LET THE WATER FLOW

Turning natural materials into a smart roofing system in support of a healthy water system for Cigondewah

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Technical research paper

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Abstract

The rapidly growing industrialization that has been happening in Indonesia causes many issues in Cigondewah, which still has a peri urban character. The ecology that used to be the main support for the economy, lost its value: the groundwater got overexploited, there is scarcity of clean water, the rice fields are polluted, the sewage system is unhygienic, flooding often happens and there is a short of income for the villagers while the volume of sales of the factories are growing.

On one hand, this pre-urbanized area, called kampung, has a health and wealth issue, which is threatening. On the other hand, the industrialization attracts people from outside Bandung to migrate and work here, which makes Cigondewah becomes denser and the demand for new living spaces is high.

An analytical solution is introduced in this paper to improve the live and work environment by a new water management system. This system is not only solving a part of the ecological issues, but will help the inhabitants to be less depended on the factories. In such a way, ecology and economy will be in balance again.

At first, the water system in Cigondewah including the ecological and economical issues will be investigated. Followed by an evaluation of using rainwater as a new water resource in a flowing system with integrating traditional and innovative solutions.

Keywords: water, Cigondewah, ecology, economy

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Preface

I hereby present my paper entitled, “Let the water flow”. This paper encloses researches to be a base for the design process that will happen in the next semester of my graduation project. The aim of my project is to improve the water management system in Cigondewah, a textile industry area in West Java, Indonesia. I have been challenged by the problems that occur in this area, which I call the pain points in this research.

My inspiration to accept this challenge came from my Indonesian background and my interest in Indonesian traditional ways of living that contains the building method and cultural and social relations. Another aspect that I found important is the ecology that is threatening in this area. This paper investigated the problems and evaluated the possible solutions. The interesting conclusions result in potential ways to solve the problems with traditional principles that can be integrated in the nowadays-Indonesian culture.

I would like to thank my research mentor Jan Jongert and my architecture mentor Mo Smit for always giving me inspirational guidance and motivation. I also wish to thank all students and professors in ITB, the inhabitants of Cigondewah and the Architectural Engineering Graduation team in supporting me in finding the information and the wonderful cooperation. Lastly, I would like to thank Faris Sjeban for the moral support during the writing process of this paper.

I wish you a pleasant and inspirational reading.

Sae Adipurnomo, June 2017, Amsterdam

Introduction

The importance of considering ecological issues can be expressed with a quotation from Sandra Postel in her book *The Last Oasis*. According to Postal, "Although water is a renewable resource, it is also a finite one. The water cycle makes available only so much each year in a given location. That means supplies per person, a broad indicator of water security, drop as population grows. Thus per capita water supplies worldwide are a third lower now than in 1970." (Williams. D, 1997, p.2)

This quotation reflects the importance of addressing ecological issues, such as climate changes, that occur because of the growing population. These changes do not only influence the ecosystem but also people's life styles. In this context, the ecosystem means the environment that we live in. This system consists of living and non- living elements that are constantly influencing each other. We, human individuals, are a part of this ecosystem. (Williams, 2007, p.2-5)

Kampung Cigondewah, a neighborhood in Bandung, Indonesia, has an overexploited and polluted environment that is caused by the textile industries in that area. The consequence is that one of the most important natural resources in that area, which is water, has been heavily contaminated. In addition to raw materials, energy, and chemicals, the water element is much needed for the processes in the industry to produce the fabrics. This contamination affects the water use of the inhabitants who live in the factory's neighborhood.

Furthermore, this ecological problem is not the only one. There are many elements that are caused and influenced by it. The diagram explains the problem chain in Cigondewah. This paper aims to examine and solve the six main problems or pain points highlighted in this diagram.

Six pain points

1. The ecology is overexploited, which decrease its value and disconnect its role as an input for the economy. One of the issues are groundwater extractions and land subsidence.

-In 1978, buildings and residents covered 65% of Bandung area, while in 1981, it became 85.6 % and in 90% in 1986. This decreases the available open land that has to absorb the rainfall.

-56% of water demand is covered by illegal extraction of groundwater.

-80 milj. m3/y groundwater is pumped up yearly by the textile industries. Not only the industry but the households in Cigondewah also obtain their water needs from groundwater extraction. (Nuraeni, 2010, p.2)

2. The irrigation for the rice fields is polluted by the textile industry, causing incertitude of rice quality.

-The water of the polluted river that is contaminated by the textile industries irrigated the rice field that produce 5% of Indonesia's rice that will be distributed to local markets outside Cigondewah. (Smit, 2016, p. 59)

3. There is a clear water scarcity for drinking, cooking, bathing, and washing for Cigondewah's inhabitants. This demand will only increase with the rapidly growing density.

-The inhabitants are forced to purchase drinking water from a commercial company that, in total, supplies 43% of the drinking water. The more expensive and the minority option is the piped water and the rest becomes illegitimately polluted water from the ground well. (Smit, 2016, p. 69)

4. Flooding often occurs in Bandung and is becoming worse during the past ten years. As a result, homes are damaged by mud, diseases spread, and the working activities of this industrial area are interrupted.

-In 2010, the water from Citarum River sank 4,474 homes in South Bandung. The flooding had temporarily (almost 3 months) paralyzed transportation to South

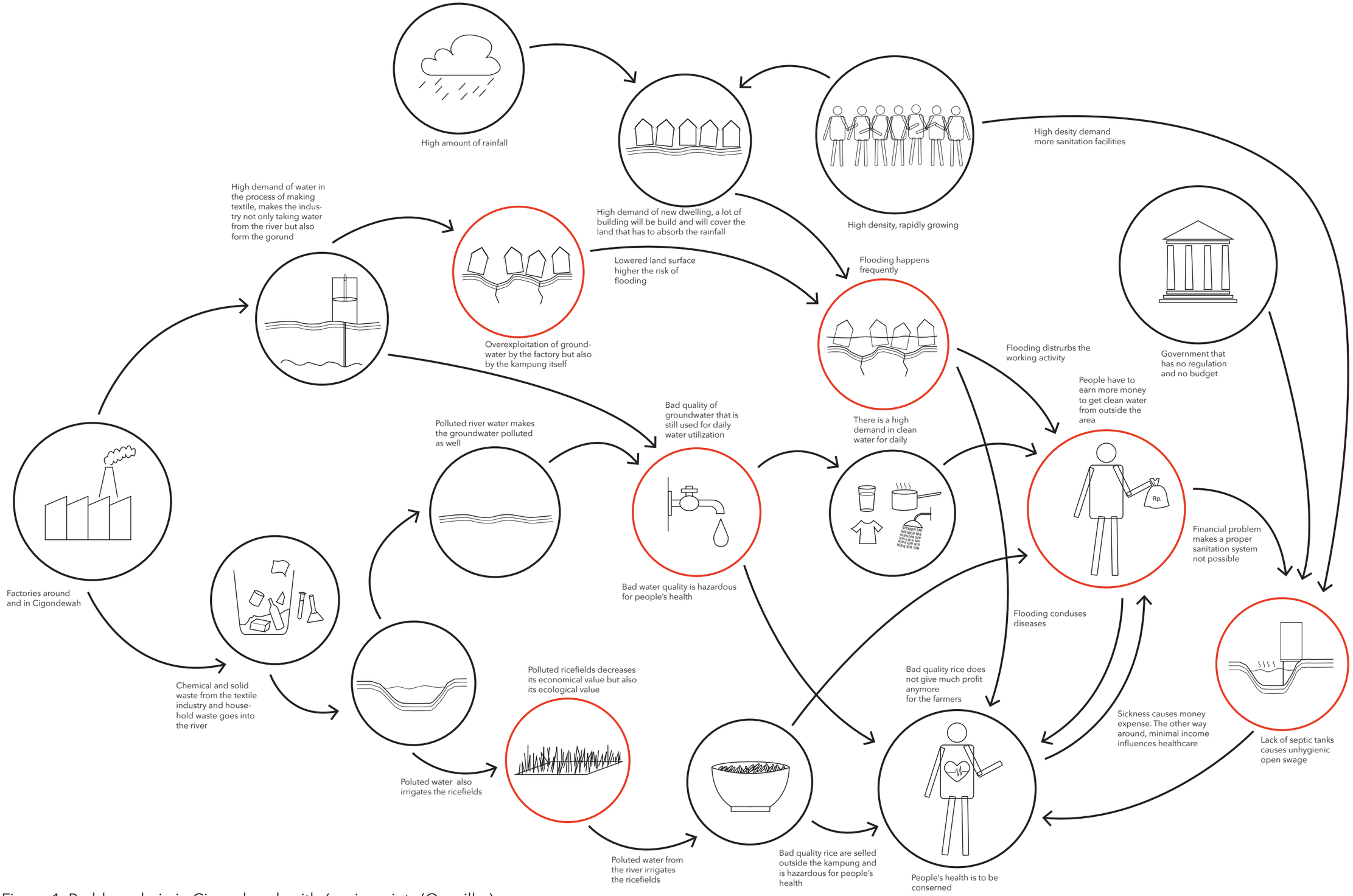


Figure 1. Problem chain in Cigondewah with 6 pain points (Own illu.)

Bandung and 17 textile industries, risking the lives of 50,000 workers. (Nuraeni, 2010, p.2)
-The flooding in March 2016 in 20 districts have left two dead and three missing, forced 8,000 people to evacuate, and damaged 35,000 homes. The flood height was between 80 cm and 3.3 m.
-On October 24, 2016, 77 mm of rain fell in the city and caused, in 1.5 hour, flooding of 2 meters. (Davies, 2016)
-Upper Citarum River Basin has an estimate of US $90 million flood damages per year. (Asian Development Bank, 2011)

5. Economy, education, and the social activities do not interact with each other. In families, only the men are working, while the women are taking care of the children without earning money. The family income is relatively low. This way, the children cannot have a good education and are not able to find an occupation in the future that can fulfill their needs. The villagers in Cigondewah lack skills comparing to the migrants who are working in the colossal factories, which makes it difficult to compete. Furthermore, instead of developing together, surviving is the main goal and this occurs in separated groups. (Interview Cigondewah, April 23, 2017)

6. There is an unhygienic open sewage system that encloses blackwater, gray water, and rainwater.
-This sewage is polluted by congested solid waste that makes the system often not working as it is supposed to.
-In Greater Bandung Area, only 45.3% of the community use septic tanks (a large part of this percentage never empty their septic tanks), 19.6% have sanitation facilities that directly discharge to the drainage system, and 25.4% discharge into the river. (Magister arsitektur ITB, 2015)

The objective of this project is to meet the need of the dwellings and use this as a platform to provide a solution to deal with the water challenges. The ecology is a key element because it is a fundamental issue for the development of the industrial area that represents the income of the majority of the kampung inhabitants. The purpose of this paper is to answer the following question: **How to use dwellings to facilitate the potential of rainwater as a new water resource in supporting the water management system that can improve the living and working conditions of the kampung?**

This question provides a basis for the design. The research has five chapters. The first chapter is a case study comparing a rural area, a peri-urban area, which is Cigondewah, and an urban area. The issue of flooding is explored in chapter two. In the third chapter, the potential of rainwater as a new water resource is investigated. Chapter four analyzes the issue of polluted rice fields. The final chapter is a translation chapter of the four thematic research chapters to the dwellings design phase in which the roof plays a key role. Based on these five chapters, a conceptual design can be structured to develop the next phases of this graduation.

Figure 2. Communal courtyard in Cigondewah (Own illu.)

Methodologies

The aim of this paper is to understand the development of the water system in Kampung Cigondewah, collecting information about the water elements, water issues, and their causes, and to investigate the potential solution to these problems. The first part of the paper provides the context, a brief introduction about the development of Cigondewah in general, to gain information about the site's history background. For this part, literature and a site visit including interviews were used as a method.

As mentioned, this research is divided into five chapters. The first chapter is a case study part. In this chapter, three areas with different characters are analyzed; Kampung Naga as a rural area, Kampung Cigondewah as a peri-urban area, and Kampung Tamansari as an urban area. The purpose of this chapter is to elucidate the development of a water system in an urbanized village. Comparing the different water resources, water usage, water element/strategies, and water issues from each area aids to understand water system the development. This chapter used literature from former students of TU Delft architecture engineering studio and the studies that have been done by the students of Institut Teknologi Bandung. In addition to this, the largest part of the information derives from interviews that were conducted during the site visit.

The second chapter explores the flooding issue in more detail. Since flooding is a problem that has not only worsened in Cigondewah but also in Bandung. The causes of flooding are essential to comprehend how the flooding can be prevented or be solved when happening. This chapter provides an overview of options regarding flooding behavior on different scales. The methods that were used for this chapter are interview sessions with professors from the ITB (Institut Teknologi Bandung) and literature research.

From the information of chapter one and two, an option for using rainwater as a new water resource is derived. This idea was evaluated based on the water usage, water expenses, the rainfall, and the filtering process. The data that were collected from the interviews and literature studies are presented and provides a conclusion.

Furthermore, the research paper continues with a chapter about the polluted rice fields. Only 1.1 hectare of rice fields is left in Cigondewah. The quality of the rice is being doubted because of the contamination by the factory's wastewater. This also decreases the economic value of the rice fields. In this chapter, an alternative for cultivating the land to obtain the economic value back is investigated. The result involves a different kind of crop that is able to filter the wastewater, which is an opportunity for economic development and, at the same time, can be used as the material for the new dwellings that will be built. Literature studies and a site visit were the methods used for this chapter.

Based on the previous chapters with their own focus, the subsequent chapter translates all the information into a design form. In this design, the roof is an essential building element that relates directly to the heavy rainfall and affects the water system. As we know, Indonesia has various kinds of cultures. In total, 35 provinces with their own traditional building method; therefore, diverse roofing technique and shapes created by the ancestors are used. Next to a literature study about the roofs in Indonesia, roofing system requirements are formulated in this chapter.

The final part of the research paper is the first step for the design phase. In this part, a concept of the design including scale, program, target, and typology are decided.

