recycle. Babaei et al. [2015] found that the studied community in Iran had a positive attitude towards waste separation at source and recycling, however the study showed inadequate knowledge and practice of solid waste management in the community. Therefore it is key to not only provide communities with a sufficient infrastructure but also acquaint them with proper waste management. However, when people need to pay for these facilities, it could become an issue since paying for something that you throw away is not embedded in Indonesian culture.

This article has shown that ontologies are shaped by activities, leading to the existence of multiple ontologies in the Surabaya River Basin. There are various ways to look at multiple ontologies, as visualised in figure 9.
We could treat all individual claims and ontologies separately (figure 9, left drawing), however it would not show the interfering, conflicting or converging, of these multiple ontologies, as explained by the following quotes:

> *"It does not imply that reality is fragmented. Instead it implies something much more complex. It implies that the different realities overlap and interfere with one another. Their relations, partially coordinated, are complex and messy."* - Law [2004]

> *"For even if objects differ from one practice to another, there are relations between these practices. Thus, far from necessarily falling into fragments, multiple objects tend to hang together somehow."* - Mol [2002]

Thereby, it would be difficult to look for many actions that would lead to a desired (or more desirable) situation. On the other hand, treating the multiple ontologies as a whole (figure 9, middle drawing) to look for one holistic solution is also not preferred, since this will discard the differences in ontologies and could lead to elimination of 'less relevant' ontologies. Therefore, we should treat the multiple ontologies and their differences and similarities in such a way, so we can make combinations that will still respect all ontologies within these combinations (figure 9, right drawing).

For some narratives I chose to use a statistical analysis to support the narratives I was describing. These statistics were supportive, not leading, as they were not only based on a p-value passing a certain threshold but also on contextual factors of the study. [Wasserstein and Lazar, 2016] For example, waste dumping actions not only depend on availability of waste collection service or facilities (as tested in this study) but also on factors as income or could be influenced by for example education. Drawing conclusions solely based on a value obtained by a statistical test does not cover the whole story and therefore should not be treated as the most essential part of the study.

Whether the null hypothesis was rejected or not depends on the significance level of 0.05. Validity of statistic conclusions not only depend on the chosen statistical tests, but also on the appropriateness of steps taken and results analysed. [Wasserstein and Lazar, 2016] Values near a p-value of 0.05 (which could be weak evidence) were not found in the statistical tests conducted by this study, meaning that the conclusions drawn from this do not hinge on that value of 0.05.

There was no significantly statistical relation between talking about the environment and what can be done, and changing actions to match your view of what one should do, is not significantly related. The theory of planned behaviour (TPB) could explain this with a lack of perceived behavioural control, where people feel that they are not in control of their (polluting) situation. Jekria and Daud [2016] suggests that information, education and training will enhance TPB and could therefore be an efficient way to stimulate people into recycling.

The study was limited in a number of ways. First of all, the data was only collected during the dry season, providing an incomplete account of the relations. Moreover, interviews were done with people who were available, in communities

Figure 9: *Various ways to deal with multiple ontologies. Left: presenting all single claims as individuals, resulting in a fragmented representation. Middle: trying to combine all ontologies for one holistic vision and solution. Right: combining some ontologies to create workable sub groups (modified from Pinterest [2019])*

with whom NGO Ecoton was working with. This suggests a biased representation of communities along the Surabaya River. However, due to the different available water and waste management systems (appendix D), and interviewing many people that are not familiar with Ecoton's work, data could be quite unbiased. The support from Ecoton was crucial due to their local knowledge and network. Translations of interviews and personal interpretation probably have influenced the collected data and thereby the interpretation of people's actions as well.

The different time scales that were considered enabled me to put the actions of the several observed 'current states' into place. It does make it difficult to say whether some 'current state' is being reproduced all the time or this is just a state from which a newer state will be produced. Thereby one could think that a two month time scale is quite long for observing people's actions, however, due to logistics I was only able to see as much as the times I visited certain communities. Luckily, members from Ecoton could fill me in with extra information when I needed it. Also asking questions relating to longer time steps helped me put actions in a time frame.

A few suggestions for future research can be proposed. First of all, as discussed earlier, conducting fieldwork in the wet season provides new observations and could provide new insights into waste-river dynamics and the people's interaction with the river. Secondly, this study can be used for a comparison study at other places. Here, patterns might emerge, which could be used for a possible common strategy tool. Or it could serve as a baseline assessment for an intervention study with for example waste facilities. This research showed that many community members are actively involved (or want to be actively involved) in environmental projects. Therefore, a final suggestion would be to initiate citizen science based projects, where community members could be included into the data collection process (e.g. measuring water quality, assessing waste facility performance or performing waste audits). Some of the advantages are that more local data is collected and that community members are gaining more responsibility and knowledge about the river water quality or waste management.

The findings presented in this study provide insights in what way communities, inorganic solid waste and the Surabaya River are related. It showed that there is great potential to stimulate communities in short-term actions, provided that

(e.g. governmental, non-governmental) offer tools and information to get the projects off the ground.

6. Conclusion

In practice, multiple ontologies on the Surabaya River water quality and proper waste handling are brought into being. Depending on time, location and actor, a somewhat different river water or waste handling was being discussed, observed or measured when considering the practices in the Surabaya River Basin.

The current state(s) that was/were observed during the fieldwork have been investigated. This thesis studied whether the actions of people with respect to inorganic solid waste and the Surabaya River were continuously reproduced or that this studied 'current situation' was just one event in time. Interviews, observations and measurements were analysed with several methods: statistical analyses using IBM's SPSS, QGIS and a flow diagram. This study showed that multiple ontologies on 'improved water quality' and 'proper waste handling' were shaped in practice. It presented the claim that some actions are continuously reproduced (for instance the burning of waste in the riverbank) and some have evolved from previous states (e.g. waste reduction trend, waste handling in Jambangan). The waste infrastructure in the area cannot keep up with the growing population and waste generation. At the same time, government and communities are making efforts to decrease waste generation. Waste accumulation in the river from upstream to downstream was observed and showed that this is a reoccurring event.

The riverbank is an important feature in this study, where humans, waste and river interact. Changes in interactions occur when following the river downstream. Most respondents have activities at the riverbank, being waste dumping and burning, fishing, transporting or doing environmental projects such as growing plants. This is the location where much can happen in terms of (short-term) actions or projects.

At the moment there is a misunderstanding among stakeholders due to limited awareness of multiple co-existing ontologies in the Surabaya River. The human agents studied in this research have a different vision on what 'improved water quality' is, and find different agents accountable for maintaining a certain quality. First of all, community members are generally optimistic or motivated to improve the water quality together. As for now, they have no access to a reliable water management system and mistrust in their available water sources resulting in relying on bottled water for drinking purposes. Secondly, governmental institutions are performing activities to try to control and maintain the water quality, but have difficulties due to various barriers.

When talking about water quality, some people express that for them controlling the water quantity is a more pressing issue. This illustrates that river water has different meanings for different people. Although many respondents who know which waste facilities are available also actually use them, there is still a number of respondents who do not know what kind of facilities are available or do not "care" about waste properly being handled.

There was no statistically significant relation found between respondents separating their waste at home and waste dumping. This is partly due to the unavailability of facilities but also due to the existence of for example scavengers. Lack of information was indicated also to be a dominant factor. In places where a waste collection service is active, there is a significant moderately strong relation to waste dumping practices. So when there is a service available, people tend to use that instead of dumping.

Governmental institutions try to keep the Surabaya River clean of waste and initiate and facilitate waste management, however, it does not reach many communities and often their activities are unfinished to be effective (e.g. cleaning waste from retention boom but let it float through instead of transport it to landfill, due to incorrect scheduling of transportation).

When studying the environmental actions of

community members, it became clear that people are motivated and willing to participate in projects (but are not willing to initiate). Through presenting statements and talking to people it shows a gap between people that are actively involved and people who are not. A significantly strong relation between familiarity of these projects and willingness to participate in these projects was found. This could explain that people who know nothing about the projects are maybe falsely accused of being "lazy" or that they "do not care".

Overall, questions regarding environmental actions tend to show a positive attitude of the respondents.

There is no significantly statistical relation between talking about the environment and what can be done, and changing actions to match your view of what one should do, is not significantly related. Within the sample of this study, it does not matter whether people talk about environmental issues and how they change their actions or the other way around. Tension in the community and conflicts arise between people actively involved in changing their habits compared to people who do not (or might not be able to) change. However, providing useful information to the community about these issues and how to actually act on that might provide a different reaction.

Ontologies provide support for environmental debates and working towards a solution. Under the 'right' conditions the fixed object, here 'water quality' and 'waste handling', becomes multiple. Important is to not just address multiplicity but also *how* this is coordinated in its entirety in a comprehensible way. For this, communication, 'morality' and trust is crucial.

> *"For as human activity reaches further into the beyond of the environment, so too must we rely increasingly upon trust to bring that beyond back into the social"* Carolan [2004].

Not striving towards one holistic picture and looking for one solution, but properly valuing the combination of ontologies, could help in producing several workable actions. Multiple ontologies enables decision-makers to use different approaches to a solution. A long(er)-term goal can be broken down into short(er)-term actions.

During this study relations between communities, inorganic solid waste and the Surabaya River have been studied, by looking at the time scale in which these relations are produced. This study showed that both relations on short term and long term were observed, being evolved from previous states or are continuously reproduced. An example for a state that is continuously being reproduced is the burning of the waste every afternoon. The waste project and community renovation initiated in Jambangan has led for instance to a newly evolved state that has broken the continuous actions of waste dumping. Furthermore, the single use plastic reduction trend is catching up and changing the respondents' actions. Valuing multiple ontologies provides for working towards a more inclusive and sustainable water and waste management in the Surabaya River.

7. Recommendations

With this study I presented the multiple ontologies concerning river water quality and waste management in the Surabaya River Basin and studied how the observed states were constructed. I investigated whether actions of people were constantly reproduced or evolved in time. This study found evidence for both types of states. Below, recommendations following this research are proposed:

- The origin of waste in the Surabaya River consists partly of actions leading to continuously reproduced states, but also to newly evolved states. The continuously reproduced states, such as dumping waste in the riverbank and waste burning every afternoon, are rooted in the area. For this, a back-casting method can be used, where a long term goal can be formulated and then a planning of (short term) actions can be put into place to reach this long term goal. For newly evolved states, which tend to be more flexible than these reproducing states, quick technological fixes (such as in Jambangan, where in a relatively short period the houses were literally turned around to face the river and a proper waste system was put

into place) could be helpful to speed up the changing process.

- The riverbank can be used as the location in which short-term actions can be initiated. Stronger enforcement is needed at these sites, as suggested by various community members and government officials, but in such a way conflict could be avoided (so in combination with information, facilities and education).
- Creating moments such as community meetings, where people can discuss their vision, what they want to know/learn/do and how people see things differently. By discussing openly about this, conflict could be avoided or at least mitigated. Organisations such as Ecoton already foster these kind of activities, but more initiation from other (governmental) organisations could also train people to do this for example.
- Regarding the information gap between institutions and communities, a (online) platform providing information from the "leading" institutions about river water quality, river pollution and also about waste handling that is easily accessible to everyone would be for both sides of communication (sending and receiving end) a promising solution. Most people in the Surabaya River Basin own a smartphone, so a mobile application would most likely be useful for the target audience.
- Ontologies showed that people in the Surabaya River Basin have mixed interests and values. This mixture could direct these actors towards a collective goal: improving the water quality in the Surabaya River and coverage of waste management systems in the communities. As most respondents were Muslim and the Muslim community in the Surabaya River Basin is very active and influential, it might be a good idea to use this network as well. However, one should be careful not to exclude non-Muslim people. These various cultural resources could make efforts to improve the Surabaya River and also improve the community waste management systems sustainable and extensive.