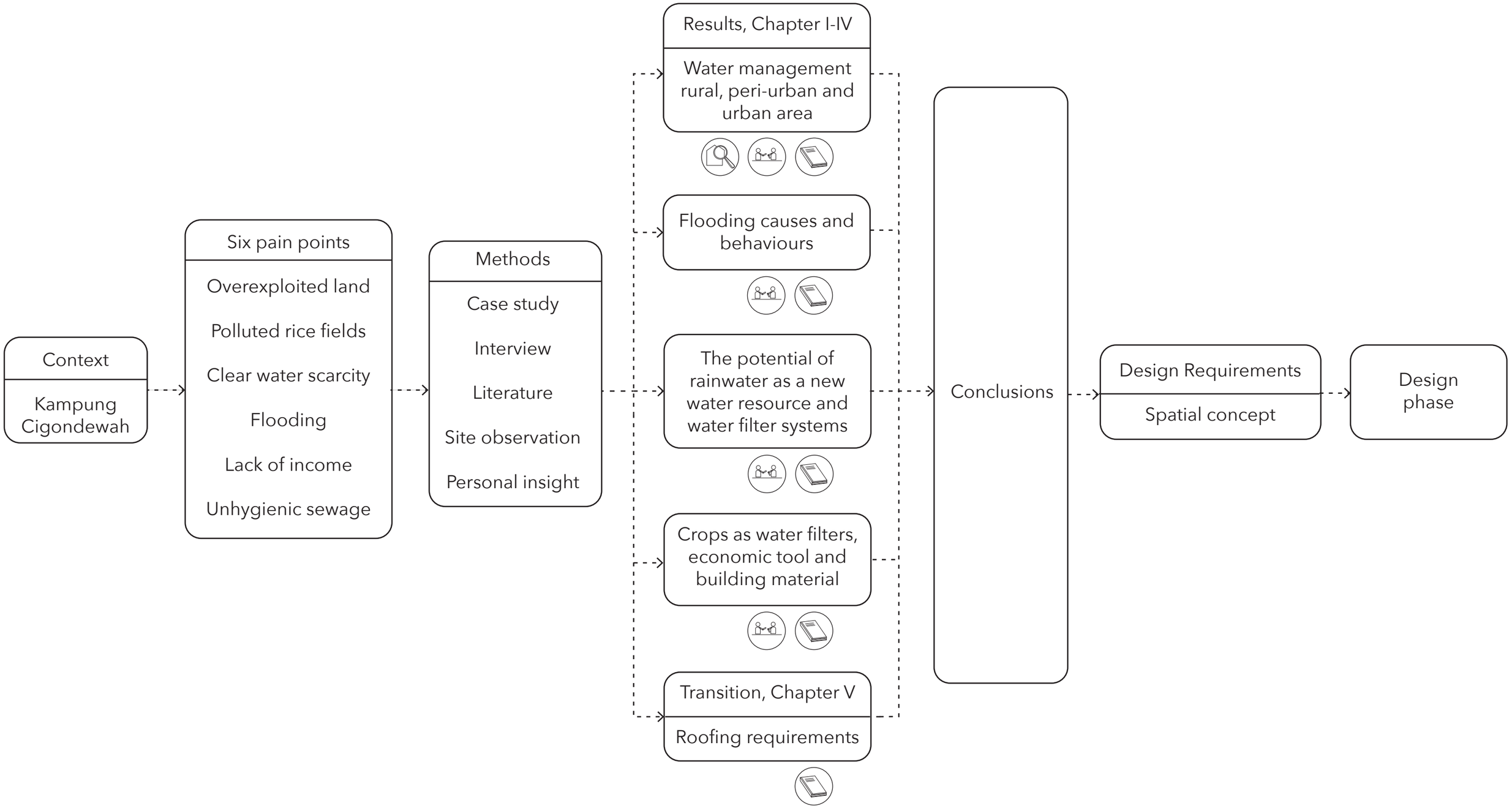


Figure 3. Methodology scheme (Own illu.)

Context introduction

Bandung, the capital city of West Java, represents the textile and fashion city of Indonesia; a city where the fashion industry is developing nationally and internationally. More than seven million people are living in Bandung, young people in majority. Bandung's textile and fashion development commenced when the Dutch as a colony connected Jakarta and Bandung in 1900. The population has grown rapidly since then, and Bandung became a luxurious city with Art Deco villas. Bandung is a city that has a great deal of green and attracts many people for recreation in the weekends.

In 1960, new technologies were introduced that boosted the industrialization. After that, with an international demand for cheap textile, labor-intensive fashion industry was established in Bandung since 1980. Many people from outside Bandung moved to the city to work in the fashion industry to earn more money. The migrant workers live in a small room they rented, which is called *kos-kosan*. (Smit, 2016, p.54-57)

This migration is also occurring in Cigondewah, an industrial area on the outskirts of Bandung. One of the largest factories in Bandung, PT Kahatex, is located in Cigondewah and employs approximately 500,000 workers. (Interview Cigondewah, April 27, 2017) Next to PT Kahatex, there are many more factories and home industries in Cigondewah.

Cigondewah is a city region that is divided by the river in two neighborhoods (*rukun warga* (RW) 2 and RW 12). Each RW consist of a few *rukun tetangga* (RTs) that are organizations consisting of a few families. Furthermore, the Cigondewah River is a key element in the textile industry in supporting the production processes. However, the wastewater management is not controlled and regulated by the government, which makes the river a place for dumping all the wastewater. This wastewater streams from the factories through the neighborhood that is located on the south part of the factories. Consequently, the water system in the kampung is dangerous and causes social, economic, and health problems. (Smit, 2016, p.73)

Figure 4. Location of Cigondewah in Indonesia (Own illu.)

Figure 5. Cigondewah river streams between the houses (Own illu.)

Figure 6. Cigondewah river streams between the factories (Own illu.)

i. Rural area - Kampung Naga

Kampung Naga is a rural area located in West Java. The kampung is located next to the main transportation line between Tasikmalaya city and Garut city. Kampung Naga consists of 99 families that are living in total of 102 buildings on a housing area of 1.5 ha. This housing area is a small part of the 10 ha of the total area. Due to the strong tradition in Kampung Naga, the population of 300 people always stays the same. To illustrate, when people become married, they have to leave the village. If someone passes away, another person can move back in again. Their tradition does not only relay on the social aspect but also on the architecture aspect. (Ningrum, 2012)

An example of the architecture regulations concerns the dimension of the house that has to be 8 x 5 m and oriented from west to east, followed by the main doors that have to face either to south or north. This type of house is a *rumah panggung*, which means a lifted house on poles. These wooden poles are standing on stones, which are taken from the river, as a foundation. Bamboo and wood are used to build the walls, floors, and columns. Finally, palm fiber and leaves are integrated into the roofing system. (Julistiono, 2011)

Based on the Sundanese cosmological concept, Kampung Naga is divided into three divisions, *Buana Larang* (underworld that contains rice fields, fishpond, fields, and a place to husk the rice), *Panca Tengah* (middle world that includes a mosque, houses, and a gathering building), and *Buana Nyungcung* (upper world which the grave of the ancestors of Kampung Naga). (Darmayanti, 2016)

The roof is made from leaves and palm fibers, composing a layer of 15-20 cm thick. This layer of roof can last 35 to 50 years. Underneath this layer, there is another structure that supports it, which is made from bamboo. This latter can last even 150 years. The bamboo structure is preserved in mud water and is conserved continuously by the smoke that comes from the kitchen. By applying this technique, a chimney is not needed in the house.

In addition, the people of Kampung Naga built their own houses. Approximately 40 people will help a family to build the house in just 5-7 days if all the materials are prepared. They are not getting paid; as it is their tradition to help each other. When preparing the bamboo so that it can be used to build, they do not use any measurement and high-tech equipment; they only use their skills

Figure 7. Kampung Naga (Own illu.)

and a knife. The wall infill is made from wood combined with bamboo weaving.

Most of the building material stems from Kampung Naga itself, such as resin, balsa, and mahogany wood. Yet, using natural materials always has a termite risk. For this problem, Kampung Naga uses limestone from a mountain in West Java to cover the wall infill so that it is protected against termites, rain, and sun. The space underneath the houses that is 70 cm high is also protects the house from termites and humidity; in this space, a cage with chickens that eat the termites is placed.

Around the village, forests can be found. These forests are protected and untouched. To produce the building materials, parents would plant the trees so the children who need to build a house can use the wood. (Interview Kampung Naga, May 5, 2017)

Figure 8. Kampung Naga site plan (Own illu.)

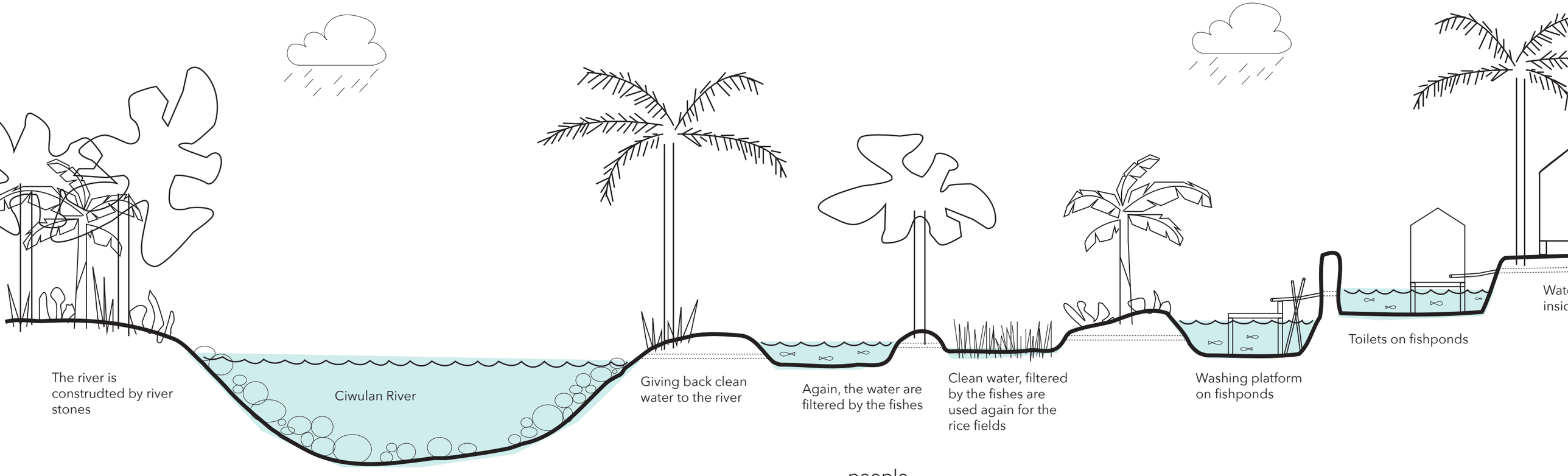


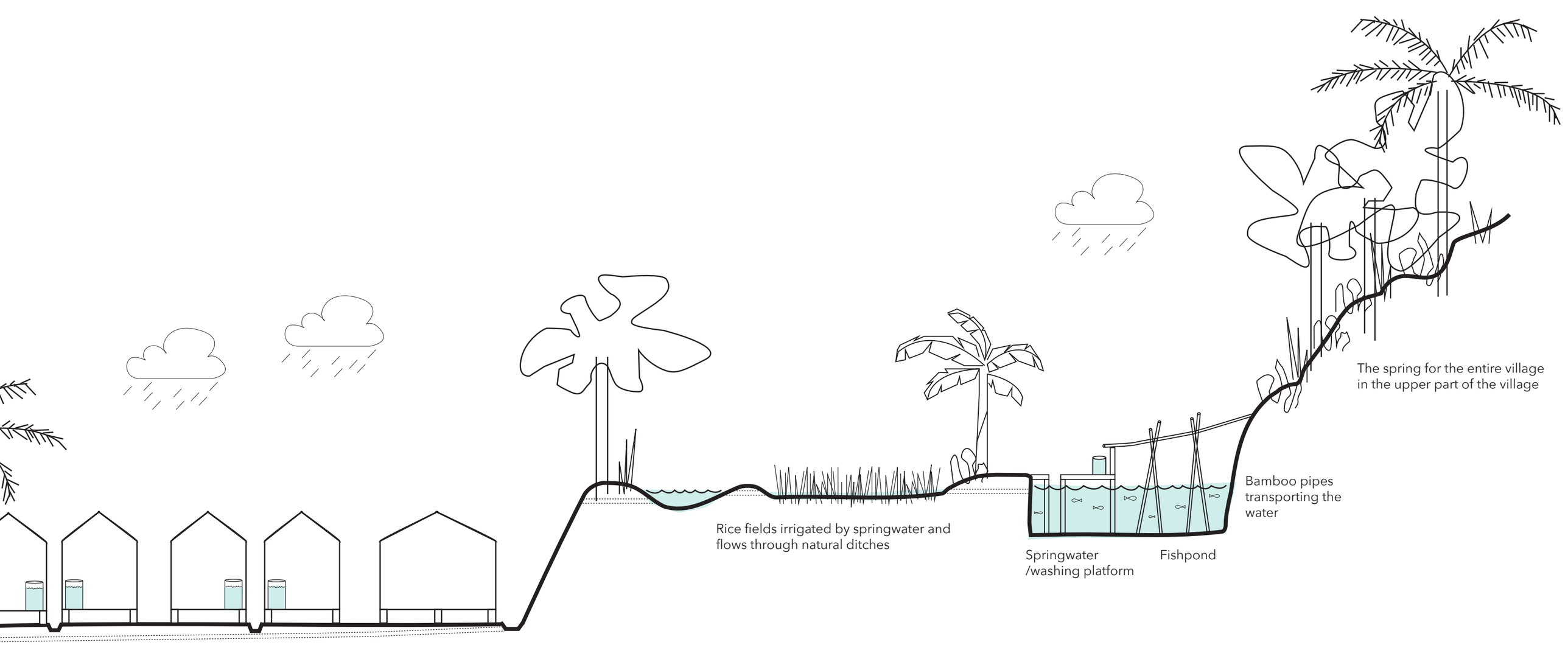
Figure 9. Kampung Naga section (Own illu.)

Water management

Drinking and cooking - An important water resource for Kampung Naga is the spring located in the upper part of Kampung Naga. This spring water is connected to a pipe made from bamboo that lays on a concrete platform built on top of a fishpond. People can go to this platform and retrieve water that they use to drink and to cook. To reach this spring water, some of the inhabitants need to walk 3 km with a bucket to carry the water. Every house has their own drum filled with drink water in their kitchen. One drum can last for three to five days for five people.