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A. Water and waste management in the Surabaya River Basin

A.1. Water resources and management

Rainwater, surface water and groundwater are abundant in Indonesia, but due to pollution access to safe water is limited. For clean water sources, 74% of the households use groundwater, 3.4% use river water, 21.2% use piped surface water and 1.4% use other water sources. Due to deterioration of groundwater quality, 28% of the recorded springs went down in the Upper Brantas River during the period 2007-2009. This deterioration in water quality of surface and groundwater and a lack of piped systems, leads to people massively relying on bottled water (which in turn generates more plastic that could end up in the river). [Schuler et al., 2012]

Water resources and population are unevenly distributed in Indonesia, where 57.5% of the population resides on Java Island with only 4.2% of the national water resources available. Not only is the water spatially unevenly distributed, during the rainy season (five months of the year) 80% of the water is available and in the dry season the remaining 20% is available. [IWRM, 2016] During the rainy season 85% of the annual precipitation is received [Fujimoto, 2013]. Infiltration of rainfall to groundwater in Indonesia is about 10%, which means that this country heavily relies on surface water as their water resource [Suprapto, 0]. In Java the surface water potential is 4%, being 164,000,000 m^3 per year [ADB, 2016]. The annual average per capita household water consumption is 183 L/cap/day in 2013, thus a total annual water consumption of 153 739 230 m^3. [Sušnik and Yuniarto, 0] Nationwide in Indonesia, domestic water use in urban areas are on average 90 to 190 L/cap/day and in rural areas on average 60 L/cap/day in 2016. This means that the people living in the Surabaya River Basin are at the higher end of the spectrum.

In 2013, 66.8% of the households in Indonesia had access to "improved" drinking water sources, meaning that the source is adequately protected from outside contamination (fecal matter in particular). Improved drinking water systems are e.g. public tap or standpipe, a piped network, a well (tube, bore, protected dug) or collected rainwater. [ADB, 2016] 18.6% of the population had access to piped drinking water and 67.8% of that water meets the WHO drinking water quality guidelines [IWRM, 2016].

In the Surabaya River Basin people get water from piped and non-piped systems (e.g. groundwater wells, bottled water), managed by public and private vendors. Piped systems cover 81%, of which 79% is covered by PDAM, the regional drinking water company, and 2% is provided by private operators. The non-piped systems are supplying the remaining 19%. In 2016 PDAM supplied water to almost 3.3 million people [PDAM, 2016]. PDAM takes 97% of its water from the Surabaya River, the remainder from the Umbulan Spring and Pandaan Spring. According to the Department of Civil Registration, 71% of Surabaya had access to safe drinking water supply in 2014. [Sušnik and Yuniarto, 0]

A.2. Waste management

Solid waste (SW) generation increases with urbanisation, industrialisation, and population and economic growth. Large cities with high density face serious household solid waste (HSW) problems. The Surabaya Area also faces this problem, caused by lack of disposal sites locations, lack of funds and lack of facilities. In the Surabaya River Basin solid waste is managed at community scale. According to NGO Ecoton the waste management coverage in Surabaya City is around 90% and for other areas in the Surabaya River Basin the coverage is 40 to 60 %, supplemented with voluntary community projects. Coverage means that there there is some kind of waste facility in place. 3R (reduce, reuse, recycle) efforts are also made in the East Java Province, but data from the Public Works department shows that in the period of 2005 to 2016, 84 projects have started but only three were indicated as still working well and three were indicated as working adequately. The remaining projects have been stopped. An impression of the landfill in can be found in figure 40, appendix G.

In 2015, eastern Surabaya generated 0.33 kg/capita/day of HSW, with the following composition: food waste (64.19%), plastics (10.79%), paper (9.24%) and diapers (6.97%).[Dhokhikah et al., 2015] Daily, 1,500-1,600 tonnes of waste are produced. Every other day the waste is collected by small wagons, operated and mobilised by people. The waste is transported from households to temporary landfills, at which sorting centres separate organics and recyclables are (informally) collected by scavengers. These scavengers sell the plastics to a sorting facility or waste bank, from where it is transported to bigger waste facilities or sold to a recycling factory or centre. About 11% of Surabaya's total waste is recycled at informal shelters. Surabaya's few recycling depots separate, clean and process plastic to be sold to factories. In the separation process, the remaining waste is going to the landfill in Benowo, 15 km outside the city, where it will be incinerated (in the process energy is generated). Daily, Surabaya's main waste bank receives approximately 60 tonnes of inorganic waste, of which 40% is plastic. Small waste banks cover around 100 households and are mostly managed by women. [Circulate Capital, 2019] [Gilby et al., 2017]

Along the riverbank houses are tightly packed and most of the houses are faced away from the river, often partly overhanging the river. This leads to easy waste dumping into the river and using the river as an open sewer. [UnileverInternational, 2001] Floodings are used to get rid of solid waste [Prasetyanti et al., 2014].

A.3. Community engagement in river and waste projects

In 1989 the Clean River Program *Prokasih* was initiated by the Indonesian Government, identifying the willingness by industry to practice pollution control [Afsah et al., 1999]. Even though pollutant concentrations decreased in the river segments where the program was implemented, the people residing close to the participating rivers believe that the rivers' condition have worsened with regard to physical characteristics (e.g. odour, colour, turbidity, trash, flow, and sediments), even after the implementation of Prokasih [Pradnja Resosudarmo et al., 1997]. Pradnja Resosudarmo et al. [1997] concluded that when a clean river program is successful in lowering the technical parameters of water pollution, river communities might still not feel the benefits of this program. The reason for this is that the river still smelled and looked bad. However, participation and support from the community is especially needed to achieve successful waste management in order to restore good river water quality. Polluting of the river water is generally anonymous and thereby nobody feels very responsible [Liu et al., 2011].

Effectively tackling the solid waste problem at its source or apply mitigating solutions in the river will decrease the negative environmental impact this waste has on aquatic ecosystems as well as on society. Dealing with the solid waste problem successfully is critically linked with the engagement of citizens [Kaza et al., 2018]. According to Darmayanti and Koudstaal [2016] the waste problem is induced by humans and should be solved by human interventions. Furthermore, according to Han et al. [2019] successful domestic waste management requires broad public awareness and attitude as well as sustainable willingness to participate (WTPP) and public willingness to pay (WTP). As reported by ADB [2016] community participation in Indonesia is still limited due to a lack of knowledge and understanding of communities and business in water resource management on the one hand and a lack of encouragement from WRM institutions on the other hand. Mawaddah and Kes [2017] found that there was no significant correlation between polluting perception and behaviour of communities in Malang (upstream region of the Brantas River).

B. Hydrology and Morphology of Surabaya River

B.1. Hydrology of the Surabaya River

The Surabaya River (dark blue line in figure 2) is a branch in the downstream area of the Brantas River, one of the largest rivers on Java Island. At the Mlirip Sluice in Mojokerto the Brantas River diverts into the Surabaya River and the Porong River. The Surabaya River heads 42 km north, through urban settlements and through the city of Surabaya, and discharges into the Madura Strait. The Porong River, a man-made flood diversion channel, heads east and supplies water the large Delta Brantas irrigation system before discharging into the sea. The functions of the Surabaya River are supplying water to Surabaya City, industries and irrigation areas, and serving as a main drain of the urban areas. The Mlirip Sluice has two main functions: flood protection and water level regulator (maintaining river flows during dry season).

The wet season is from December to May and the dry season is from June to November. During the wet season approximately 20% of the Brantas River enters the Surabaya River, during the dry season a larger share of the Brantas River enters the Surabaya River. This is due to the fact that the Surabaya River supplies many industries as well as the drinking water company of Surabaya PDAM, supplying (drinking) water to almost 3.3 million people. The remaining water of the Brantas River flows through the Porong River supplying water to a large agricultural area. Average monthly discharge in the Surabaya River during the wet season is above 50 m^3/s (between 57.5 and 74.6 m^3/s in the period of 2009 to 2016) and for the dry season it is less than 50 m^3/s (between 31.5 and 48.3 m^3/s in the period of 2009 to 2016) (see figure 10). The discharge and water level of Surabaya river is controlled and monitored by Perum Jasa Tirta I (further indicated as PJT). Figure 11 shows the average water elevation during the period of 2009 to 2016, clearly showing a difference in average between the wet and dry season of about one meter. In an interview with PJT a water level difference of two meters between wet and dry season was mentioned.

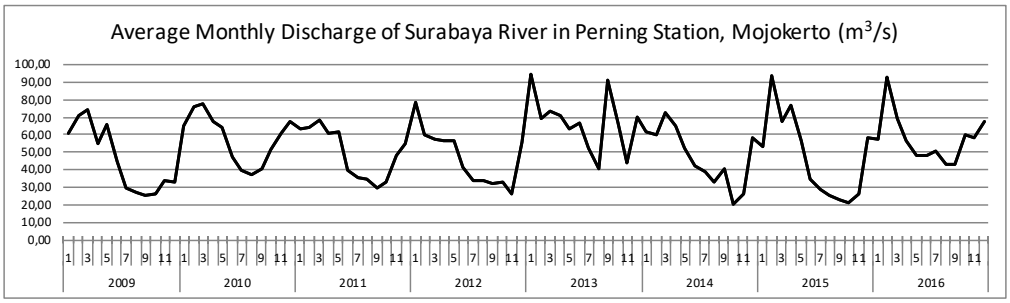

Figure 10: *Hydrograph of Surabaya River in Perning Station, Mojokerto in the period 2009-2016, as provided by Perum Jasa Tirta I*

PJT has installed two floating retention booms for controlling floating debris (both organic and non-organic) in the Surabaya River. The first boom is installed just before Mlirip Sluice and the other one just before Gunung Sari Sluice. Twice a week the booms are cleared off debris and the debris are being transported to the landfill. According to PJT, during the dry season the volume of debris is on average 156 m^3 per week. During the wet season, the volume of debris is approximately double the volume.

Ideally, these retention structures stop debris from entering Surabaya River and also stop debris from leaving Surabaya River. However, as concluded from observations and interviews with PJT and the cleanup team of the Cleaning and Gardening Department, reality shows that cleanups often entail debris being removed from the boom and released downstream of boom.

While meandering through the regencies of Mojokerto, Sidoarjo, Gresik and Surabaya, tributaries join the Surabaya River. In the outsides of the curves of meandering rivers, increased flow is present, leading to

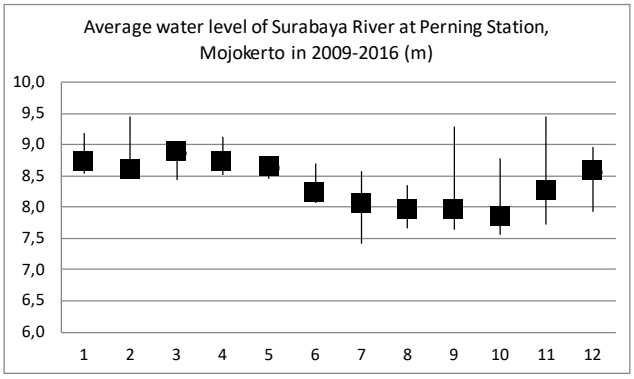

Figure 11: *Average water level of Surabaya River at Perning Station, Mojokerto in the period 2009-2016 [Setyo Rini et al., 2017]*

mixing of the water column. According to Hohenblum et al. [2015], during lower flow rates plastic floating on the surface tend to float close to the riverbanks instead of in the middle section of the river.

The Surabaya River divides after the Gunung Sari Sluice (in Surabaya) into the Mas River and the Wonokromo River. The Mas River flows north and discharges into the Madura Strait on the north coast and the Wonokromo River flows east and discharges into the Madura Strait on the east coast [BAPPEKO, 2000]. Gunung Sari Sluice is a regulatory structure that maintains river levels upstream for irrigation and also for the water intake of the Karang Pilang water treatment plant.

B.1.1 Morphology of the Surabaya River

The Surabaya River meanders through four regencies -Mojokerto, Gresik, Sidoarjo and Surabaya- before discharging into the Madura Strait. The river has no steep bottom gradient, resulting in a absence of waterfalls and rapids. Mixing of the water column occurs at water infrastructures such as the Mlirip Sluice at the start of the river and where bridges are present. The land use on the river banks and in the floodplains is mostly agricultural in the upstream part and transitions into urban areas when going downstream. Although by law it is not allowed to build within 50 meters from the river in rural areas and within 10 meters from the river in urban areas, many urban settlements were present within these protected areas. Observations during boat surveys showed that in the upstream part the riverbanks consist of a vegetated riverbanks with signs of bank erosion and further downstream man-made riverbanks were mostly present. In the upstream part an abundance of riparian vegetation was present and this decreased downstream.

C. Studied communities

C.1. Wringinanom

About 300 households of Wringinanom are member of a waste collecting and sorting facility (purple area in figure 12) and pay a small fee. Residual waste, about 40% of the total amount of waste, is transported by truck to the landfill every other day. This facility has received no support from any governmental institution since 2018 and operation and payment of workers is financed by selling recyclables and homemade compost. Half of the interviewees are not a member of the waste facility (indicated by black squares in figure 12) and dispose of their waste near home or in open spaces. Containers specifically for diapers are placed in some areas, but still people bury or throw diapers in the river. Observations showed that dump sites are mainly located on riverbanks. Some people burn their waste in front of their house. Only one of the interviewees does not know what kind of waste facilities there are in the community.

Waste audits of ten households that represent a general "Indonesian community" were performed over the span of one week. These households consisted of three up to ten persons and some had also a *warung* or *toko*. The audits showed that in a week time these ten households generated 188.6 kg and the composition of household waste being for 61.2% organic, 1.0% recyclable waste and 27.8% non-recyclable waste (a more detailed overview can be found in table 12 and 13 in appendix I). Figure 51 shows a waste audit activity.

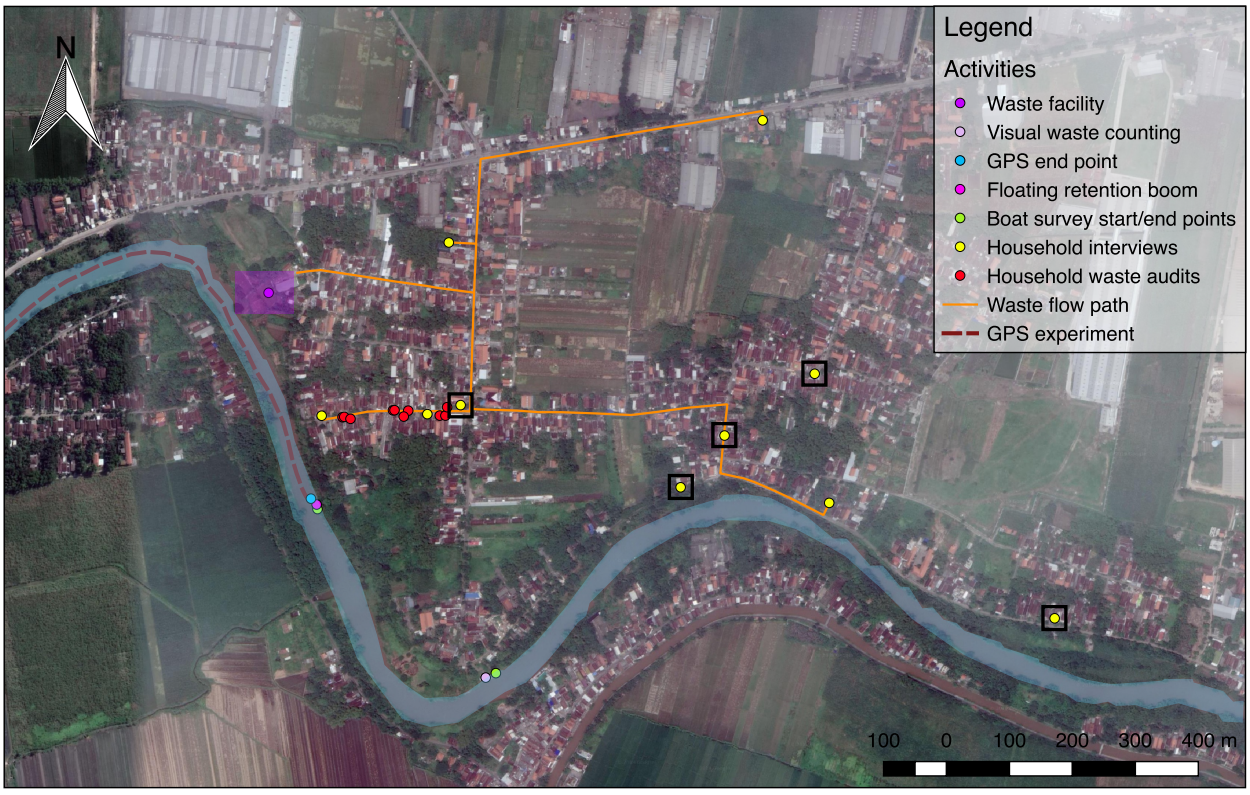

Figure 12: *Map of the community Wringinanom with performed activities. The purple area indicates the waste facility area. Black squares around household interviews indicate that these households are not connected to the waste collection service. The orange line shows the potential path the waste karts take to go to the facility.*

C.2. Bambe

Figure 13 shows Bambe community. No waste collection service is present in this community (table 8). Therefore, 70% of the respondents sees open spaces as the only way to dispose of their waste and almost half does it near their home (some selected multiple answers). Two persons burn their waste near home and only one person disposes of their waste in a nearby container.

Figure 13: *Map of the community Bambe with performed activities. The bright coloured areas represent locations where river bank waste audits were carried out. The open dump is the only "waste facility" that the community has at the moment of research.*

C.3. Jambangan

This community has had a project in which the houses situated directly at the river have been turned to face the river and also sufficient waste facilities have come into place. There is a facility (indicated by the purple area in figure 14) that collects, sorts and composts waste from 3000 households in this community. 30% of the waste they collect is inorganic, of which half will be send to the landfill. They generate power and make their own compost and animal food. Limitations of the facility were identified to be a lack of physical space (they want to expand) and lack of personnel. If they could expand they also want to upcycle rubber materials into sandals and alike. People indicate that there is a lot of education on waste management in Jambangan.

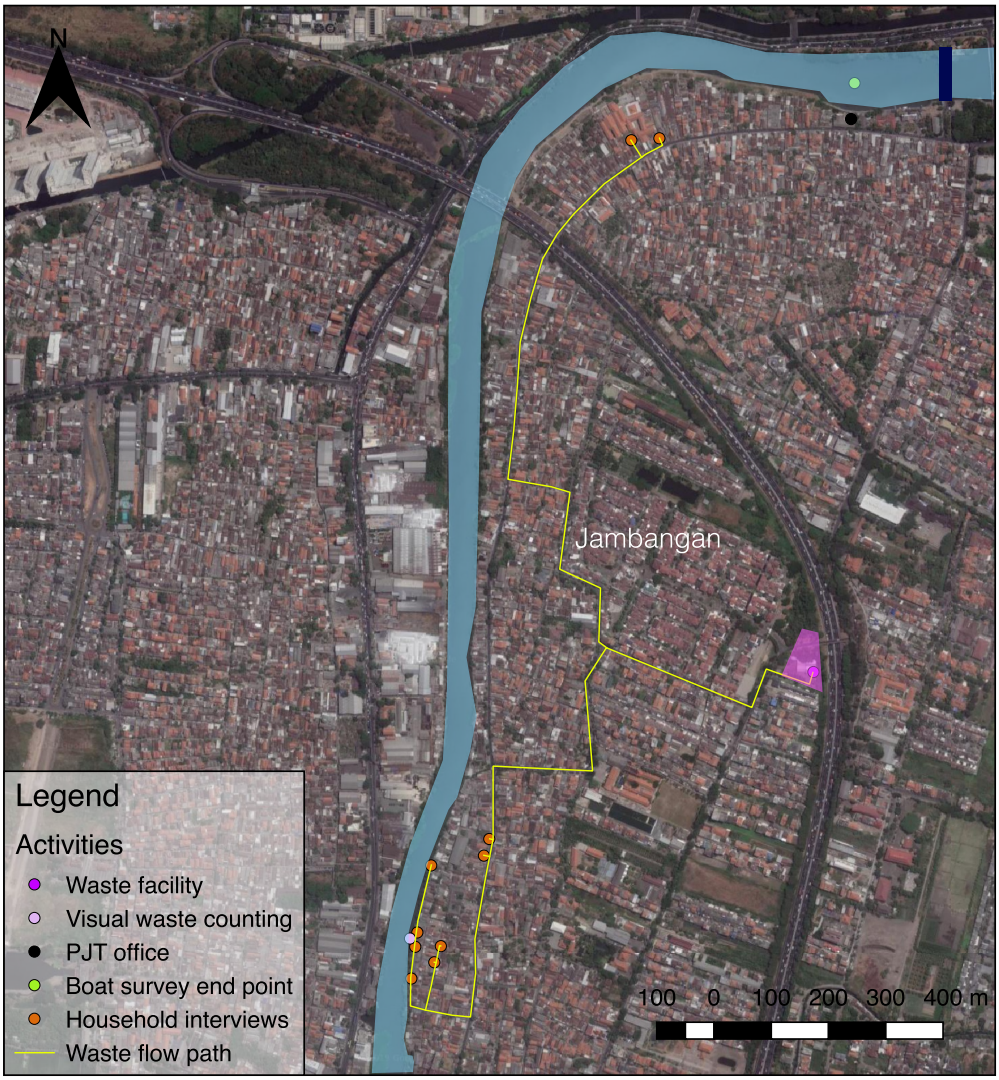

Figure 14: *Map of the community Jambangan with performed activities. The purple area indicates the waste sorting and composting facility. The yellow line shows the potential path the waste karts take to go to the facility. The dark blue rectangle in the top right represents Gunung Sari Sluice.*

C.4. Wonorejo

Even though the community of Wonorejo is not situated along the Surabaya River, but rather downstream along the Wonokromo River, it is still interesting to include in this research as Wonorejo is home to many fishermen who depend on the river downstream of the Surabaya River.

The coordinator of the women group goes around Surabaya to collect the trash in the downstream region (around and in the river), on the beach and out of the sea. They have a cleanup schedule for this, every three weeks on Friday they look for an area with the most waste (this is different every time) and clean it up. The focus of these cleanups is on the east of Surabaya (downstream from Wonorejo). Figure 37 in appendix F shows the land use in the part of the Wonokromo River where the fishermen fish.

In the community there are two types of trash bins: one at everyone's house and public/general trash bins. They want to separate waste, but not everyone understands the reason why so they stopped separating the waste. Another reason for not separating their waste is so scavengers can get the valuables out and earn a little extra money from that.

C.5. Buffer zone

C.5.1 Buffer zone calculations

Information from table 6 is used to calculate data in table 7. In the main text the data is rounded to whole numbers.

Table 6: *General information of buffer zone and MSW*

Buffer zone area (km^2)	14.23
MSW density (kg/m^3))	116

Table 7: *(Calculated) population and waste generation data from year 2000 and 2015*

	2000	2015
Population density (people/km^2)	1,360	1,682
Population in buffer zone	19,353	23,935
Waste generation (kg/capita/day)	0.22	0.33
Waste generation in buffer zone per week (m^3)	258.36	476.63

C.5.2 Buffer zone maps

In this part of the appendix the buffer zone analysis maps (area within 150 meters of the river assumed to be where people still directly dump waste into the river) are presented. Figure 15 shows the buffer along the entire Surabaya River. Figures 16, 17 and 18 show detailed maps of the studied communities and the buffer zone.