This spring is used to for the entire village and is never dry. Once the dry season last until seven months, but the spring was still flowing and also provided water to the other villages surrounding Kampong Naga that were without drink water. The forbidden forest, where no one can enter, protects this water spring. There are two springs in the village; however, one of them does not have clean water because it is mixed with the soil from the rice fields.

Washing, bathing, and sanitation - The rest of the water that stems constantly from the spring is first collected in a fishpond. This water is then distributed to the river via the neighborhood trough bamboo pipes and ditches. This spring ends up



in the fishponds. As seen in the section, there are fishponds between the houses and the river. Above the fishponds, the toilet and the bathroom/dishwashing spaces are located. This way, the dirt is the food for the fish. To protect the fish in the fishpond, they place bamboo that has small branches to scare the birds so that they will not eat the fish.

The washing facilities are built from bamboo and from concrete. It has the shape of an open box and water that is streaming out from a bamboo pipe. Moreover, the people of Kampong Naga use soap in washing activities. This soap also goes into the fishponds, but because of the water facilitations always flow, the soap or other dirt only remains on the surface. They used to make their own soap from rice husk to wash their clothes or husk ash mixed with water and then use it as shampoo.

In total, fifty toilets are located in Kampung Naga. Everybody can use these toilets even if they belong to someone else. By always first distributing the wastewater that is coming from the washing, bathing, and sanitation to the fishponds for purification, they return clean water to the nature, which, in this context, is the river.

Rice field's irrigation – Next to the spring water, an irrigation system also streams in Kampung Naga to water the rice fields. This irrigation derives from a river that is higher than Kampung Naga. In 1965, the government built a reservation to split the water to another village located below Kampung Naga.

To maintain the rice fields, they also use natural materials; the *Suren* trees that are growing around the villages. The leaves are used as a pesticide for the rice fields. In addition to using natural pesticide, they also use fish to clean the rice fields before planting new ones.

Rainwater - Kampung Naga does not harvest rainwater in a particular tank, yet they do manage the rainwater. To illustrate, small ditches made from stone are placed underneath the roof ends between the houses to collect the rainwater from the roofs and to lead this to the fishponds. Through this method, they discovered a way to deal with the rainfall and to integrate this into their water management. (Interview Kampung Naga, April 24, 2017)

ii. Peri-urban area - Kampung Cigondewah

Cigondewah is a peri-urban area situated in the southwest of Bandung city. Before 1980, this kampung was a rice-producing village. Subsequently, the textile and the garment industry arose and changed the settlement.

Cigondewah consists of RW 2 and 12, accommodating homes for 742 families (1,500 people) on a land of 12 ha. This population is continuously growing. Because of the textile industry, many migrant workers came to live in this kampung. This created a new typology that is called *kos-kosan*, which is a combination of a family house connected with a few rooms for the migrant workers. (Smit, 2016. p. 74)

As can be observed in the site plan, the houses are built ubiquitously without any regulations, making the area dense in comparison to Kampung Naga. The inhabitants do no longer use natural material but mainly red clay bricks, concrete, aluminum, and light cement brick for the construction and walls, and applying corrugated steel plate or ceramic, plastic, or asbestos for the roofing system.

The sporadically built houses combined with the wastewater that runs through this peri-urban area, causes an unorganized and polluted water management.

Figure 10. Kampung Cigondewah (Own illu.)
Figure 11. Kampung Cigondewah site plan (Own illu.) (next page)

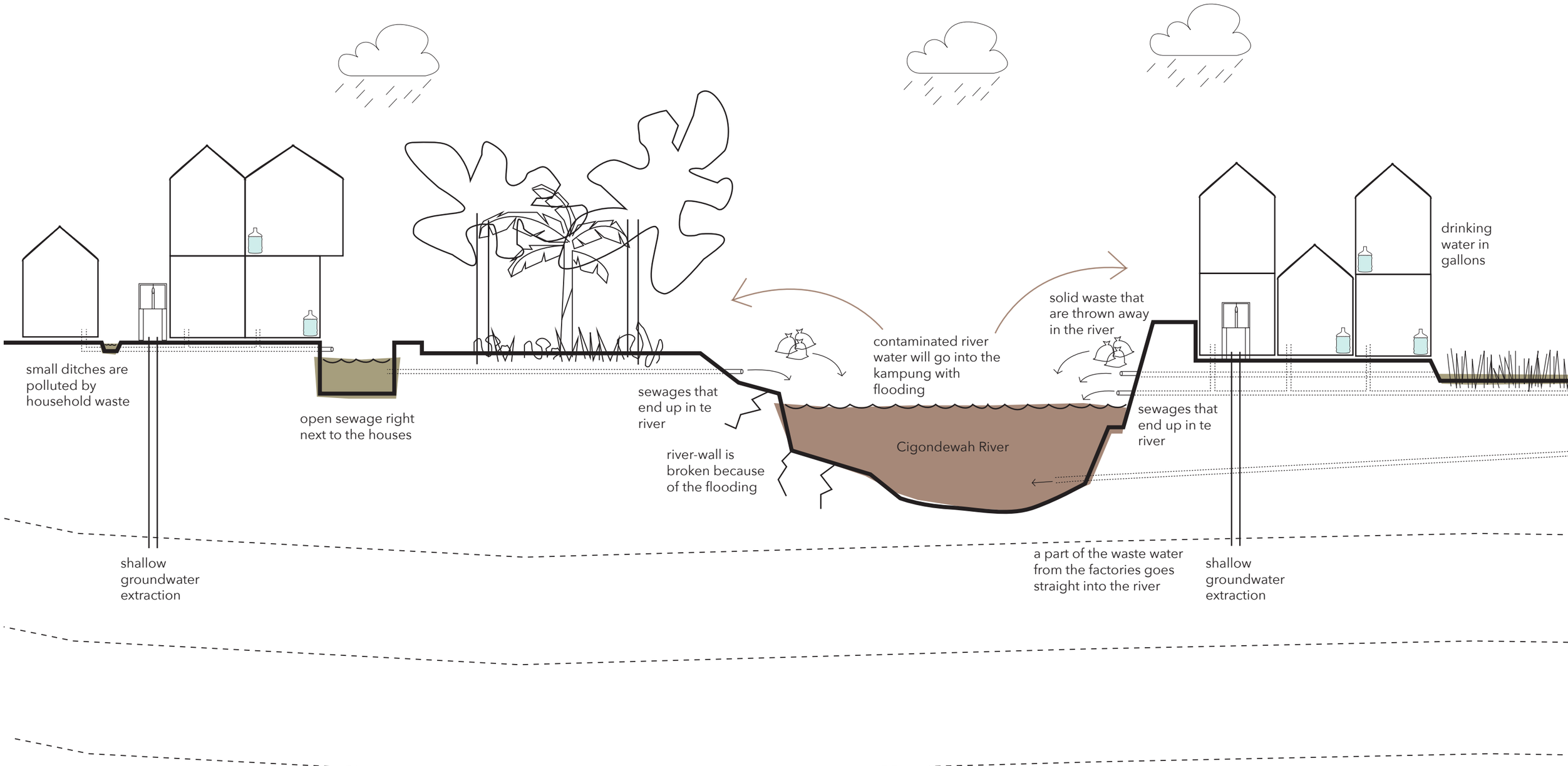
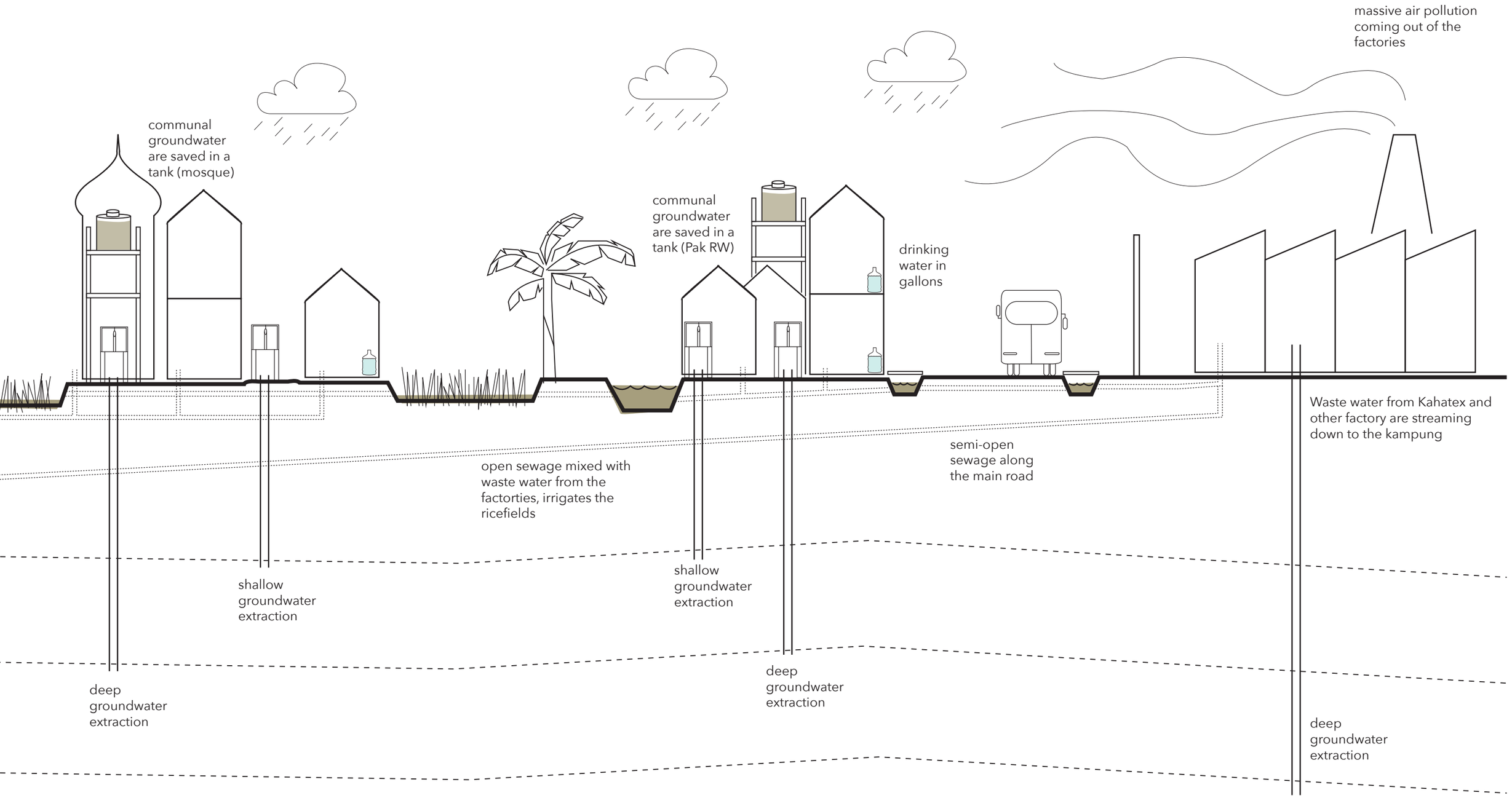


Figure 12. Kampung Cigondewah section (Own illu.)

Groundwater – Cigondewah does not have a spring where the inhabitants can use the water for their daily live. The Cigondewah River cannot be used because of the contamination. Therefore, they take water from the ground to fulfill their water needs or occasionally purchase water in gallons from small shops in the kampung. (Interview Cigondewah, April 23, 2017)

The groundwater is divided into two types: the shallow ground well pumps for the houses and the deep well pumps for the industry. (Magister arsitektur ITB, 2015) As seen in the section, obtaining water from the ground is not a good solution because it is polluted and it also causes land subsidence. However, the extraction increases rapidly every year. (Taller, 2009)

Most of the inhabitants use groundwater for all their utilizations, which are drinking, cooking, bathing, flushing, and washing. Before drinking the groundwater, they always cook it first. The inhabitant's think that by cooking the water, all bacteria and the toxic form the factory wastewater will be gone. According to Lieselotte Heederik who is the creator of a water filter product, this way of thinking is incorrect. By cooking the water, the toxic concentration will only become higher and is harmful to humans. (Interview Cigondewah, April 22, 2017) To use this groundwater, some people have a communal well where they can freely use the water, other people have their own well, and the rest pays money to one family that has a well based on the amount water they use each month.



Sanitation - Cigondewah has an underdeveloped sewage system that mainly consists of open sewage, encloses black water, gray water, and rainwater. This sewage is polluted by congested solid waste that makes the system often not working as it is supposed to. Moreover, 60% of RW 12 are using conventional septic tanks, 40% are using pipes that end up in the river, while in RW 2, only 5 % are using conventional septic tanks and 95% are using pipes that flow to the river. For the sanitation facilitation, only 58% has its own toilet and so 42% has to use the community-based sanitation. (Magister arsitektur ITB, 2015)

Textile industry - In addition to the houses, as previously mentioned, the factories around the area are also extracting groundwater in massive amount. The factories are not only disturbing the groundwater system but also intensely use the river both as a water resource and as a sewer. This industry also changed the river's quality by throwing toxic waste directly into the river. The Indonesian regulation prohibited this action on paper, but, in fact, there are no inspections. (Greenpeace, 2013) In addition to using the river as a sewer for their wastewater, the inhabitants also throw wastewater into ditches that lead into the neighborhood and irrigate the rice fields.

Rainwater - The way in which Kampung Naga is dealing with the rainfall is examined in chapter II.

iii. Urban area - Kampung Tamansari

Taman Sari Kampung is located in the northern part of Bandung. Taman Sari is an example of an urban area. The settlement is composed of houses that do not have a decent building quality and infrastructure. With a high density of 2,013,963/ha the open land is covered with houses that mostly have an informal land use and land ownership. The small houses that are built along the Cikapundung River are constructed from the same materials as in Cigondewah: bricks, concrete, steel, and aluminum. The only part of open land left are the small alleys.

Yet, it is noteworthy that this urban area also was a rural area with its West Java village characteristics. This area had large plots with rice fields and fishponds around it with houses on piles made from bamboo and wood. Moreover, the inhabitants even could drink the water from Cikapundung River.

The government of Bandung desired to turn this area into a city park. However, the planning failed due to the lack of state regulations and control that could not stop the rapid growth of the kampung. This undisciplined development resulted into a slum area. (Reerink, 2014)

In 1929, the kampung was improved. The government managed to provide electricity, sewage facilities, and infrastructure.