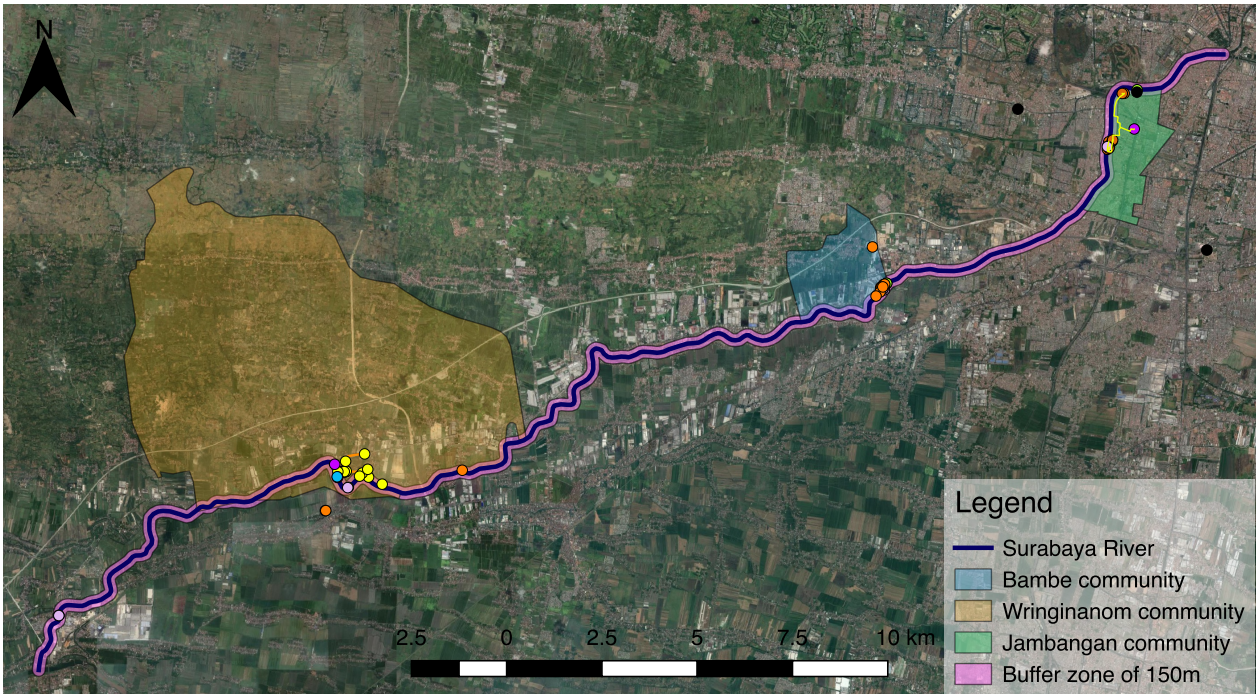

Figure 15: *Surabaya River showed with buffer zone of 150 m where it is assumed people could/would directly dump waste into river.*

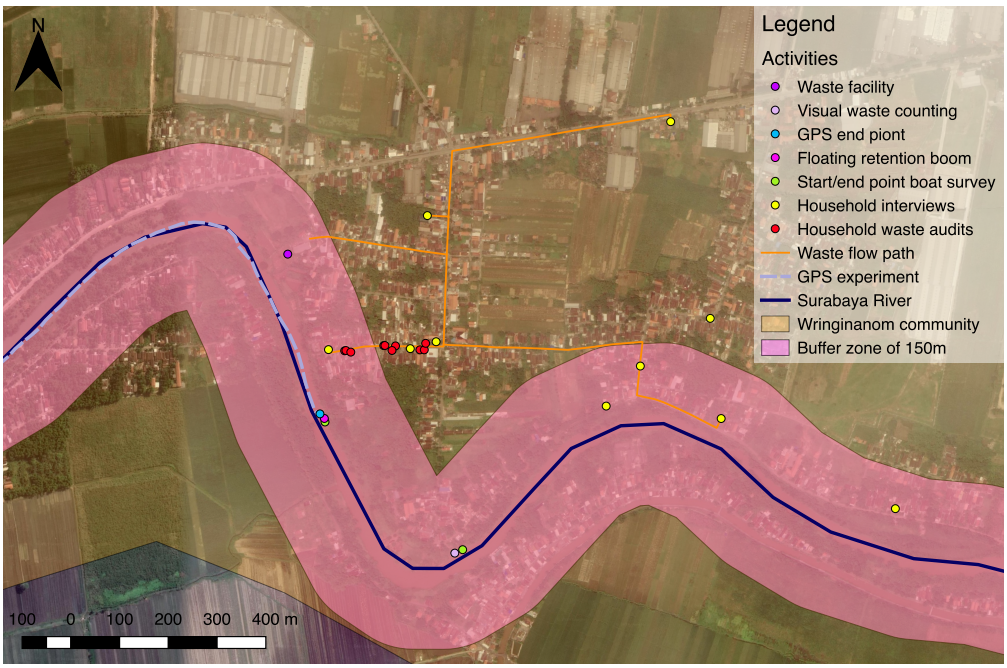

Figure 16: *Detailed map of buffer zone in Wringinanom community. The orange area indicates the Wringinanom community area.*

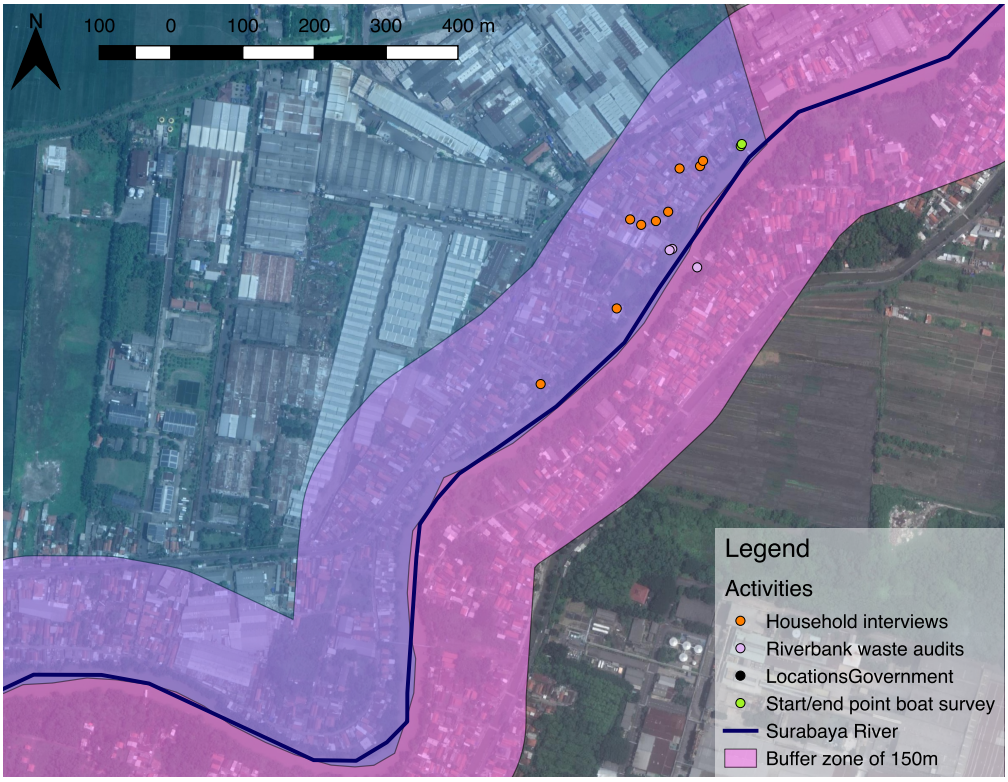

Figure 17: *Detailed map of buffer zone in Bambe community.The blue area indicates the Bambe community area.*

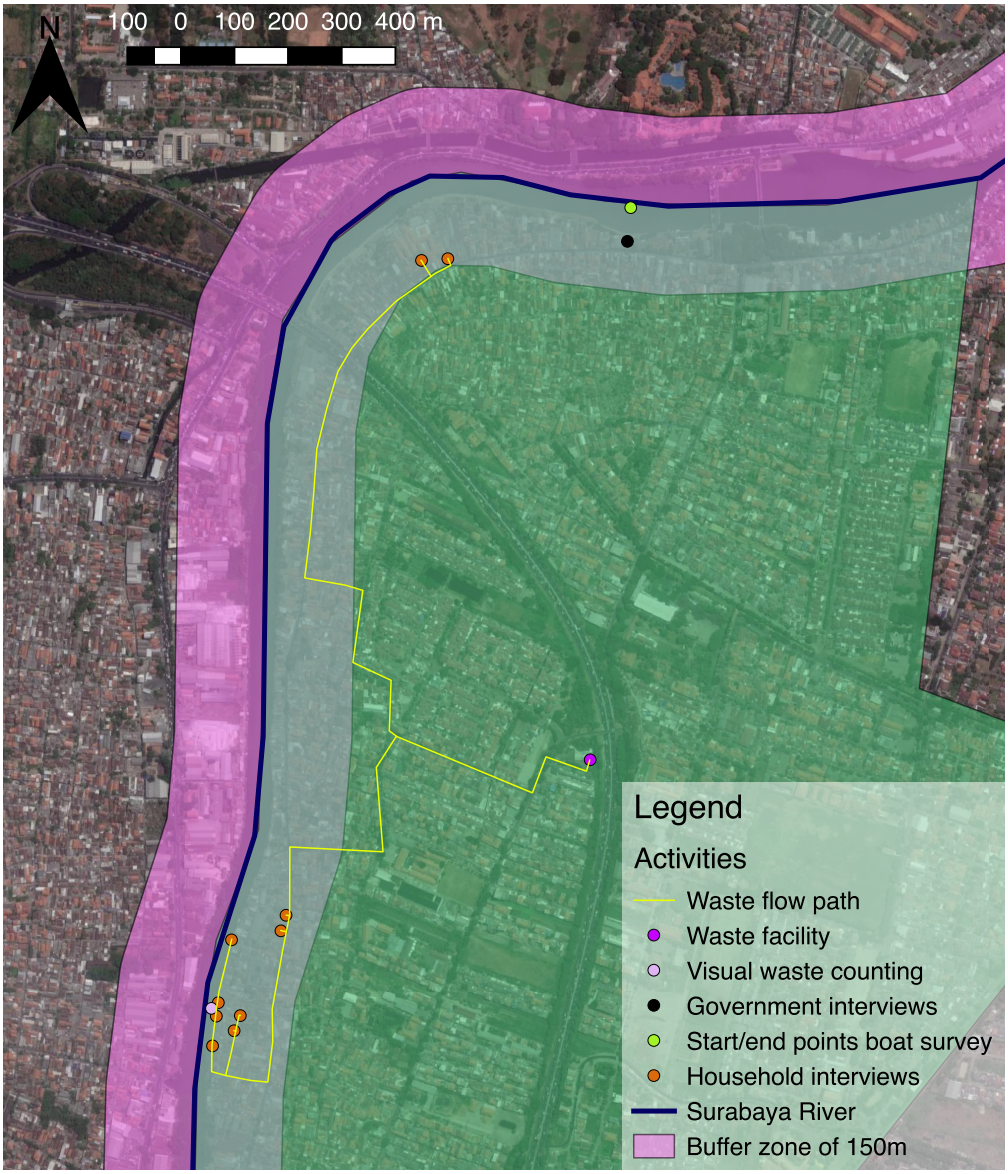

Figure 18: *Detailed map of buffer zone in Jambangan community. The green area indicates the Jambangan community area.*

D. Interviews samples

Table 8: *An overview of sampled interview types and locations*

Name community, regency	**Type of interview (no. of participants)**	**Water management facilities**	**Waste management facilities**
Wringinanom, Gresik	Structured, Household (10)	Groundwater well	Community initiatives
Sumengko, Gresik	Group discussion, Women (11)	Groundwater well	Community initiatives
Penambangan, Sidoarjo	Group discussion, Women (8)	Groundwater well	Community initiatives
Bambe, Gresik	Structured, Household (10)	Groundwater well PDAM	Community initiatives
Jambangan, Surabaya	Structured, Household (10)	Groundwater well, PDAM	Collection service, Community initiatives
Wonorejo, Surabaya	Group discussion, Women (5)	Groundwater well, PDAM	Collection service, Community initiatives
Wonorejo, Surabaya	Group interview, Fishermen (4)	Groundwater well, PDAM	Collection service, Community initiatives