The recent plan for Kampung Tamans Sari is to create a new project in that area with apartments that can accommodate three times more than the current residents. (Interview ITB, April 20, 2017)

Figure 13. Kampung Taman Sari (Own illu.)

Figure 14. Kampung Taman Sari site plan(Own illu.)

drinking
water in
gallons

sewages that
end up in te
river

Cikapundung River

drinking
water in
gallons

sewages that
end up in te
river

PDAM water
are saved in
tanks

shallow
groundwater pumps that
are contaminated and
aren't used anymore

drinking
water in
gallons

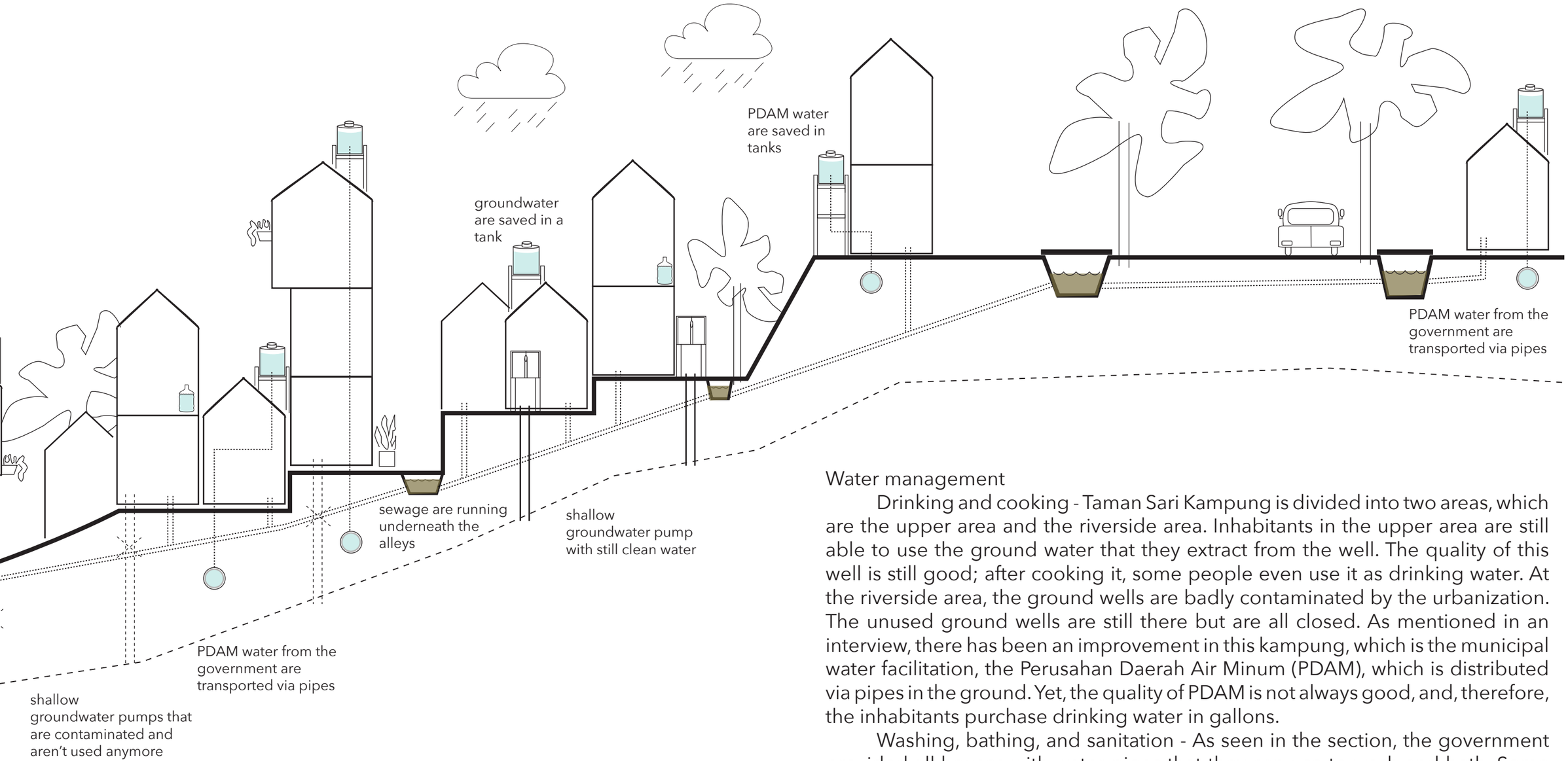
PDAM water
are saved in
tanks

sewage are running
underneath the alleys

PDAM water from the
government are
transported via pipes

flooding often
happens in the lower
area

Figure 15. Kampung Taman Sari section (Own illu.)



Water management

Drinking and cooking - Taman Sari Kampung is divided into two areas, which are the upper area and the riverside area. Inhabitants in the upper area are still able to use the ground water that they extract from the well. The quality of this well is still good; after cooking it, some people even use it as drinking water. At the riverside area, the ground wells are badly contaminated by the urbanization. The unused ground wells are still there but are all closed. As mentioned in an interview, there has been an improvement in this kampung, which is the municipal water facilitation, the Perusahan Daerah Air Minum (PDAM), which is distributed via pipes in the ground. Yet, the quality of PDAM is not always good, and, therefore, the inhabitants purchase drinking water in gallons.

Washing, bathing, and sanitation - As seen in the section, the government provided all houses with water pipes that they can use to wash and bath. Some people have their own sanitation facilitation, while others use the public toilet. In comparison to Cigondewah, the sewage system in this urban area is better. The sewages run underneath the streets and alleys but still end up in the river without wastewater processing.

Rainwater - One of the interviewees said that she uses rainwater for their daily live by filtering it; however, this is not the case for the majority of the kampung. The rainwater runs from the upper part to the riverside part, which often causes flooding. The water runs fast through the kampung because there are no drainage systems that can slow down the runoff. (Interview Kampung Taman Sari, April 25, 2017)

iv. Conclusion of three case studies

Categorization	Kampung Naga	Kampung Cigondewah	Kampung Tamansari
Density	x	xxx	xxxxxx
Housing structure	structured	organic	organic
Wild green	xxxxxx	xxx	-
Rice fields	xxxxxx	xxx	-
Irrigation water quality	very good	very bad	-
Water quality in the river	good	very bad	bad
River wall	natural	damaged dam	dam
Drinking water sources	spring	gallons, well	gallons, PDAM, well
Drinking water price	free	Rp.	Rp. Rp.
Drinking water quality	very good	very bad	good
Washing water sources	spring, irrigation	well	PDAM, well
Washing water price	free	free, Rp.	Rp. Rp.
Washing water quality	very good	very bad	good
Groundwater extraction	-	xxxxxx	xxx
Water infarstructure (rainwater runoff)	very good	-	x
Sewage processing	processed	-	-
Flooding	-	xxxxxx	xxxxxx
Rainwater usage	-	-	-

x : a little
xxx : medium
xxxxxx : a lot
- : none/not applicable
Rp. : relatively cheap
Rp.Rp. : relatively expensive

To summarize the case studies, a categorization table is created. In the table, it can be observed that growing population greatly affects the water system. In addition to the density, the way in which the settlement occurred in the kampungs also influences the structure of the water system. When a kampung grows, a circular water system is difficult to create and to maintain. The open land, such as the rice fields or fishponds, is another aspect of kampungs that affects the water management of a particular area.

Furthermore, the price of the water management differs among the kampungs, which is described in chapter 3. In all the case studies, a difference in the groundwater extraction can be perceived; to illustrate, the rural area conserves the groundwater, the peri-urban area overexploits the ground water that is contaminated and the urban area cannot make use again of the groundwater due to the heavy contamination.

Moreover, the three areas do not use rainwater as a water source. However, while Kampung Naga has a runoff system to prevent flooding, Kampung Cigondewah and Taman Sari do not possess this system, leading to frequent flooding.

i. Reasons for flooding in Kampung Cigondewah

Cigondewah and other parts of Bandung have been dealing with flooding issue for more than ten years and it only becomes worse. This problem affects many elements and has a negative effect on health and economy.

To solve this problem, the flooding in Cigondewah needs to be elucidated and the causes of the flooding in that area need to be explored. This diagram illustrates the six causes of the flooding in Cigondewah.

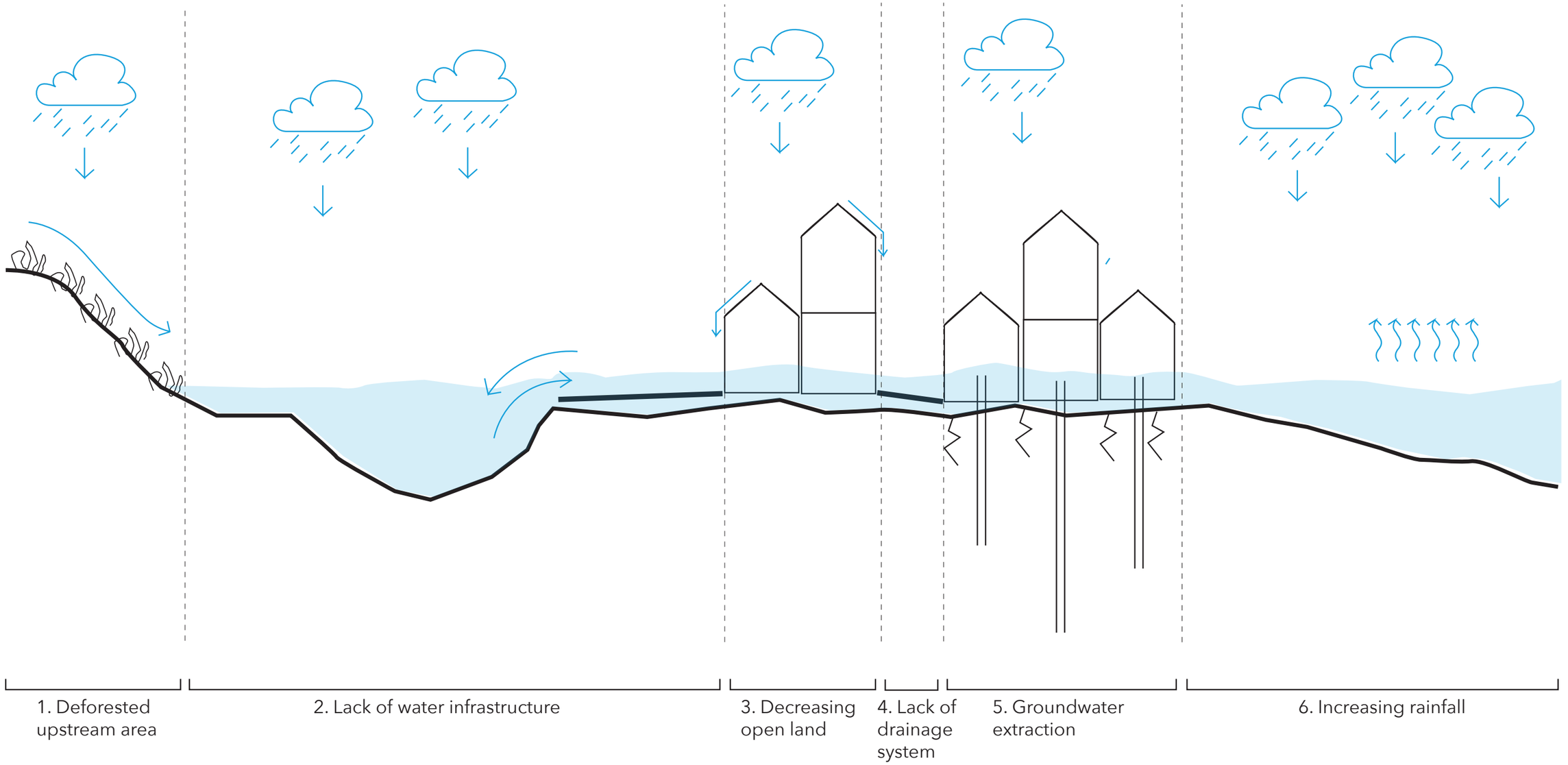


Figure 16. Flooding causes section (Own illu.)

Figure 17. Deforested land for agriculture use in Bandung (source 1)

Figure 18. Broken river wall (left) and undworkable water ditch in Cigondewah (right) (Own. illu)

1. Deforested upstream

The upstream of a river is key element for the river itself. It, for instance, determines the quality and the quantity of the water and controls the stream of the river. (Calder, 2008)

Nevertheless, nowadays, the area surrounding the upstream of the river that should be protected by forests is no longer protected because the forestland is used for planting crops. Consequently, the water quantity in the upstream cannot be absorbed by the forest, causing the water to go down faster than it normally does. (Interview ITB, April 20, 2017)

2. Lack of water infrastructure

The rainfall is becoming heavier each year, and there is a lack of water infrastructure. This entails that there are not enough ditches in the kampung that can accommodate the rain and stream it to the river. Moreover, the proportion of the water has changed while the infrastructure is underdeveloped. Therefore, an inability exist to receive all the rain, followed by a water overflowing water from the river going into the kampung. (Interview ITB, April 20, 2017)

Figure 19. Houses and factories creates density in Cigondewah (source 2)

Figure 20. Concrete covered alleys with unorganized water pipes (Own illu.)

3. Decreased open land

In 1978, buildings and residents covered 65% of the Bandung area. In 1981, this became 85.6% and 90% in 1986. This decreases the open land that has to absorb the rainfall.(Nuraeni, 2010) In addition, the huge amount of rainfall cannot be stored by, for example, wetlands. In the kampung, the remaining open land besides the streets and alleys are also often not planted, which makes the absorbing process slower and flooding will still happen.

Bandung has only 12% green open land left. The green space in Bandung is 8 m2/person, which is low comparing with, for instance, 45.5 m2/person in Amsterdam. (see site plan Cigondewah in Chapter I) (Yu Sing, 2017)

4. Lack of drainage system

Rainwater that falls has to be absorbed by the ground. However, with the kampung settlements, the buildings reduce the open land. Additionally, main roads, streets, and alleys that remain are covered with concrete pavement. For this reason, the water cannot be absorbed within a kampung. This lack of drainage system is also one of the main issues that cause flooding. To prevent this, a drainage system should be there to facilitate the process of absorbing rainwater.

Figure 21. Wells in Cigondewah (Own illu.)

Figure 22. Heavy rain in Cigondewah (Own illu.)