Table 9: *Demographic profile of the respondents of the household interviews (some numbers add up to over 30 respondents, this is when more people from the household joined the interview)*

Attribute	Description	Percentage (%)
Gender	Male (2)	6.6
	Female (29)	93.5
Age	<15 (0)	0
	15-30 (4)	13.3
	30-45 (17)	56.7
	45-65 (9)	30.0
	>65 (0)	0
Years in community	<10 (9)	33.3
	10 - 30 (12)	44.4
	>30 (6)	22.2
Household size	<3 (12)	40.0
	4 - 5 (15)	50.0
	>5 (3)	10.0
Education	Uneducated (0)	0
	Elementary School (4)	12.9
	Junior High School (11)	35.5
	Senior High School (11)	35.5
	Academy Diploma (1)	3.2
	University Graduation (4)	12.9
Occupation	Unemployed (0)	0
	Own business (4)	11.1
	Government employee (6)	16.7
	Private employee (21)	58.3
	Small informal business (5)	13.9
Monthly Income (IDR)	<500,000 (0)	0
	500,000 - 1,500,000 (2)	6.7
	1,500,000 - 3,000,000 (2)	6.7
	3,000,000 - 5,000,000 (23)	76.7
	5,000,000 - 7,500,000 (2)	6.7
	>7,500,000 (1)	3.3

E. Interviews

E.1. Individual interview and women group discussion

Questions and statements were organised by theme. In between square brackets the options for answers are indicated.

E.1.1 General information

These questions were only asked during the individual household interviews.

1. Name of the respondent [open question]
2. Age of the respondent [<15; 15-30; 30-45; 45-65; >65]
3. Years of living in this community or area [open question]
4. Gender of the respondent [male; female; other]
5. Please specify your household composition [total members HH; no. of males; no. of females]
6. Education of respondent [uneducated; elementary school; junior high school; senior high school; academy diploma; university graduation]
7. Total number of household members that are employed [open question]
8. Employment status of respondent [unemployed; own business; government employee; private employee; street vendor/small informal business; other]
9. Average monthly household income [< Rp500,000; Rp500,000-Rp1,500,000; Rp1,500,000-Rp3,000,000; Rp3,000,000-Rp5,000,000; Rp5,000,000-Rp7,500,000; >7,500,000]

E.1.2 Household waste generation, disposal and service

These questions were only asked during the individual household interviews.

1. Can you roughly identify what the composition of your generated waste is by ranking the different waste types (1 being most, 5 being least)? [kitchen waste; plastic; paper; others]
2. Can you roughly identify the quantity of your generated waste in a unit such as a specific volume (a bucket, bag or container)? [kitchen waste (unit); plastic (unit); paper (unit); others (unit)]
3. Do you separate different types of waste in your home? [yes; no]
4. Where do you dispose your generated waste? [nearby container; near home; open spaces; it is collected by a waste service; other]
5. Are there any 3R (reduce, reuse, recycle) facilities/infrastructure in your neighbourhood? (mark all that apply) [home composting; composting centre; waste bank; recycle shops; other; none]
6. Do you make use of them? [home composting; composting centre; waste bank; recycle shops; other; none]
7. In your opinion, which of these is a priority concern about waste in this area? [littering and looks bad; effect on human health; effect on environment; threat to river; there is no concern; other]

8. What do you think the main problems with current solid waste management system are? [waste lying around; waste ending up in the river; rats; smell; flies; there are no problems; other]
9. Do people in your neighbourhood/area dump their waste alongside the garbage bins instead of putting it inside those bins? [yes; no]
10. What do you think the reason would be that some waste is not disposed of? [difficult to put waste inside the bin due to the height of the bin; difficult to put waste inside the bin due to waste and litter spread around the bin; they do not care about the waste being in the bin or outside; the facilities are not sufficient; stray animals; other; N/A]
11. Do you think that more facilities will help to reduce waste ending up at locations it is not supposed to be at? [yes; no]

E.1.3 Water use

These questions were only asked during the individual household interviews.

1. What water sources do you use? [groundwater well; river; pipelines/water supply system; rainwater; other]
2. What do you use these sources for? [open question]
3. How far from home are these sources? [open question]
4. Do you use different water sources in the wet and dry season? [yes (specify); no]
5. Do you treat your water? [yes (specify); no]
6. Do you think your water sources are clean/safe? [yes; no]
7. Is the quality of your household water during dry season different than during wet season? [yes (specify); no]
8. Did these sources change over time? [yes (specify); no]
9. Have you experienced a decrease in quality over the past years? [yes; no]
10. Do you drink bottled water? [yes, the only way I drink water; yes, when I am not at home; no]

E.1.4 River and river pollution

These questions were only asked during the individual household interviews.

1. Where do you use the river for? [work; transport; drinking water; bathing/washing; dishes; throwing waste; as a toilet; other (specify)]
2. Has this changed over time? [yes (specify); no]
3. Do you experience nuisance from the solid waste in the river? [yes (specify); no]
4. What do you think is the root cause of waste in the river? (mark all that apply) [agriculture; industry; people; none; other (specify)]
5. Who do you think is responsible for keeping the river clean? [government; river basin authority; industry; drinking water company; communities; other]

6. How large is the impact of river pollution on your daily life? [very large; large; small; very small]
7. What are you more concerned about? [air pollution; water pollution; waste pollution; damage to scenic beauty; noise pollution; no concerns; other (specify)]

These statements were both asked during the individual household interviews and the women group discussion. All statements have the following possible answers: strongly agree, agree, disagree and strongly disagree.

1. "People contribute enormously to the solid waste problem in the river" [strongly agree; agree; disagree; strongly disagree]
2. "People in my neighbourhood throw waste in the river"
3. "It is okay to throw waste in the river"*
4. "Polluting surface water is okay, since rain and the rive will wash away the waste"*
5. "At places where a lot of waste is in the river, it is okay to throw more waste in"*
6. "People in my neighbourhood care about a clean river"
7. "People in my neighbourhood collect waste out of the river"
8. "The quality of the river water is getting worse if not prevented"
9. "Prohibition to throw garbage into the river would be a good solution"
10. "Cleanliness of the river water should be maintained"
11. "Clean water sources should be protected"

E.1.5 Environmental involvement/participation

These questions were only asked during the individual household interviews.

1. Have you ever received any information on river pollution? [yes (specify); no]
2. Do you think the information about river pollution is useful to you? [yes; no]
3. Did the information on river pollution changes your behaviour? [yes (specify); no]
4. Are you familiar with any projects regarding river pollution cleanup or waste? [yes (specify); no]
5. Did you or any of your family members ever participate in any community cleanup activities or other voluntary cleanups (river related)? [yes (specify); no]
6. How often do you talk with your neighbours / friends / relatives about the environment, river pollution and similar topics? [always; often; sometimes; never]
7. Did any of your neighbours / friends / relatives changed their waste behaviour or water sources due to river pollution? [yes (specify); no]
8. Do you feel a moral obligation to participate in such projects? [yes; no]
9. Do you consider that environmental degradation has a negative effect on your family? [yes; no]

10. Do you think environmental projects will be successful in improving river water quality? [yes; no]
11. What kind of projects would you support / participate in with respect to river pollution? [open question]

These statements were both asked during the individual household interviews and the women group discussion. All statements have the following possible answers: strongly agree, agree, disagree and strongly disagree.

1. "People in my neighbourhood participate in waste reduction or cleanup programs"
2. "I believe that the river can be brought back to its natural state with healthy river quality"
3. "Participating in an environmental project will help to combat river pollution or improve the water quality"

E.2. Group interview, fishermen

Three fishermen and one employee of the fish pond were interviewed to understand the way they view inorganic solid waste pollution and how it affects their lives.

Questions

1. Where do you use the river for? [work, transport, leisure, others]

We use the river for different purposes: (1) for looking for fish, (2) as transportation, (3) for irrigation for the fish pond, (4) for collecting waste from the river and sell it to a waste bank (e.g. plastic bottles). We donâĂŹt use the river as a toilet because the fish will die.

2. Are you financially dependent on fishing? [yes / no]

Fishing is our main job. if we are not looking fish (which happens at night) we have another job.

3. How do you catch your fish?

We use a professional fishing net, rods, and other nets (on sticks for example).

4. Where do you catch it?

We catch our fish in the Surabaya River. If there is not enough fish in the river (due to pollution or other causes) they go even more downstream, even unto the the sea. We fish in two rivers, on the Apur River (on the left side, lot of waste) and on the Surabaya river (on the right side, downstream of Brantas, less waste). They only look for fish in the Surabaya River, since the Apur River is too polluted (the colour of the water is black). During the wet season, when the water level in the river is higher they only fish in the downstream area and sea. They cannot look in the river.

5. Did you feel like something has changed over the years?

The type of fish we catch has stayed the same, the amount of fish has changed due to solid waste, it has decreased. Our largest by-catch are diapers, after that it is plastic. We just throw it back, because we have not enough room in the boat. we can only store fish and our nets / other fishing gear.

6. How is river pollution affecting your daily life? (Solid waste from households in particular)

(Solid) waste from industry kill the fish. (a) There has been a dramatic increase of fish death over the last few years. (b) The propellers/thrusters of the boat are damaged by the plastics. We have been living in this area for 25 years and since we live here there is already a lot of waste. (c) Sometimes we catch the fish or crabs that have plastic on them. We donâĂŹt know whether there are micro plastics in the fish because we sell the fish directly to the vendor (they do not clean the fish of its organs). (d) Sometimes fish get trapped in a net that is floating around, so as waste instead of

purposely being used by fishermen.

7. Who do you find responsible?
The industry is responsible. In the downstream we care about the river.

8. Do you see people throw waste in the river?
We do not throw waste in the river.

9. What do you think the solution is?
There must be a different way to solve the problem than how it is done now, since it is an upstream-downstream problem. The barrage in front of the PJT office (and operated by PJT) already blocks the waste from travelling downstream through the river.

10. What kind of activities do you do yourself to protect the river and your jobs?
The Surabaya government already cleaned up the river here, but not continuously, only every 2 weeks. The only activity that we do is that we only throw our waste in the trash bin.

E.3. Interview PJT

Water operator, responsible for water allocation and water infrastructure operation and maintenance. Monitors water quantity and quality.
1. Have you noticed any change in water quality or river pollution over the years? What is the most remarkably changed?
We measure water quality at Karang Pilang, Ngagel and Gubeng.

2. How do you deal with inorganic solid waste in the river?
What kind of measures have you put into place to prevent the waste from flowing further downstream (and eventually into the ocean) *Retention boom. It has been in the water for 10 years. During the rainy season there is much more waste than during the dry season. Approximately double the amount, and also double the amount of water plants will grow. The reason is that during the wet season the river water level is on average 2 meters higher, therefore it will also transport the waste from the riverbanks and riparian vegetation downstream.*

3. What types of inorganic solid waste do you mostly collect from the river? And can you estimate an amount? Has this changed over the years? (type and amount)
Mostly organic, plastics and diapers. We collect them with the floating retention boom. This boom is emptied two times per week by people and the waste is put on the riverbank. An excavator is used to clean up the waste from the riverbank and put it unto transport towards the landfill. Every time the clean up is done, 12 trucks with a volume of 6-7 m^3 each are filled up with waste and transported. So that is on average 156 m^3 of waste per week.

4. What do you think the biggest source(s) of inorganic solid waste in the river is/are?
From domestic and industrial sources.