5. Groundwater extraction

A case study in Shanghai has demonstrated that groundwater pumping is strongly related to land subsidence that causes flooding in the end. (Chai, 2004)

The United States faces the same problem. With the increasing groundwater extraction, the land subsidence also increases. Water that is pumped mainly derives from a layer consisting of sand and gravel that has spaces between it. By pumping the ground water up, the water pressure in the sand and gravel is lowered. Consequently, the drainage process that is performed by the clay and silt beds becomes slower. This layer of clay and silt beds becomes compact and thinner, and the effect can be seen on the ground surface, which is the land subsidence. This damage is almost impossible to be repaired, as even with recharging the ground water, the land surface cannot go back to the original shape. (Hoffmann, 2003)

The consequence is that t the ground has less space to store water, which also enhances the chance of flooding.

6. Increased rainfall

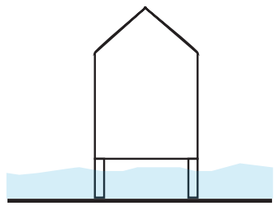
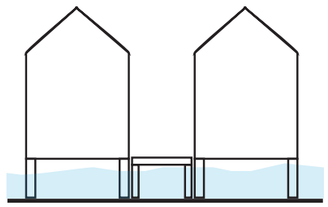
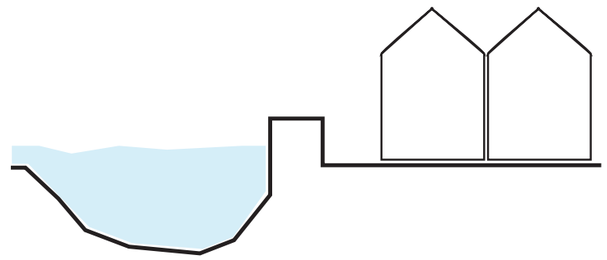
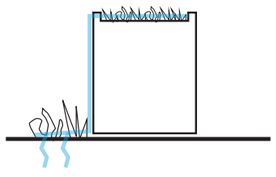
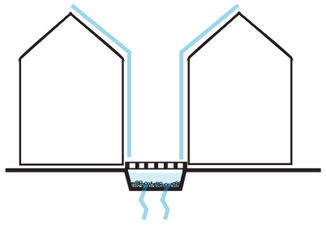
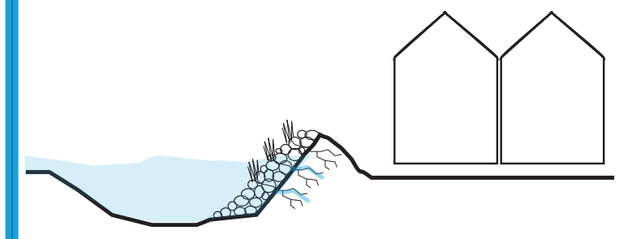
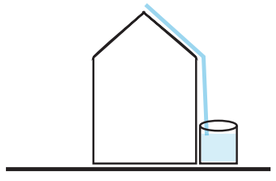
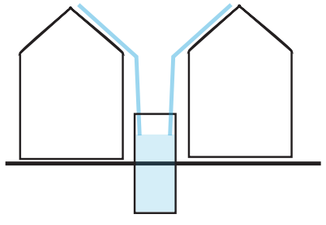
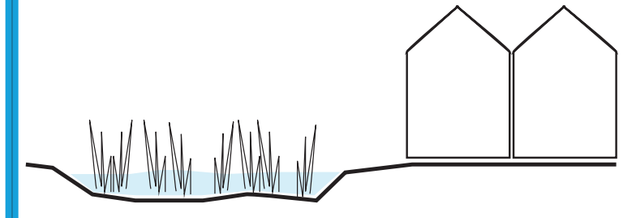
Cigondewah's mean annual rainfall is 2300 mm (high), which means there will be 2,300 l water falling down on 1 m2 per year. Based on a rainfall program, Kampung Cigondewah has a total savings of 292,938,810 liters of water a year with a lawn area of 750 sq ft. (save-the-rain, April 4, 2017)

Nonetheless, the amount of rainwater used in Cigondewah is only 5%. This amount of water infiltrates the land in that area, while the rest flows into the river. A positive aspect about the rainfall is that the quality of the rainwater in Greater Bandung is good. (Taller,2009)

The increasing rainfall amount is caused by the climate change, which is the increased temperature. The increased temperature speeds up the evaporation of the surface water, which is also already increased, as can be observed in the rising sea level. The rainfall would increase 15% with each temperature rise of 1 degree Celsius. (Interview ITB, April 20, 2017)

ii. Flood-related behaviors

Now that the causes of flooding in Cigondewah are listed, the focus is on the solutions to prevent the flooding. Based on the case study Kampung Naga, literature study, interviews, and site observation, three behaviors to deal with flooding are evident. For Cigondewah, these behaviors can be employed on three different scales.

BEHAVIOR/SCALE	Housing	RT (a few families)	RW (a few RT's)
Avoid	 Houses can be built on piles to avoid the flooding	 Small alleys between teh houses can be risen by lifted pathwyas	 Protecting the RW by creating a dam along the river
Buffer	 Slowing down the runoff by creating green roof and small gardens next the the house	 Drainage system in every alleys and streets	 Renaturalisation of river wall, so the water can still be absorbed while the kampung is still protected
Store and use	 Harvesting the rainwater to use it for flushing, bathing and even drinking	 Communal water harvesting, using the space that was used for the well	 Creating wetlands that can store the storm water

: most suitable behavior for Cigondewah

Figure 23. Table of different flooding related behaviors on different scales (Own illu.)

After analyzing the different kind of behaviors in dealing with flooding, a number of conclusions can be drawn. These flooding behaviors can be applied to in the future houses that will be built in Cigondewah on more than one scale. From the first scale, which is the housing scale, the avoiding and buffering ones are the most suitable for Cigondewah. As such, the houses should be built on poles to avoid flooding that can come anytime, while the buffer technique is required to slow down the runoff from all the houses in Cigondewah, since the open land is almost completely occupied with houses.

The third behavior, which concerns storing and using, is a valuable but does not fit properly in Cigondewah. This because most of the water facilities are used communally, making the RT scale of storage and use more suitable. In this RT scale, there is also a way to avoid flooding. The lifted alleys on piles will not work if the existing houses are not all built on piles. Another alternative is the buffer behavior, which involves making ditches underneath the alleys with a drainage layer on top of it so the rainwater can be buffered in that space and slowly streamed to the river.

The final scale is the RW scale, which can be related to a public scale, that in this context is the entire area, Kampung Cigondewah, and everybody influenced by it. On this scale, the avoidance behavior can be realized by making a dam at the riverside to protect the kampung. Yet, this way does not always work. To illustrate, in Cigondewah, the strong river stream breaks the existing dam/river wall, and this causes flooding in the kampungs. Another option is to construct a dam with natural materials, such as stones combined with vetiver plants, to make the dam stronger. By doing this, the water can be filtered by the plants and is more easily absorbed into the ground (this filter system is explained in the next chapter). In a situation where the annual rainfall is high, a high amount of rainwater needs to be stored. As a communal water store used for daily water usage is not enough, wetlands can be made by using open land that is left in Cigondewah.

i. Groundwater extraction

In this chapter, the potential of using rainwater as a new water resource is evaluated. First, the most used water resource, which is the groundwater, is investigated. Second, the expenses of water and the water need are listed and calculated. Finally, the ways of using rainwater for the daily life are explained.

This map illustrates a number of the spots where the ground wells are located in Cigondewah. The full dots represent the deep well, and the empty dots are the shallow wells. The next diagram demonstrates the majority and minority of the different wells, whether it is shallow or deep, and being used communally or privately.

Figure 24. Map of well locations in Cigondewah (Own illu.)

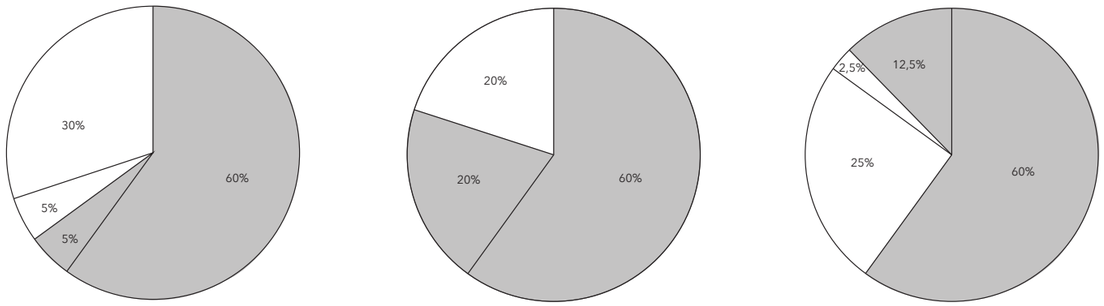


Figure 25. Diagrams of well usage in Cigondewah (Own illu.)

Diagram 1 - RW 12

Communal

In total, 60% of the inhabitants are using the deep well, with parallel distribution system. The water is transported with pipe looping and branches distribution. The gravitation distribution system from a water tower is 7 m high and the average cost per month is Rp.30,000-Rp.70,000 (2-5 euros). When a house is rented, the average cost per month is Rp.300,000-Rp 500,000.

Furthermore, 5% of the residents are using water from the public toilet.

Private

Moreover, 30% of the people are using water from a shallow well, while 5% are using water from a deep well. There are 23 wells in total, one unit in RT 1, twelve units in RT 2, four units in RT 3, and 6 units in RT 4. The shallow wells near the river are not used due textile factory waste contamination. (Magister Arsitektur ITB, 2015)

Diagram 2 - RW 2

Communal

In total, 60% are using deep well, three from the five RTs are using this well, while 20% are using water from a shallow well, for the public toilet.

Private

In addition, 20% of the dwellers are using water from a shallow well. There used to be many wells, but most of them are not used anymore due to factory waste contamination. (Magister Arsitektur ITB, 2015)

Diagram 3 - RW 12 and RW 2

Communal

As can be observed, 60% are using deep well, and 12.5% are using shallow wells in public toilets.

Private

In private, 25% are using shallow well and 2.5% are using deep well.

Because the use of the main water resource is overexploiting the environment and has an inferior quality due to the textile factory contamination, it is necessary to realize another water resource. The increasing rainwater is a potential solution for this issue. The table on the next page provides an overview of the costs that the inhabitants have and how much water they use each month.

ii. Water usage and expenses

Kampung Naga

Price &	Drinking	Cooking	Bathing, washing	Toilet	Outcome for water		Outcome for Rent	Income
					Total	Per Person		
Pak Ucu and his family (5 persons)	Rp. 0 (4days=1 barrel=159 L) springwater		Rp. 0 fishponds	Rp. 0 fishponds	Rp. 0 (1193 L)	Rp. 0 (239 L) Rp. 0 L/person	Rp. 0	Rp. ... Producing food, building materials, selling food or souvenir,

Kampung Cigondewah

Price &	Drinking	Cooking	Bathing, washing	Toilet	Outcome for water		Outcome for Rent	Income
					Total	Per Person		
Ibu Desy, 2 kids, husband (4 persons)	Rp. 64.000 (Rp. 4000/gallon) mineral water gallons	Rp. 33.000 (Rp 3.000/m3) Pak RW	included the rent (Standart 30 L/person/day) kos-kosan well		Rp. 97.000 (11304 L)	Rp. 24.250 (2826 L) Rp. 8,6 /L/person	Rp. 500.000	Rp. 2.000.000
Ibu Lia, 2 kids, husband, mother in law, sister in	Rp. 50.000 (Rp 3.000/m3) mosque (extra water usage for small shop)		Rp. 0 (Standart 30 L/person/day = total 5400 L) private well		Rp. 50.000 (22000 L)	Rp. 8.350 (3666 L) Rp. 2,3 /L/person	Rp. - (own house)	Rp. 2.000.000
Ibu Lira, 1 kids, husband (3 persons)	Rp. 64.000/week (Rp. 4000/gallon) mineral water gallons		Rp. 0 (Standart 30 L/person/day= 2700 total) communal well		Rp. 64.000 (3004 L)	Rp. 21.333 (1001 L) Rp. 21,3/L/person	Rp. - (own house)	Rp. 2.000.000
Ibu Siti and her husband (2 persons)	Rp. 40.000 (Rp. 5000/gallon) mineral water gallons	Rp. 0 (does not cook)	included the rent (Standart 30 L/person/day) kos-kosan well		Rp. 40.000 (152 L)	Rp. 20.000 (76 L) Rp. 263/L/person	Rp. 450.000 (inclusive washing water)	Rp. 4.000.000
Factory worker (1 person)	Rp. 17.000 (Rp. 4250/gallon) mineral water gallons	Rp. 0 (does not cook)	included the rent (Standart 30 L/person/day) kos-kosan well		Rp. 17.000 (76 L) (only drink water)	Rp. 17.000 (76 L) Rp. 224/L/person	Rp. 400.000 (inclusive washing water)	Rp. 2.000.000

Kampung Tamansari

Price &	Drinking	Cooking	Bathing, washing	Toilet	Outcome for water		Outcome for Rent	Income
					Total	Per Person		
Ibu Li	Rp. 24.000 (Rp. 6000/gallon) aqua mineral water gallons	Rp. 110.000 (Rp. 7400/m3) PAM			-Rp. 134.000 (14978 L)	-Rp. 33.500 (3744 L) Rp. 8,9 L/person	not known	not known

Conclusions of the water usage and expenses table

1. Factory workers that live in a kos-kosan using water for drinking, clothes washing, bathing

- Monthly
cost: Rp. 244/L/person
usage: 976 L/person (76 own expend + 900 L included rent)
Total expend :Rp. 18.600/person

- Yearly
usage: 11.712 L/person
Total cost : Rp. 223.200/person/year
This price is exclusive water expend that is included in the rent that they have to pay per month.