5. Do you have a strategy for the future with coping with the changing water quality of your raw water?
Our future plans are to educate people that the river is not a dump site. People are lazy or there are no facilities, or they do not care or do not respect the environment. Furthermore we want to have more 3R projects. Measures upstream consist of dredging and measures downstream are water quality (organic and inorganic) and quantity (for industry) control and monitoring.

There already is a collaboration with two cities: Sidoarjo and Surabaya. We use the retention boom and clean bridges. But they need to collaborate with more cities. Lack of human resources and capacity is the reason that that has not happened yet and that we sometimes have to let the waste pass the boom.

6. What do you consider to be the most urgent matter to your activities at the moment? *The main issue is solid waste and a decline of water quality. We need to provide good water quality.*

7. What do you think the solution to river pollution is?
First we need to get all stakeholders together, then agreement should be reached. After that the communities must be educated and also facilities for waste management should be provided and equipment for cleaning the river. We already have several projects such as a campaign at the riverbank, involving students and providing facilities in some villages.

E.4. Interview BBWS

River basin territories organisation. Monitors water quantity and quality. Promoting community development in water resources management, providing water data and information.

1. What is your responsibility with respect to the Brantas river (and especially in the Surabaya River)
BBWS operates under Public Works. We manage the water resources in the Brantas River Basin. This includes planning, construction and operation and maintenance of all water resources. The Brantas River Basin accounts for 2,200 rivers and tributaries, which serve as drainage. The river basin covers 20 regencies.

2. How do you deal with inorganic solid waste in the river? Are you taking measures in any way? How are you preventing inorganic solid waste from entering the ocean?
Operation of the infrastructure is a collaboration between BBWS (doing the policy related activities) and PJT (PJT operates in 400 river tributaries in the Brantas Basin).

People also contribute. We also work on increasing public awareness. We have a river school program for people living around the river, but just at some places, not everywhere. There are too many stakeholders involved. For those who want information, we have a website with information on it.

At this moment we lack human resources to provide information, training and education to everyone.

We have a policy to control and monitor the river water quality. For this, we need all stakeholders involved (including NGOs and others). But there are too many!

3. What do you think is the reason people throw their waste into the river? What do you think that could change this?
It is a combination of lack of knowledge and our culture. We believe that if waste is burned, people will get sick. Therefore, the waste must go into a cold place, such as water.

More facilities could be a solution and also a more constant stream of information. Information and communication is key, otherwise the facilities will not be properly used.

4. What is your future strategy to combat river pollution of inorganic solid waste?
It is a problem that cannot be solved. It needs an integrated strategy, including all the stakeholders, from upstream until downstream, everyone. The strategic plan would be: (1) make an integrated plan, (2) introduce public enforcement and raise public awareness and (3) activities should be constructed, through socialisation. However, this is not yet possible because of (a) financial constraints, (b) human resources constraints and (c) integrated element of the problem; stakeholders are not well connected.

Public awareness should go hand in hand with the connection of people and the government.

E.5. Interview EPA

E.5.1 EPA Gresik Regency

Environmental agency of Gresik Regency.
1. What is your responsibility?
Our responsibility is to provide transportation from waste collecting centre to landfill. We have one landfill. Members pay money. This waste service only covers 30% of the Gresik Regency. This is because the operational costs are too high, so we cannot expand (transportation costs would go through the roof).

2. How do you deal with inorganic solid waste in the river?
We are not involved with the river, only with the solid waste management. But what we do is providing containers for diapers and a sanitary landfill. Moreover, through socialisation and education about waste we want to minimise the entering of MSW into the river.

3. Have you seen a big increase of municipal solid waste over the past years?
Due to a growing population and new industries other facilities needed to be build.

4. What do you think is the reason people throw their waste into the river?
The people do not know where to dump their solid waste. The river makes the waste disappear. There should be facilities in every area. We also want to build an incinerator, but we still have no permission from the government. There should be an environmentally friendly solution.

5.Almost all the people that I have interviewed say they only use the river for transport, so taking the *tambangan*. Do you think that people will use the river differently when it is not so polluted?
It is in our culture to throw away the waste like this because it is easy. Some people also use the river to swim or wash their car.

We have made a master plan in 2016 with the following priorities: (1) material recovery in each village in the regency, (2) education to reduce the waste. We have a website where we provide information, people can look it up to find information. (3) Waste banks and other 3R facilities. Some waste banks provide education about waste reduction.*

6. How do you deal with imported plastics entering your environment?
We do not get the data from industries on imported waste so we also cannot provide you with this information.

7. What is your future strategy to combat river pollution of inorganic solid waste?
Our solutions is education, but people have to ask for it, because if we would go around each village no one would be interested in waste.

8. How do you want to educate people about the right way if they do not have enough facilities to provide them with tools to do the right thing?
(1)We should provide facilities for this, but limited budget, we have pushed the mayor and house of representatives for this and also have asked for financial aid from international donors. people cannot adapt/change without sufficient facilities. (2) Also law enforcement.

E.5.2 EPA East Java Province

Environmental agency of East Java Province
1. What is your responsibility with respect to the Brantas river (and especially in the Surabaya River) and how do you deal with inorganic solid waste in the river?

We are responsible for the quality of the river water. The performance is measured by the Water Quality Index. With respect to the river, we focus on the (big) industries. Every month the water quality is monitored and when the level of a certain parameter is exceeding, the industry is fined.

For communities we only encourage them and we provide education. We have an obligation to give information to communities. So, we have a website where the annual report about river water quality can be found. I do not know for sure if people know where to find this information.

Other performance indicators we use for the environment is the Air Quality Index and the type of land use.

2. Have you seen a big increase over the past years?
No, it is the same.

3. What do you think is the reason people throw their waste into the river? What do you think that could change this?
It is a complex problem. It involves upstream and downstream. It involves industrial, domestic and agricultural waste.

4. What do you think the reason is that people do not drink the piped water from PDAM?
PDAM has standard water quality. It is not good for drinking, we have to boil it first. They are planning on extracting water from a new source upstream. This source is a spring, not a river, so better water quality.

PDAM only provides drinking water quality at public spaces (e.g. offices, etc.), not at home. The quality of the water that you get at home is lower, not for drinking.

5. What do you think the reason is that people throw waste in the river?
We have to increase education, this way their habits might change. We have insufficient infrastructure (waste). People with low incomes cannot afford transport for the waste, we cannot pay the fee.

6. Almost all the people that I have interviewed say they only use the river for transport, so taking the *tambangan*. Do you think that people will use the river differently when it is not so polluted?
The people think the river is too dangerous for other purposes. It is too risky. The river water flows too fast and the river is too deep to swim in.

7. What is your future strategy to combat river pollution of inorganic solid waste? Or to increase water quality in the Brantas River / Surabaya River?
The water quality of the river must be improved. At the moment, it is categorised as a class III, in the next 2 to 3 years it must go to class II. The following instruments are needed/put into place for this: policy and regulation. About 18 million people depend on the Brantas River. At the moment we have 39 landfills, of which half of them are sanitary landfills.

E.6. Interview PDAM

Regional drinking water company in Surabaya.

1. How many HH do you supply to? Has this changed over the years?
They supply water to 560.000 households at the moment. Has increased.

2. For which purposes can your water be used in a household? I have conducted several interviews with people that are a member of your service and they said they do not use your water for drinking and cooking, because the quality is bad. What do you think about the fact that people do not use your water for drinking and cooking because they think it is not safe? Do you ever receive complaints? How do

you deal with this?
Drinking water quality is according to the drinking water standards. But, after distribution, due to leakage of some pipes, the water can get contaminated. There is a yearly program where they renew pipes. We can renew 40 km of pipes every year and the current network of pipes is bigger than 5.800 km. For the next year they have increased their target to 100-150 km per year.

3. I read that you are doing the following treatments from raw water to tap: pre-sedimentation, flash mixing, aeration, clarification, filtering and reservoir settling). Has this changed over the years? More treatment processes/ increased treatment? Is it different in the wet and dry season? Did the treatment costs change over the years? Is this calculated in the fee for the customers?
We still use the conventional system. there is a pilot project where they provide a primary zone system to 150 households, where ultra-filtration is implemented. This pilot project offers drinkable water straight from the tap.

The costs are higher in wet season, due to higher turbidity, than dry season. We have to add more chemicals (sometimes the chemicals do not solve the water quality issue). This is not calculated to the customers.

Monthly fee for household is 3000 Rp/m^3, with this PDAM can fully recover their costs and also make a small profit.

Sometimes we experience bad water quality in rainy season, when it goes from rainy to dry season and also in dry season, because then the same amount of wastewater effluent enters the river but there is less water in the river.

4. 97% of your raw water is coming from the Surabaya River, do you experience a change in water quality / efforts over the years? Do you find it threatening? How do you contribute to improving river water quality?
Yes, for our activity. The costs of the company will increase and so will the costs of the costumer. The water quality will influence the process and final product.

We have some programs, but we do not directly control pollution. We have worked together with communities and government to set up an early warning system. We have a good communication system with PJT. We also have a conservation project in the upstream area (reforestation).

5. What kind of river pollution in the raw water you receive from the Surabaya River are you dealing with at your facility? Has this changed over the years (in sort or amount)? Which is difficult to treat?
Turbidity and organic pollutants. From agriculture we receive a high concentrations of P and N in the dry season. Detergent only sporadically pollutes the water.

Organic pollutants are difficult to treat: BOD, COD, nitrite.

6. Do you think solid waste from domestic sources is a problem to the river? And to your company? Do you experience any (other) kind of nuisance from domestic solid waste?
We control this with a screen, but not that is not all the way down to the bottom so sometimes it enters the filter system. Mostly clothes and plastic bags.

We check for microplastics but it is still safe and we also send samples to a laboratory in Jakarta.

7. In the past, did anyone get sick from your water? (recorded)
We get complains sometimes but not directly related to health issues. Mostly complains about smell and turbidity.

8. Do you have a strategy for the future with respect to meeting the water demand and also coping with water quality of your raw water?
Upgrade and modify technology in the treatment plant. We have to optimise the process and have to do research into other chemicals.

9. What do you consider to be the most urgent matter to your company at the moment? (leakage, raw water is too polluted, something else)?
Firstly, the fluctuation of water quality; This can be a daily fluctuation where the quality during the day is worse than at night, so we have to add extra chemicals. Sometimes we still cannot meet the standards, but then we will (1) still distribute water, or (2) we stop distribution, or (3) decrease the water quantity of distribution to monitor. We coordinate with PJT if they can provide more water to the river in order to dilute the water pollution. That happens not so often, we can still deal with it. Only in cases when industry discharges too much polluted water.

Secondly, distribution pipes; due to leakage and insufficient pressure, bacteria can contaminate the water that is being transported.

10. Who do you find responsible for this solid waste? What do you think is the reason people use the river as an easy disposal site?
It is complicated because there are too many parties involved: BBWS, PJT, EPAâĂę We pay retribution to PJT for amount of water and for good quality, however, EPA is responsible for good water quality, not PJT.

We want to make a master plan for long-term goals for the Brantas water quality, where all stakeholders are involved. The old master plan was only about the water infrastructure and did not involve all stakeholders. IWRM needed.

The reason people use the river as an easy disposal site is because of the peopleâĂŹs mindset. They dump their waste on no oneâĂŹs land, then it is not their responsibility and problem anymore. Why is this still going on? (a) separating waste is time consuming and (b) there is no enforcement for dumping, furthermore (c) people are not used to pay for something that they throw away (that is also the problem with the waste management services). The price of waste management should be included into the price of a bottle. They should also combine the costs of clean water and wastewater together in the fee.

Moreover, there is no awareness at industry, they do not treat their wastewater properly.

11. Do you provide information about water quality to your customers? Yes they give information during regular meetings. However, they cannot push people to come to these meetings.
But we do have a campaign to use community water. We have set up 26 refilling stations in public spaces and at schools (not at universities). The refilling stations get extra treatment, which costs 60 million rupiah per unit extra plus there is maintenance. In total 40,000 US dollars.