2. Villagers that live in their own house using water for drinking, clothes washing, bathing, cooking, dish washing, flushing toilets and cleaning the house

- Monthly
cost: Rp. 11/L/person
usage: 2500 L/person
Total expend :Rp. 27.500/person

- Yearly
usage: 30.000 L/person
Total cost : Rp. 330.000/person/year

The expense on water for the entrie Cigondewah (RW 12 and RW 2)

Workers
1500 people x Rp. 223.200/person/year
Is Rp **334.800.000(22.490 euros)** per year
17.568.000 L

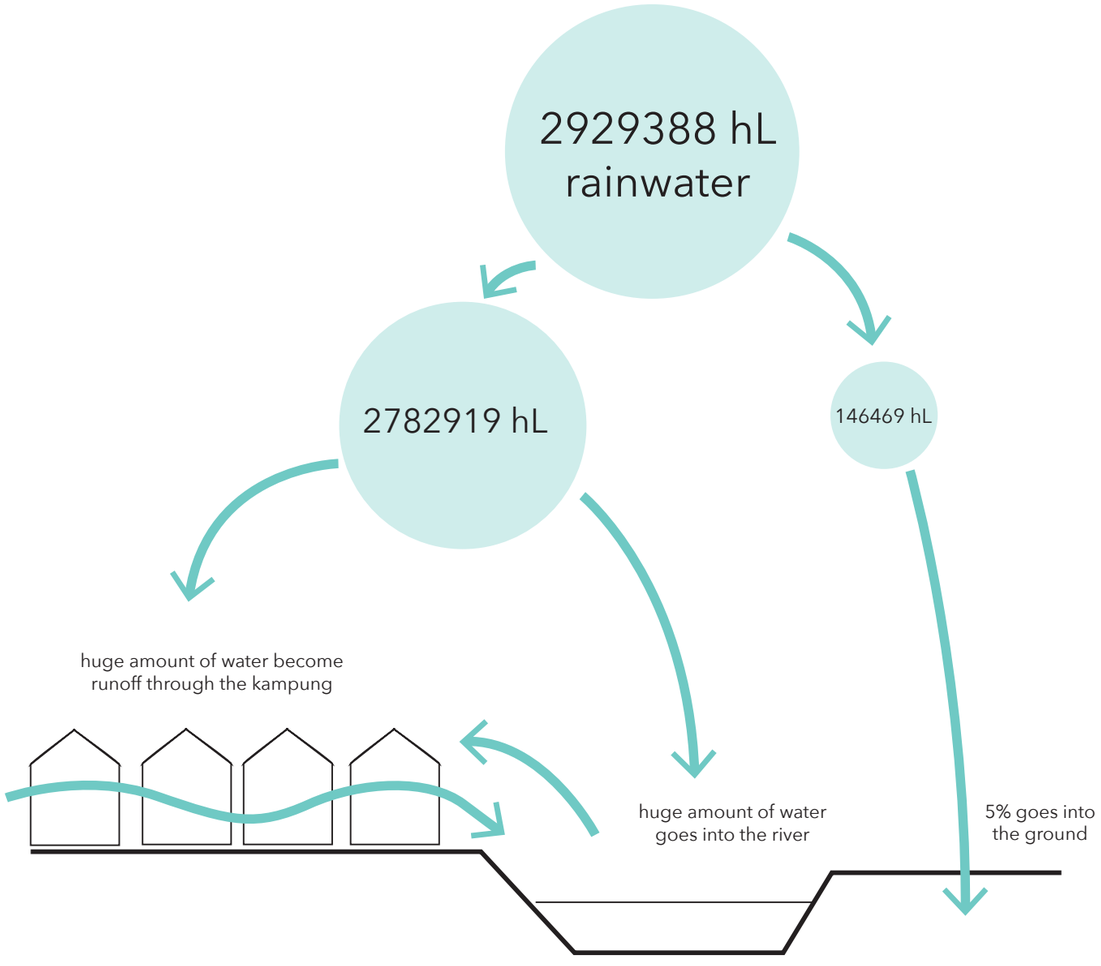
Villagers
742 families : 2968 people x Rp. 330.000/person/year
Is **Rp. 979.440.000(65.792 euros)** per year
With water usage of **89.040.000 L**

Total
Water usage for Cigondewah per year is **106.608.000 L**
With an expense of **Rp. 1.314.240.000 (88.282 euros)**

These calculations are made based on data collected from the interviews and the research that has been conducted by the students of ITB. With the total water need of Cigondewah combined with the rainfall that Cigondewah can collect, the flow of water can be illustrated in two diagrams. Furthermore, Cigondewah's expenses regarding water can be saved and part of it can be used to invest in filter systems. This way, people will spend less money and receive clean water. Hence, their health and wealth will be improved.

iii. Rainwater usage approach

Current situation - 2017



Future situation - 2027 (replacing all water resources with rainwater)

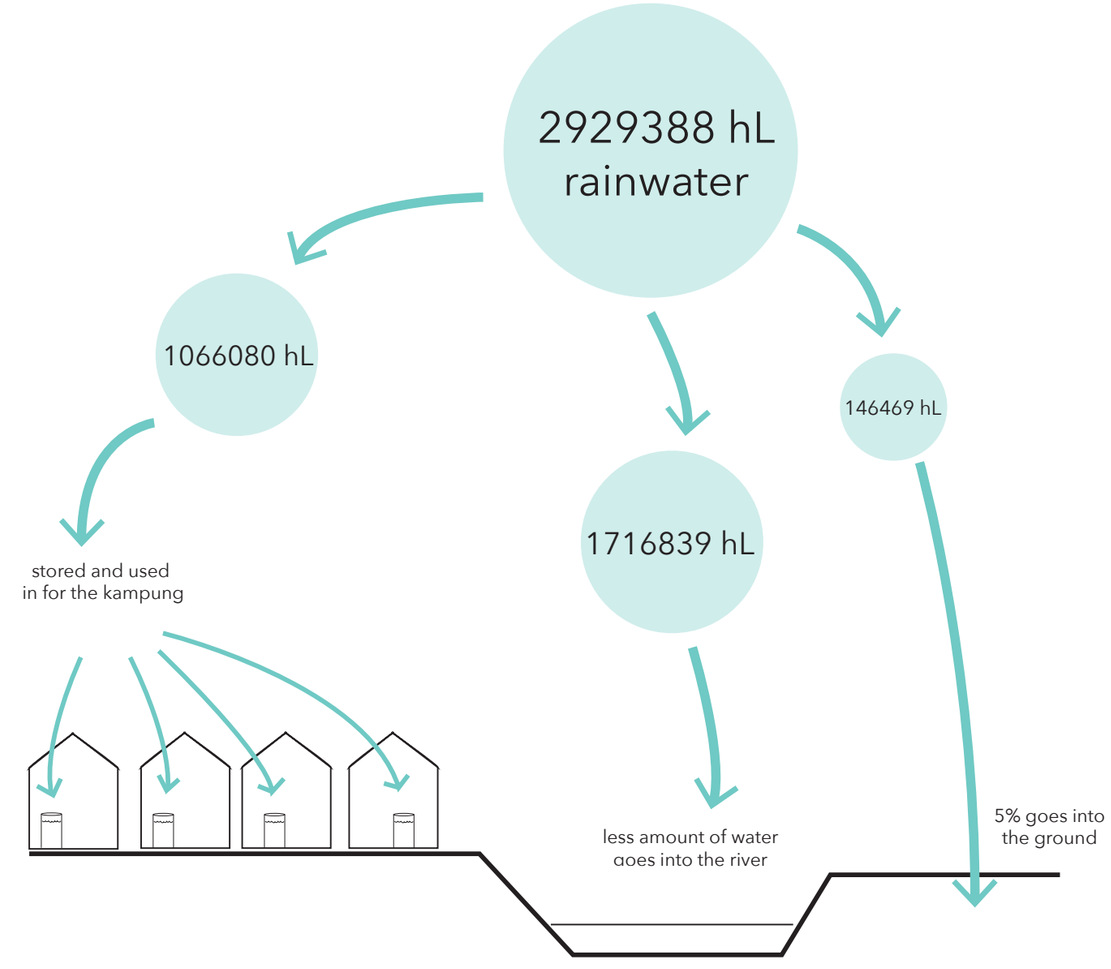


Figure 26. Rainwater usage changes after the approach (Own illu.)

iv. Drinking water filter on household scale

Based on the calculation, rainwater could be a new water resource for the population of Cigondewah. There is enough rainfall to fulfill all the inhabitants' water needs. However, because of the air pollution by the factories and the traffic, the rainwater contains harmful substances. Hence, a filter system is needed.

Nazava is a company that designs rainwater filters. The product price differs from Rp. 185,000 to Rp. 1,025,000. This filter is not only able to filter the rainwater, but also the groundwater and piped water. Nazava water is nine times cheaper than purchasing gallons of water and three times cheaper than cooked groundwater, which is a main motivation for the inhabitants to use this filter. Nazava filter has been tested in 29 laboratories in and outside the country, including the Netherlands. (Heederik, 2017)

The founder of Nazava, Lieselotte Heederik, mentioned in the interview a few points that need to be remembered when using the filter. One of them is the importance to always closing the basket, because otherwise it will become moldy. Next to this, the filter should always be filled with water so that the pressure will be higher and it will filter faster. There are two reasons why this product is not used yet in Cigondewah. The first one is because the inhabitants do not know about this product and only know about Pure it, a relatively expensive filter that they see on the television. The second reason is because they do not believe that the water will be clean enough by just filtering it without cooking it after. However, by cooking the water, the concentration of the toxic will be higher and will be more harmful for the body. A presentation from Nazava to a group and personal explanation to the inhabitants of Cigondewah has been given during the site visit, and their reactions were positive. (Interview Cigondewah, April 22, 2017)

1. Nazava Bening Small

This filter costs Rp.205,000 and is the smallest model that Nazava has. This product is suitable for workers that are renting rooms or small families. The amount of water that fits in this filter is 6 l and can filter 3 l/hour, which means that it can filter approximately 50 l per day. After a while, the filter needs to be changed. One filter can be used to filter in total 7,000 l (350 gallons), which is 1-2 years. There is a special indicator tool to measure if the filter needs to be changed.

The filter contains activated carbon that is made of coconut shell from Indonesia. This filter is made in the Netherlands and will also be tested in 30 labs in the Netherlands. (Heederik, 2017)

Figure 27. Small Nazava filter (source 3)

v. Drinking and non-drinkable water filters on community scale

1. Nazava Manganese 8 Inch

This type of Nazava filter is made for a communal use. This product costs Rp.1,800,000. This filter is especially designed to filter ground well water that smells rusty, has the smell of rotten eggs, has a yellow color, contains oil, or has a black layer on the water. This filter is capable to filter water that contains a high amount of iron. The filter can be connected with silica and carbon to modify to a different filter depending on the problem of the contaminated water. The height of this product is 120 cm, with a diameter of 20 cm and weighs 20 kg. The speed of filtering is faster than the smaller model, namely 500 l/hour. (Heederik, 2017)

Figure 28. Manganese Nazava filter and Tabwater Nazava filter (source 4 and 5)

2. Nazava Tab water

The Nazava Tap Water is made to filter as much water as possible. A key element for this is the pressure from water pomp or a tower. The speed of this filter is 60 l/hour and it costs Rp.405,000. Similar to the small filter, this can also process 7000 l before the filter has to be changed. (Heederik, 2017)

3. Plant tub

The function of this water filter system is to filter washing wastewater that comes from bathing or dish washing. First the water will go through a filter tub with eceng gondok plants (which is explored in the next chapter). After that, water will be filtered again in an eceng gondok tub, and then it will go to a tub where morning glories are planted. Finally, the water will go into a fishpond that functions as an indicator. The water that is already filtered can be reused again for bathing, washing, flushing, or watering plants. As can be observed in figure, the plant filter tub contains of various plants. The layers from bottom to top are sand, stones, gravel, palm tree fiber (ijuk), soil, and plants. (Yu Sing, 2017)

Figure 29. Plant tub and rainwater tub (source 6)

4. Rainwater tub

This filter uses rainwater for its function. The rainwater that will be used in this system can be stored rainwater or rainwater from a drainage system. The water is first collected in a tub so it can go through the deposition process. Next, the water will go through two tubs that are composed of different layers. The layers from bottom to top are sand, gravel, activated carbon, and broken tiles as to top layer. The water that is filtered can be used to water the plants, for bathing, washing, flushing toilets, and cooking. (Yu Sing, 2017)

vi. Drinking and non- drinkable water filter on public scale

1. River filter

Another scale that can integrate a water filter system is a public space scale. The river is one of the main public water spaces. This figure illustrates a filter in a form of plant element that can be placed in the river and can filter a small part of the contamination in the river. (Yu Sing, 2017)

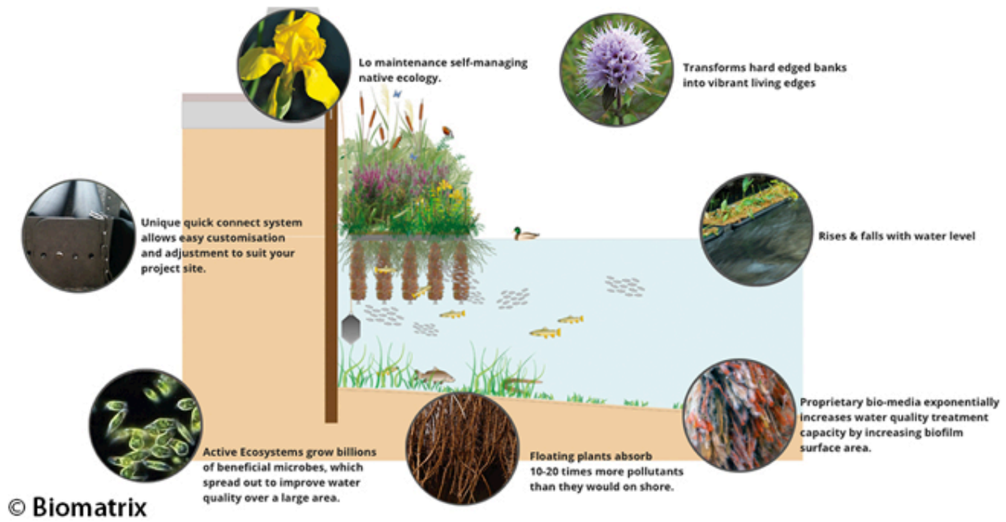


Figure 30. Plants river filter (source 7)

2. Vetiver river wall

The vetiver plants that can be grown along the river are natural erosion protectors. This is because of this plant's long roots that hold the soil. This plant does not only protect but can also filter the water they absorb. In the figures bellow a transformation of a river look can be observed. The river that had hard edges now has natural edges that also become stronger. (Yu Sing, 2017)

Figure 31. Transformation to a vertiver river wall (source 8)

3. De Watermaker: a water-purifying vertical city park.

De Watermaker created a water filter system that can stand on its own as a building but can also be integrated into another building, for example, above the roof. It is a construction where large boxes with water are constructed in diverse levels. These boxes are filled with plants that filter the water, which creates diverse gardens with their own qualities, depending on the filter process and the substances that are being filtered. The rainwater streams from one level into another level through the open boxes forming a staircase. The water flows through this system twice. The final steps are sterilization by a machine and quality control. In addition to filtering water, this system also has other values. It cools down the temperature in the area and contributes a new atmosphere with the sound of streaming water. By placing this system on a general parking lot or office building, 19,200 l drinking water can be produced in 24 hours. By selling the drinking water, the budget will slowly be refunded. A part of the water will be consumed and the rest will flow to a pond and can be used for the sanitation needs. (hetkanWel, 2015)

Figure 33. Water-purifying vertical city park (source 9)

vii. Conclusion of water filters

Categorization	household scale	communal scale				public scale		
	Nazava small	Nazava manganese	Nazava tab	Plant tub	Rainwater tub	River plants	Vertiver river wall	De Watermaker
Drinking usage	✓	✓	✓					✓
Washing usage				✓	✓			
River water						✓	✓	
Using rainwater as resource	✓	✓	✓		✓			✓
Using household waste water				✓		✓	✓	

Based on the comparison of various filter alternatives, there are several suitable options for the project of developing the water system in Cigondewah.

Rainwater for drinking water: All these filters have their own value. The most potential drinking water filter for Cigondewah is the Nazava Manganese because the use of this product is communal and it fits with the inhabitants' culture by using water facilitations together as a community. This can clearly be seen in the use of communal ground wells. Compared to the filter Watermaker system, the Nazava is much easier and does not require high-tech machines. Yet, a reason to not use the Nazava Tab Water is that when using rainwater, there is not always pressure or a pump, which will make the Nazava Tab Water not working.

Rainwater for washing and bathing: The most potential filter for this is the rainwater tub filter. This filter can be built easily and can be communally used.

Wastewater (washing water) processing: The most suitable filter to process wastewater from household so that water can be reused is the plant tub. This filter can easily be made and has also a community scale, which makes it easier to realize and to maintain it.

River water processing: Both the floating plant cluster and the vetiver river wall are suitable for Cigondewah, because they are both low tech and reduce the toxic that is contained in the river. In addition to filtering, these filters also have an esthetic value in maintaining the river.

i. Causes and the consequences

A small part of Cigondewah consists of rice fields. The textile factory, PT Kahatex, owns this land. By renting the land, which also means paying the factories to plant rice, makes the economic value of these rice fields for the farmers small. Another aspect that reduces the value of these rice fields is the polluted soil. The water that irrigates the rice fields derives from the wastewater from the textile factory, PT Kahatex itself. The color of the water is black and it smells. This wastewater goes through an open canal directly into the rice fields and ends up in the river.

Wastewater is waste that comes from the factory's processes such as bleaching, coloring, printing, cooking, dressing, and finishing in a liquid form. The largest waste problem that is caused by a textile industry involves the coloring process. The chemical waste substances that are mixed with water are color pigments, heavy metal (Pb, Cd, As, Cr, Cu, Zn), and halogenated hydrocarbons. In addition, the waste also contains remnants of oil and small pieces of textile that can clearly be observed in the river as well. (Kementrian Lingkungan Hidup, 2005).

As a result of a research that has been conducted in Sambungmacan Central Java, a textile industry area, two heavy metals have been found the soil, which are cadmium (Cd) and copper (Cu). The negative side effect of these heavy metals for the human body cannot be immediately perceived but is threatening for health. First, cadmium stems from the coloring process and is also used as a stabilizer. If a chronic poisoning takes place, it can damage the urinary system (kidney), blood system (anemia), and respiration system (lungs diseases) and can induce bone fragility. These substances are also dangerous for animals and plants. Second, copper is found in air pollution and by rain, this substance also ends up in the wastewater. Copper attacks the liver and can cause Wilson disease; copper can also damage the neurological and psychiatric part of the body.

The situation in Sambungmacan is similar to the one in Cigondewah, as their wastewater also contaminates the rice fields in the area. After an investigation, it was concluded the rice fields soil contains a high amount of heavy metal, even though this industry already has a wastewater processing system (IPAL). There are three biological treatments that can be performed to reduce the amount of hazardous substances. The treatments are phytoremediation and bioremediation and using organic substances. In this research, the method that was used is phytoremediation. Hence, they examined the physical and chemical characteristics of the soil and followed by a study of potential plants that can absorb the hazardous substances. They investigated five plants, which are mendong (Fimbristylis globulosa), bundung (Scirpus sp), and enceng gondok (Eichhornia crassipes) that are not edible, and rice plants (Oryza sativa) and sawi (Brassica juncea) that can be consumed. The soil kind that is taken from the polluted area and is used as samples belongs to vertisol soil. The findings indicated that the soil contained 31.38 mg/kg Cu and the Cd amount is 1.18 mg/kg. By applying the different kind of plants, the outcome revealed that these plants reduce a certain percentage of the Cd substance. To illustrate, mendong reduces 23%, bundung 22%, enceng gondok 36%, rice plants 22%, and sawi 21%. Nevertheless, evidence does not yet exist that these plants also reduce the Cu substances. (Kurniasih, 2008)

Figure 34. Rice fields contain liquid waste (Own. illu)

Figure 35. Rice fields contain solid waste (Own. illu)

ii. Potential crops in water filtering, handcrafts and building material

Mendong (*Fimbristylis globulosa*)

Mendong is a grass plant; these plants can grow in an area that is 300-700 m above the sea level, with full sunlight and a great deal of water. It is a plant that can grow in a swamp and grow 1000 mm high (Steenis, 1987). Moreover, the plant looks like grass; it can be 20-120 mm long and is 1-5 mm thick. The section of mendong is round, like small tubes.

In Yogyakarta, mendong plant is used to make handcraft as bags, pillowcases, maps, carpets, wallets, shoes, sandals, prayer rugs, phone casing, and hats.
One plant can grow four times after cutting it in harvesting. The planting begins with growing seeds. After a while, a group of germs will grow and can be separated and will grow into a larger plant. Mendong only needs three to five months to grow before harvesting time. After harvesting, the mendong will be dried in the sun, and it only takes one day. These dried mendong will then be woven into a mat. There are two ways to preserve the mendong mats before they will be made into products. The first one is by painting the mat with a chemical liquid to protect it from insect and fungus. The other method is by soaking the mat in water that is mixed with mud for four days and four nights. The latter method is the traditional way of preserving and also provides a nice gray color to the mat, and the mat will also be more elastic.

This plant can grow everywhere in Indonesia; in Borneo, they call it purun and in Sumatra the plant is known as bayun. In addition to gray, the dried mendong can be dyed with other natural dyes such as ketapang leaves to make it dark blue and teak leaves to provide it with a dark red color.

Besides handcrafts, this woven mendong can also serve as wall infill similar to the woven bamboo that they apply in traditional houses in Kampung Naga and other part of Indonesia. Next to water filter, handcrafts, and building material, mendong can also be planted to create wetlands. This is because mendong requires a great deal of water, same as rice fields. (Interview Yogyakarta, April 14,2017)

Figure 36. Mendong plant and handcrafts (Own. illu)

Eceng gondok (*Eichornia crassipes*)

Eceng gondok is a plant that grows wildly in brackish water surfaces (fishponds or lakes) and swamps. Enceng gondok can grow almost everywhere from lowlands to areas 1600 m above the sea level. This plant floats, which means the stem that is 400-800 mm cannot be seen. The green, round, and thick leaves are about 70-250 mm long by 30-70 mm wide. The part of the stem that is near the leaves has a balloon shape filled with air. The part between the stem and the beginning of the leaves is where new plants will grow, spreading above the water, while the hairy roots are growing in the water and can be 300-600 mm long. (Steenis, 1987)

Eceng gondok is also a plant that can be transformed into a handcraft. The process to make handcrafts out of eceng gondok consists of a few steps. The first step is to wash the eceng gondok so there is no longer dirt on it. The next step is cutting the leaves with a knife, as only the stems are needed. The third step is drying the eceng gondok. This can be done with only placing it in the sun. Subsequently, the dried eceng gondok are ready to be weaved and turned into a handcraft product.

In addition to handcrafts, eceng gondok has other benefits. For instance, eceng gondok contains many vitamins, can be used to make paper, can be used as fertilizer, can be a media to grow mushrooms, can be a medicine for sore throat or skin diseases, and can also be used for cattle fodder. (masFikr, 2016)

Figure 37. Eceng gondok plant and handcrafts (source 10,11,12,13,14)

Lotus (*Nymphaea*)

Lotus is a plant that grows in water. The roots are in the water, while the leaves with a diameter of 20-30 cm are floating on the surface. This plant can be found in lakes, ponds, or swamps. Lotus often grows in tropical and subtropical regions. (Hidayat, 2004)

A research has been conducted about lotus plant and water filtering. They tested whether the lotus plant can reduce the concentration of ammonia and phosphate that are in the black water coming from the houses. In 24 hours, with fito-biofilm technique, the amount of ammonia was by 60% reduced, while the phosphate amount was decreased by 52.38%. This result is better than the research that has been carried out with enceng gondok plant, which reduced 38.4% ammonia and 49.1% phosphate. (Parwaningtyas, 2012)

Bundung (*Scirpus sp.*)

Bundung is a straight and sturdy plant that grows like mendong in groups with roots that go deep into the ground. It is a grass-like plant with a height of 800-2000 mm. This plant can be mostly found in swamps areas in Borneo.

Figure 38. Lotus plant (source 15)

Figure 39. Bundung plant (source 16)

Conclusion

Categorization	Mendong	Eceng gondok	Lotus	Bundung
Filtering factory waste water	23 %	36 %	-	22%
Filtering blackwater	-	✓	✓	-
Filtering household waste water	-	✓	✓	-
Fast growing	✓	✓	✓	✓
Building material potential	✓	✓	-	-
Handcraft	✓	✓	-	-

Mendong and eceng gondok are plants with the most potential because they both can absorb the most toxic waste from factory wastewater, they both grow fast, and they both can be a material to make handcrafts and wall infill. Since woven mendong is thinner than woven eceng gondok, eceng gondok mats can be a good wall infill material for the outside of the facade, while mendong could be an interior wall infill. Furthermore, to filter wastewater from the households, lotus appears the best option.

ii. Flow intervention

CURRENT FLOW - 2017

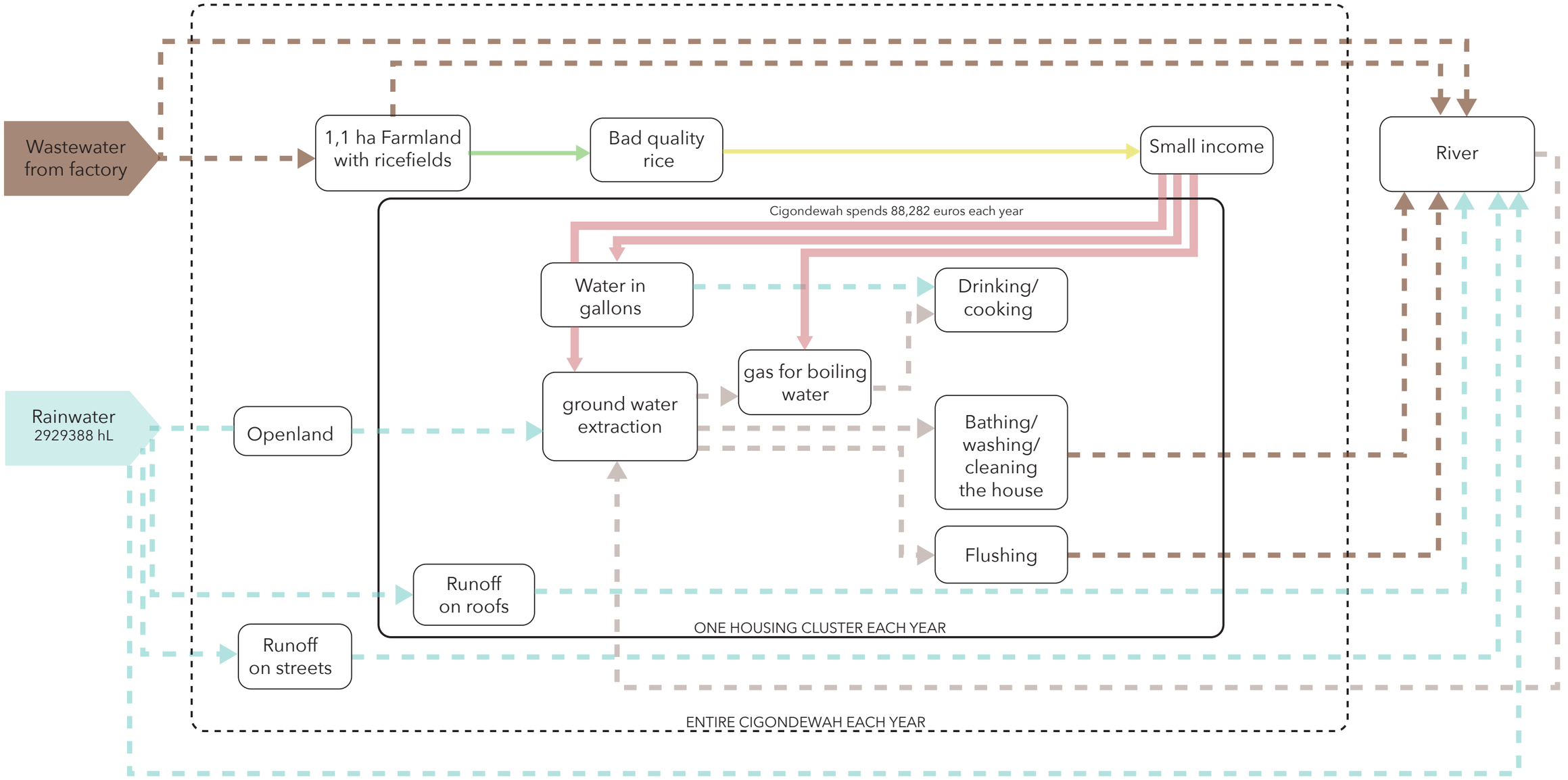


Figure 40. Current flow (Own illu.)