At schools people use it the most, because there the teacher can push the children to use it. However, drinking from taps and stations is not something in their culture, they prefer bottles.

E.7. Public Works

Interview with a woman, Hanie, from Public Works, who is the national facilitator of 3R projects (directly under the minister) responsible for implementation of 3R projects.

1. Can you tell me about the 3R projects?
The collecting centre program started in 2005. Since 2005 to 2012 the work has been contracted to other people. To establish a facility the centre, the cost for building and equipment is about more than 1 billion rupiah. Since 2013 funds from the ministry was given directly to the community. They have to make a plan on how to work on the facility. The cost for the building of the facility, reduced up to 50% because it was given directly to the community who is managing it. There are requirements the community needs to form a group who is responsible for the maintenance of the facility.

2. How many are still working? (In East Java)
Only 10% is still operating. The reason is that usually the problems occur after the facilitator finish their one year project. Besides building the facility we also support/manage the facility for a year, after that it is handed over to the community. And then it is starting to become a problem. This is because there is jealousy between the members of the

groups (1), sometimes the local government does not want to be involved in the facility because they think it is a problem for the centre, they (the government) does not need to take care of it (2), sometimes the community group have a problem with the people around them (3).

Maintenance really depends on the community contribution, the government only gives 3% for the operation of the facility.

3. What do you think is a good solution? What kind of future plans do you have?
We acknowledge that there is a problem in the sustainability of the facility. Since 2017 we have changed the requirements: the local government has to send a letter for asking the ministry for building a facility. They have to provide 65,000,000 rupiah of their own budget for the operation. In this way ownership is created and a partnership arises. Before EPA was able to do it directly to the ministry.

Sometimes I think it causes problems, because sometimes the local government does not want to be involved because they say that the ministry will never give operations to them. So they do not want to participate.

4. How do you educate people or engage communities in such projects?
I play an important role in this: I am trying to connect the community needs with the local government. We try to find out which budget fits into the program. At centres. Activities that we organise at centres include education, raising awareness and offering training. The main problem is the operational costs.

5. You have the Green and Clean competition/programme in Surabaya which gets a lot of attention, but at the same time the Surabaya River is polluted. Don't you find that a little contradictory?
Actually, it is really contradicting: Surabaya is "green and clean" but at the same time there is garbage in the river. We provide a lot of money just for sweeping the streets clean (just to maintain the image). We are not really making an effort for garbage in the river. I will give you an example: sweeping streets for a year is 25 billion rupiah, and that the tipping fee (fee the city has to pay to send their garbage to the landfill) increases every year. A few years ago we had to pay 64 billion rupiah for 1 year. The spirit of competition works, however, when the competition finishes, then people stop separating waste. Only 10% still separates their waste afterwards. The mayor gives incentive money for the competition to join.

6. How do you deal with upstream pollution flowing into the city?
Usually we make a barrage (with a net) and we send people to clean this. Also dredging the river. Send everything to the landfill. It is different in Surabaya because we schedule the cleaning and we also schedule the waste to be picked up by trucks. Even in Surabaya there are a lot of suburban areas which do not have waste transportation. We are concentrating all the things in the centre of the city so everyone sees how clean the city is.

F. Boat observations

F.1. Boat survey: Mlirip - Wringinanom

Figure 19: *Average land use (Mlirip - Wringinanom)*

Figure 20: *Solid waste caught in riparian vegetation (Mlirip - Wringinanom)*

Figure 21: *Average dump site (Mlirip - Wringinanom)*

Figure 22: *Barely any floating waste (expect for GPS device in picture)(Mlirip - Wringinanom)*

Figure 23: *GPS tracker and other floating solid waste (Mlirip - Wringinanom)*

Figure 24: *Zoom in of a stretch showing the GPS device travel path (Mlirip - Wringinanom)*

F.2. Boat survey: Wringinanom - Bambe

Figure 25: *Average land use (Wringinanom - Bambe)*

Figure 26: *Solid waste caught in riparian vegetation (Wringinanom - Bambe)*

Figure 27: *Average dump site (Wringinanom - Bambe)*

Figure 28: *Some floating waste at right side of the picture (Wringinanom - Bambe)*

F.3. Boat survey: Bambe - Gunung Sari Sluice

Figure 29: *Average land use (Bambe - Gunung Sari Sluice)*

Figure 30: *Solid waste caught in riparian vegetation (Bambe - Gunung Sari Sluice)*

Figure 31: *Average dump site (Bambe - Gunung Sari Sluice)*

Figure 32: *A lot of floating inorganic solid waste (Bambe - Gunung Sari Sluice)*

Figure 33: *Washing clothes (Bambe - Gunung Sari Sluice)*

Figure 34: *Bathing/playing (Bambe - Gunung Sari Sluice)*

Figure 35: *Catching worms for fishing (Bambe - Gunung Sari Sluice)*

Figure 36: *Open defecation still happens (Bambe - Gunung Sari Sluice)*

F.4. Boat survey: Wonorejo - Madura Strait

Figure 37: *Little waste in riparian vegetation, including parts of fishing nets*

Figure 38: *Fisherman placing his net over the whole river cross section in order to catch as much fish as possible. Often he also catches inorganic solid waste, making the net heavy*

G. Waste facilities and mismanagement

Locations of pictures have regency of location indicated between brackets.

G.1. Waste facilities

Figure 39: *Waste bank in Prenambangan (Sidoarjo)*

Figure 40: *Landfill of Gresik Regency (Gresik)*

Figure 41: *Supported collecting and sorting facility in Jambangan (Surabaya)*

Figure 42: *Not supported collecting and sorting facility in Wringinanom (Gresik)*

Figure 43: *Diaper containers at a bridge to prevent illegal dumping into Surabaya River (Surabaya)*

Figure 44: *Floating retention boom before Gunung Sari Sluice (Surabaya)*

G.2. Waste mismanagement

Figure 45: *Illegal dumping site in Wringinanom (Gresik). Every afternoon, the waste gets burned.*

Figure 46: *Inorganic solid waste caught in riparian vegetation along Surabaya River*

Figure 47: *Workers let solid waste through floating retention boom before Mlirip Sluice (Mojokerto)*

Figure 48: *Riverbank becomes dump site from retention boom before Gunung Sari Sluice (Surabaya)*

Figure 49: *Organic composting container is misused in Jambangan (Surabaya)*

Figure 50: *Garbage bin size is not sufficient for the pick up schedule in Jambangan (Surabaya)*

H. Substantiation of the statistics used

H.1. Steps for statistical testing

Table 10: *Table showing steps taken for the statistical analysis [Gunawardana, 0]. Data with an * was separated into all options being a separate question answered with yes/no in SPSS*

Hypothesis	Waste dumping and separation	Waste dumping and collection service	Familiarity and willingness	Information and behavioural change
Type of hypothesis (difference/ association)	Association	Association	Association	Association
Data type	Nominal/ Categorical	Nominal/ Categorical	Nominal/ Categorical	Nominal/ Categorical
No. of variables	Two	Two	Two	Two
Which data from appendix E	E.1.2.3 and E.1.2.4*	E.1.2.4*	E.1.5.4 and E.1.5.5	E.1.5.6 and E.1.5.7

H.2. Statistical test

Table 11: *Summary of results of the performed statistical tests*

Hypothesis	**Test**	**Value**	**Asymptotic Significance (2-sided)**
Waste dumping and waste separation	Pearson Chi-Squared (χ^2)	0.222	0.638
	Continuity Correction	0.010	0.921
Waste dumping and waste collection service	Pearson Chi-Squared (χ^2)	6.266	0.012
	Continuity Correction	4.543	0.033
	Phi (ϕ)	0.457	0.012
Familiarity and willingness	Pearson Chi-Squared (χ^2)	13.032	0.000
	Continuity Correction	10.458	0.001
	Phi (ϕ)	0.659	0.000
Information and behavioural change	Pearson Chi-Squared (χ^2)	0.475	0.491
	Continuity Correction	0.102	0.749

I. Waste audits

Four types of waste audits are done. Figures 51, 52, 53 and 54 shows how the waste audits are done.

Figure 51: *Household waste from one day is sorted and thereafter weight per category*

Figure 52: *Waste audit at river bank dump site. Four wooden sticks of 1m are used to demarcate the sample site and size*

Figure 53: *Waste being retained by the floating boom structure*

Figure 54: *Waste collected by the floating retention boom is categorised and dried before being weighted*

I.1. Household waste generation

Over a period of one week the waste from ten households, sampled in such a way that it represents average household waste generation in a community along the Surabaya River, was collected in order to know the amount and composition of said waste generation. This data can be linked to the waste audit data of the floating boom experiment to be able to estimate the weight of the domestic waste bags and also to place it into perspective with respect to the amount of people.

Table 12: *Categorised data from waste audits at ten households over a period of one week (kg)*

General information		**Organic**	**Recyclable**		**Non-recyclable**		
Name HH (no. HH members), extra info	**Day**		**High value**	**Low value**	**Multi-layer (plastic packaging)**	**Diapers**	**Paper and residual**
Ibu Salamah (4), toko	1	0.575	0.110	0.310	0.175	-	0.400
	2	0.195	0.060	0.325	0.135	-	0.135
	3	0.185	0.110	0.185	0.145	-	0.185
	4	0.120	-	0.075	0.045	-	0.165
	5	-	-	-	-	-	-
	6	0.020	0.025	0.015	-	-	0.040
	7	0.060	0.105	0.385	0.210	-	0.145
Total per category		*1.155*		*1.705*			*1.780*
Average per category		*0.193*		*0.284*			*0.297*
Ibu Pardi (4), toko	1	1.380	0.615	0.175	0.155	-	0.950
	2	0.315	-	0.005	0.070	-	0.095
	3	0.240	0.015	0.075	0.075	-	0.150
	4	0.090	-	0.050		-	
	5	0.275	-	0.095		-	
	6	0.215	-	0.035		-	
	7	0.660	-	0.110		-	
Total per category		*3.175*		*1.225*			*2.265*
Average per category		*0.454*		*0.175*			*0.324*
Ibu Harti (8), warung	1	5.565	-	0.920	0.085	-	0.360
	2	8.970	0.165	1.065	0.145	-	0.920
	3	15.430	0.370	2.075	2.480	0.110	1.975
	4	5.260	-	1.275	0.205	-	1.235
	5	8.655	-	1.265	0.730	0.980	2.275
	6	9.355	0.160	1.430	0.195	0.575	1.525
	7	9.390	-	1.275	3.530	0.150	0.350
Total per category		*62.625*		*10*			*17.825*
Average per category		*8.946*		*1.429*			*2.546*
Ibu Parni (10)	1	1.755	-	0.325	0.140	5.010	0.715
	2	2.335	-	0.325	0.185	0.630	0.375
	3	0.730	-	0.200	0.140	4.405	0.575
	4	1.025	0.085	0.260	0.150	1.895	0.605
	5	0.360	0.000	0.025	0.025	0.225	0.025

Continued on next page

Table 12 – *Continued from previous page*

General information		Organic	Recyclable		Non-recyclable		
Name HH (no. HH members), extra info	**Day**		**High value**	**Low value**	**Multi-layer (plastic packaging)**	**Diapers**	**Paper and residual**
	6	1.100	0.095	0.220	0.185	1.010	0.645
	7	1.785	0.230	0.215	0.440	0.755	0.150
Total per category		*9.090*		*1.980*			*18.285*
Average per category		*1.299*		*0.283*			*2.612*
Ibu Nuryati (3)	1	1.120	0.165	0.330	0.105	-	0.435
	2	2.155	-	0.095	0.050	-	0.095
	3	1.730	0.125	0.145	0.075	-	0.135
	4	0.195	0.060	0.075	0.055	-	0.165
	5	-	-	-	-	-	-
	6	2.175	0.135	0.110	0.095	-	0.280
	7	1.385	-	0.095	0.285	-	0.065
Total per category		*8.740*		*1.335*			*1.840*
Average per category		*1.457*		*0.223*			*0.307*
Ibu Eka (5)	1	1.530	-	0.235	0.040	-	0.935
	2	0.460	0.080	0.110	0.055	-	0.035
	3	1.850	0.075	0.260	0.115	-	1.105
	4	1.005	0.135	0.190	0.050	-	0.510
	5	0.170	-	0.020	-	-	0.220
	6	1.620	0.135	0.130	0.095	-	0.235
	7	0.290	-	0.015	0.070	-	-
Total per category		*6.925*		*1.385*			*3.465*
Average per category		*0.989*		*0.198*			*0.495*
Ibu Ngateni (5), warung	1	0.525	-	0.140	0.095	-	0.275
	2	-	0.050	0.095	0.070	-	0.120
	3	0.320	-	0.065	0.055	-	0.065
	4	0.355	-	0.055	0.060	-	0.075
	5	0.530	-	0.130	0.080	-	0.205
	6	0.205	-	0.050	0.055	-	0.065
	7	0.345	-	0.135	0.240	-	0.105
Total per category		*2.280*		*0.720*			*1.565*
Average per category		*0.326*		*0.103*			*0.224*
Ibu Sulami (4), warung	1	1.520	-	0.120	0.045	-	-
	2	1.825	-	0.180	-	-	0.090
	3	2.245	-	0.100	0.090	-	0.050
	4	1.780	-	0.215	0.050	-	0.380
	5	2.286	-	0.145	0.120	-	0.265
	6	1.180	-	0.090	0	-	0.235
	7	1.535	-	0.195	0.155	-	0.130
Total per category		*12.370*		*1.120*			*1.610*
Average per category		*1.767*		*0.160*			*0.230*

Continued on next page

Table 12 – *Continued from previous page*

General information		Organic	Recyclable		Non-recyclable		
Name HH (no. HH members), extra info	**Day**		**High value**	**Low value**	**Multi-layer (plastic packaging)**	**Diapers**	**Paper and residual**
Ibu Mun (4)	1	-	-	-	-	-	-
	2	0.080	-	-	-	-	0.080
	3	-	-	-	-	-	-
	4	2.155	-	0.130	0.130	0.080	0.535
	5	0.400	0.115	0.190	0.070	0.190	0.170
	6	-	-	-	-	-	-
	7	-	-	-	-	-	-
Total per category		*2.635*		*0.320*			*1.255*
Average per category		*0.878*		*0.107*			*0.418*
Ibu Suwaji (4)	1	-	-	-	-	-	-
	2	0.655	0.275	0.175	0.090	-	1.340
	3	0.995	-	0.140	0.065	-	0.120
	4	0.760	-	0.110	0.055	-	0.070
	5	0.655	-	0.150	0.075	-	0.295
	6	2.355	-	0.025	0.085	-	0.085
	7	0.970	-	0.040	0.190	-	0.055
Total per category		*6.390*		*0.965*			*2.525*
Average per category		*0.913*		*0.161*			*0.421*

Table 13: *Summary of data from the household waste audits*

	Organic	**recyclables**	**Non-recyclables**	**Total**
Total per category of one week for ten HH	115.4 kg	20.8 kg	52.4 kg	188.6 kg
Average per category of one week for ten HH	17.2 kg	3.1 kg	7.9 kg	
Percentage per category of one week for ten HH	61.2 %	1.0 %	27.8 %	100 %

I.2. Visual waste counting

Upstream (Mlirip), midstream (Wringinanom) and downstream (Jambangan).

Table 14: *Data from visual waste counting at three points along the Surabaya River: Wringinanom (midstream), Jambangan (downstream) and Mlirip (upstream).*

Location (regency); time of measurement	**Wringinanom (Gresik); 11:15-12:15**	**Jambangan (Surabaya); 16:00-16:30**	**Mlirip (Mojokerto); 11:40-12:10**
Duration	1 hrs	0.5 hrs	0.5 hrs
Size			
Items, small	39	46	45
Items, large	11	10	3
Total	50	56	48
Categorisation of items			
Plastics	22	50	35
Diapers	28	6	13

I.3. Floating retention boom

Floating retention boom experiment setup.

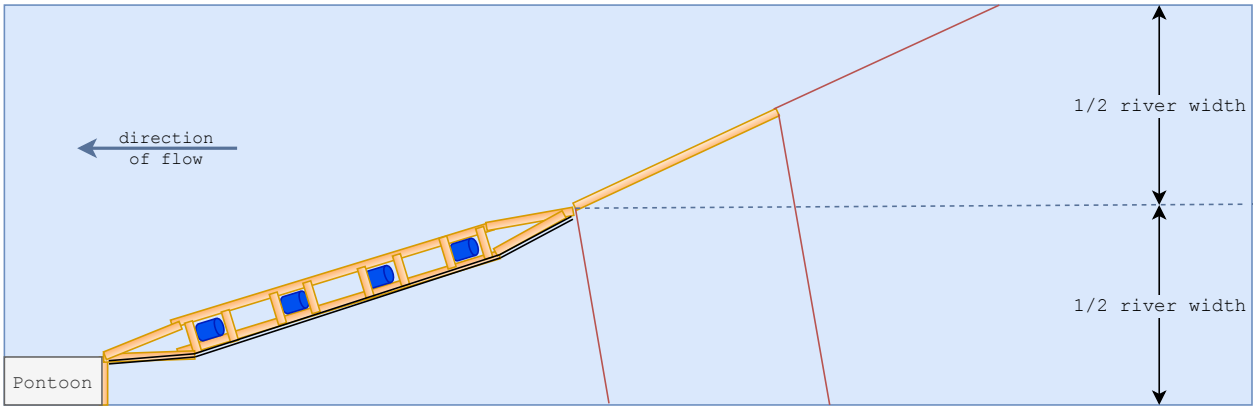

Figure 55: ***Top/Bird's*** *view of river cross section showing the floating retention boom structure setup for floating solid waste capturing. The double black line represents the net attached to the structure. The red lines indicate the supporting ropes for keeping the structure in position. The bamboo at the pontoon represents the coarse bamboo grid.*

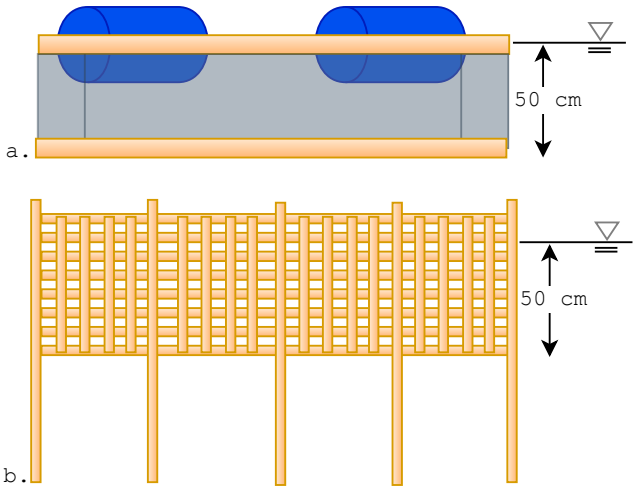

Figure 56: *Details of floating retention boom structure. From top to bottom: a. side view of retention boom with net attached to structure to retain floating solid waste. The net has a mesh size of 15x15 mm, enabling the capturing of meso and macro floating debris; b. A coarse bamboo grid installed at the pontoon to retain floating debris from being transported by the river under the pontoon.*

Floating retention boom captures approximately half of the floating solid waste of the river and since the boom is installed in a straight river section it can be estimated that the total floating solid waste that is passing through the river during the time of the experiment is double the amount of that is captured. This results in 58.37 kg of waste in 134 hours, i.e. 0.436 kg per hour. *Domestic waste bags and diaper bags are not weighted, however the weight can be deduced from the household waste generation data.

Table 15: *Data from the waste audit from the floating retention boom, where the time after which the waste is previously collected from the boom is mentioned*

Activity	**Waste audit no. 1 (after 64 hrs)**	**Waste audit no. 2 (after 29 hrs)**	**Waste audit no. 3 (after 41 hrs)**	**Total**
Category, weight (kg)				
Plastic bottles	1.450	0.845	3.810	6.105
Hard plastic	-	-	3.015	3.015
Plastic bags	2.485	1.470	3.885	7.840
Multi-layer plastic	1.410	0.190	1.350	2.950
Cardboard and Paper	0.145	0.135	0.375	0.655
Glass	1.455	-	1.860	3.315
Rubber	0.955	0.260	0.795	2.010
Styrofoam	0.955	0.205	1.350	2.510
Metal	0.265	0.190	0.330	0.785
Total	*9.120*	*3.295*	*16.770*	*29.185*
Category, items (-)				
Domestic waste bag (S-M)	20	3	9	32
Domestic waste bag (L)	8	6	9	23
Diapers, individual	30	19	36	85
Diapers, bag ($\leq$10 pieces)	31	4	39	74
Diapers, bag (>10 pieces)	6	9	39	54
Plastic bottles, pieces	57	32	159	248
Glass, pieces	22	0	18	40
Metal, pieces	3	1	6	10
Total	*177*	*74*	*315*	*566*

I.4. Riverbank waste audit

Table 16: *Data from the waste audits performed at three river bank locations, waste categorized by amount of items*

	Krembangan, Sidoarjo	**Bambe, Gresik**	**Bambe, Gresik**
Characteristics site			
Dump site size	2 x 3 m	3 x 9 m	9 x 9 m
Sample size waste audit	1 x 1 m	1 x 1 m	1 x 1 m
Waste categorisation			
Plastic bags (no. of items)	13	10	13
Plastic food packaging (no. of items)	23	14	37
Organic (no. of items)	8	3	5
Cardboard and paper (no. of items)	5	5	0
Residual	0	6 (diapers and textile)	9
Comments	-	Residual waste includes diapers and textiles. On sample site also a lot of (half) burnt waste	Residual waste includes diapers and shoes. On sample site also a lot of (half) burnt waste

I.5. Waste dump count during boat survey

Three times a boat survey was carried out, where per time the amount of dump sites (categorised by size) were counted. In table 17 the results from this survey are presented.

Table 17: *Counting of dump sites (categorised by size) during the three boat surveys .*

Survey part	**Dump site size**			
	Small (<2m)	**Medium (2 - 5m)**	**Large (>5m)**	**Total Total**
Mlirip - Wringinanom				
First part: Mojokerto (left bank); Sidoarjo (right bank)	17	-	16	33
Second part: Gresik (left bank); Sidoarjo (right bank)	7	-	2	9
			Total	42
Wringinanom - Bambe (left bank: Gresik; right bank: Sidoarjo)				
First part: rural land use around river	20	1	4	25
Second part: urban land use around river	34	15	9	58
			Total	83
Bambe - Gunung Sari				
First part: Surabaya (left bank); Sidoarjo (right bank)	120	21	5	146
Second part: Surabaya (both banks)	22	1	1	24
			Total	170

I.6. Waste accumulation for flow diagram

Table 18: *Waste accumulation analysis translated to a flow diagram (Sankey Diagram). *Assumed that at 30% of the number of the present riverbank dumpsites waste dumping in that times 1 m^3 volume occurs. **Assumed that the volume balance is made due to everything else coming from tributaries.*

Source	Target	Volume (m^3)
Mlirip Sluice	Surabaya River	1
Visual waste counting upstream section	Surabaya River	13.9
Riverbank waste counting upstream section*	Surabaya River	12.6
Floating retention boom point measurement	Surabaya River	10
Visual waste counting midstream section	Surabaya River	7.2
Riverbank waste counting midstream section*	Surabaya River	24.9
Visual waste counting downstream section	Surabaya River	16.2
Riverbank waste counting downstream section*	Surabaya River	51
Tributaries**	Surabaya River	19.2
Surabaya River	Gunung Sari retention boom	156