FUTURE FLOW WITH INTERVENTIONS - 2027

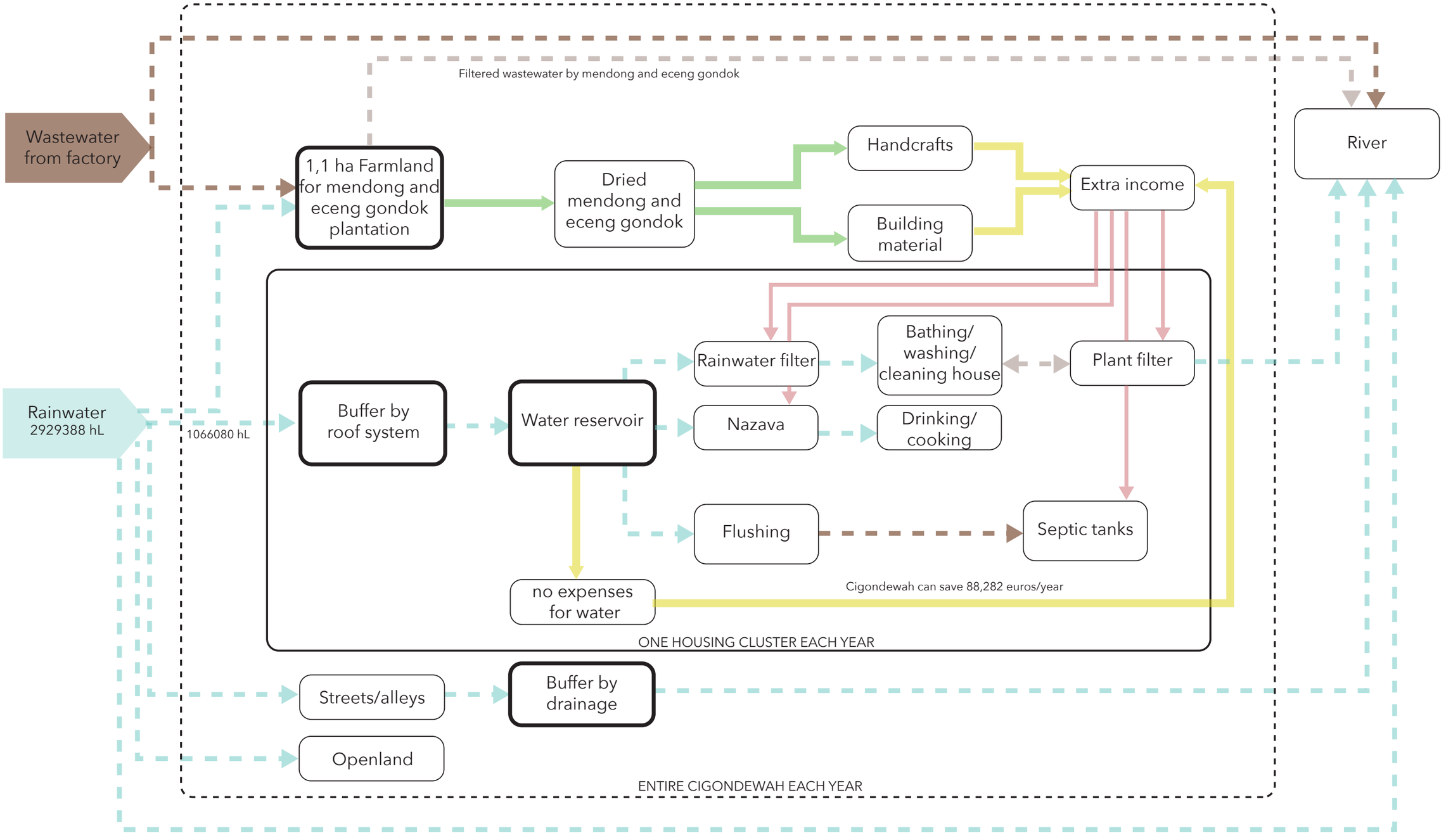


Figure 41. Future flow (Own illu.)

i. Traditional Indonesian roofing systems

Based on the previous four chapters, it is evident that the existence of the houses highly affects the water system in a certain area. The fact that houses in general are covering up the ground, which is a natural element that needs to absorb the rainwater is a point that needs to be considered. The need to build new houses for the growing population is, in this case, an opposite matter.

The problem can potentially be solved by not regarding these houses as a barrier for a valuable water system but as a tool to create a new water system that can support the live-work environment in Cigondewah. Here, the roof of a house plays a key role. To illustrate, a roof can collect rainwater or serve as a buffer for the runoff. Thus, it needs be examined how a roof system can play a part in a water system.

For this reason, this chapter analyzes different kinds of roofing techniques in Indonesia that correlate with the traditional building methods from each province. The aim is to learn how the ancestors dealt with the climate. At the end, a requirement proposal for a roofing system is formulated to support the design phase.

1. Baanjung house
Location: Suku Banjar, South Kalimantan
Characteristic: The house has a roof extension on the left and right side of the house. The roof has a acute angel of 45 degree.
Material: Wooden shingles from ulin or rumbia trees.

Figure 42. Baanjung house (source 17)

2. Sasak house
Location: Lombok Island
Characteristic: The roof is mound shaped with a distance of 1,5-2 m from the ground level.
Material: The roof is supported with wooden and bamboo construction, straw and weeds are used for the outer layer. The walls are made from straw ash, buffalo/horse dung and also the sap from banten and bajur trees.

Figure 43. Sasak house (source 18)

3. Hanoi house
Location: Papua
Characteristic: The house is for 5-10 people. The house is not spacious and does not have any windows; this is designed to stand the cold air.
Material: The roof shape looks like a cone and is made from straw and weeds.

Figure 44. Hanoi house (source 19)

4. Baduy house
Location: Banten
Characteristic: The shape of the house looks like a saddle and extend from the left to the right side of the house.
Material: The roof is made from sulah nyanda leaves, nyanda means leaning stance, which the position should not be straight but leaning to the back. The house foundation is river stone to prevent landslide. The walls are made from bamboo using sarigsig technique. A technique in plaited work without making any measurements first.

Figure 45. Baduy house (source 20)

5. Tongkonan house
Location: Toraja, Sulawesi
Characteristic: The roof has a curved shape and looks like a boat. The function of the house is to facilitate sleeping and cooking but also to save corpses.
Material: The house is made from bamboo and there are some buffalo horns at the front side of the house.

Figure 46. Tongkonan house (source 21)

6. Joglo house
Location: Jawa tengah
Characteristic: The open space in the front of the house functions as a living room (Ruang pendopo), Ruang pinggitan or the main room locates in the middle of the house, Ruang sentong has a storage function while the Ruang gandok tengen and gandok kiwo at the left and right side of the house are bedrooms.
Material: Ceramic roof tiles and wood.

Figure 47. Joglo house (source 22)

7. Mbaru Niang house
Location: Wae Rebo, Flores
Characteristic: It has a cone shape and consists of five levels, and it is 15 m high.
Material: Lontar leaves, ijuk, worok wood and bamboo, build without nails, tali rotan is used to tie the construction together.

Figure 48. Mbaru Niang house (source 23)

8. Uma Bokulu house
Location: Sumba Barat Daya
Characteristic: The shape looks like a tower, the height can be 30 m. The house is divided in three parts, the tower, the main building and the lower part.
Material: wood, bamboo, stones for the foundations, and straw for the roof.

Figure 49. Uma Bokulu house (source

9. Gadang house
Location: West Sumatra
Characteristic: It has a high and strong appearance. The shape of the roof has a story behind it. and stands on wooden piles.
Material: wood

Figure 50. Gadang house (source 25)

10. Buton house
Location: Sulawesi tenggara
Characteristic: Four levels house, build with wood construction without using nails.
Material: wood

Figure 51. Buton house (source 26)

(Dewi A, 2003)

ii. Roofing requirements

All the traditional roofing construction is designed to adapt with the climate. All these roofs use natural materials and are built with low-tech equipment. The durability of these roofs is proven to be long, which adds extra value. During the interviews, the inhabitants indicated that the durability is also one of the key elements of a building. For them, their house is their investment.

Roofing requirements
1. The roof needs to be able to collect the rainwater so it can be harvested effectively for further usage.
2. Another option is to make the roof as a buffer to slow down the runoff of the rainwater.
3. The roof should be able to deal with the climate, which means managing the airflow for a good ventilation and dealing with the heat.
4. The materials of the roof should be local material that come from the area and can be processed by the inhabitants themselves.
5. The roof has to use low-tech methods so that the inhabitants can build it themselves.

The subsequent chapter discusses the design concept and demonstrates how to integrate the main architecture element.

Family kos-kosan

Target - This project aims to facilitate the living of small families or starters, focusing on the women and children, whom are the most of the time in and surround the house. Reflecting back to the sixth pain point in the problem statement about the economical issue that is happening in Cigondewah, where people find it hard to find a job and get a proper income. In this case I see the women in this Kampung as a potential to improve their financial situation. These women have the time, the motivation and the skills. The idea is to design a workspace in this housing cluster, where they can do workshops together and create a small handcraft business using the materials that they plant, which are the crops plantation. Furthermore, the disappearance of a water system, the contamination and the water disasters, make the initial relation between people and water become disconnected. (Stokman, 2008) Education about water is therefore essential and should be integrated from a young age. This is why children are becoming agents in this mission. This project should design a space where children can learn, play and connect to water again.

Typology - The typology would not only be housing but a work-live housing. This is inspired by the way of living in Cigondewah, which integrates these two activities in one place.

Program - Compact family houses with an inner courtyard (where the drinking water filter will be placed), workspace, playground, sanitation (toilets and bathrooms) and a kitchen will be the programs in this project.

Site - The ideal situation would be close to an open land for creating plantations, next to the river (in an approach to make a connection between the two RW's through the river, creating a bridge is an option) and next to a public space, since all the children from the neighborhood should be able to use a playground (security gazebo, mosque, football field).

Scale - The housing cluster will be designed for approximately ten families.

Main elements in the project:

- Roof as an overall element covering the entire cluster. This also will be the main construction, with a lighter construction, which defines the spaces underneath.
- Water system
- The vision is to make one example project and slowly apply the concept to the rest of the existing houses. The idea in dealing with the existing houses is first to build a massive roof system above the houses, which will create a permanent protection. This is in order to start the process of slowly transforming the houses to this new concept.

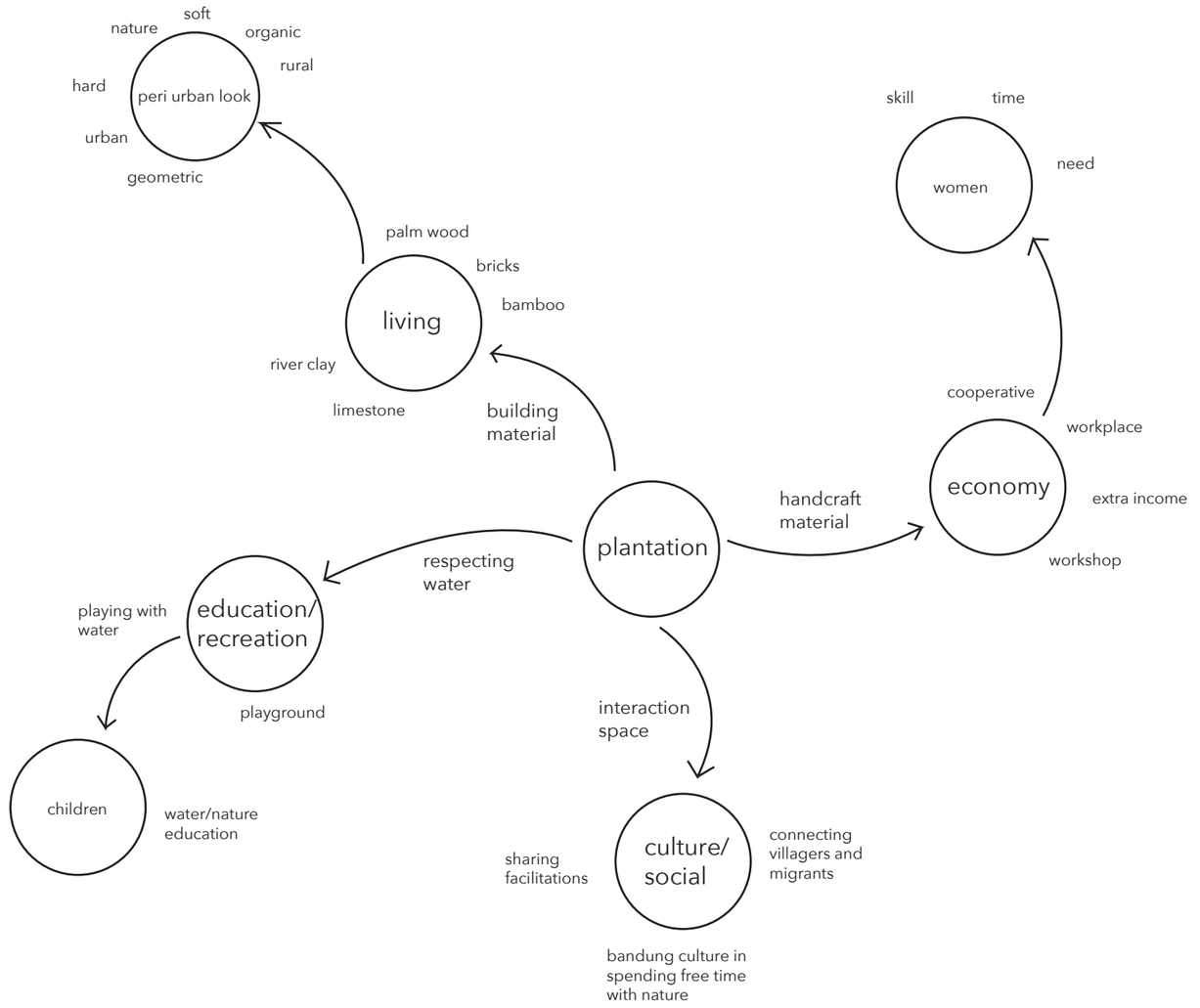


Figure 52. Strategy chain (Own illu.)

Conceptual design

Floorplan

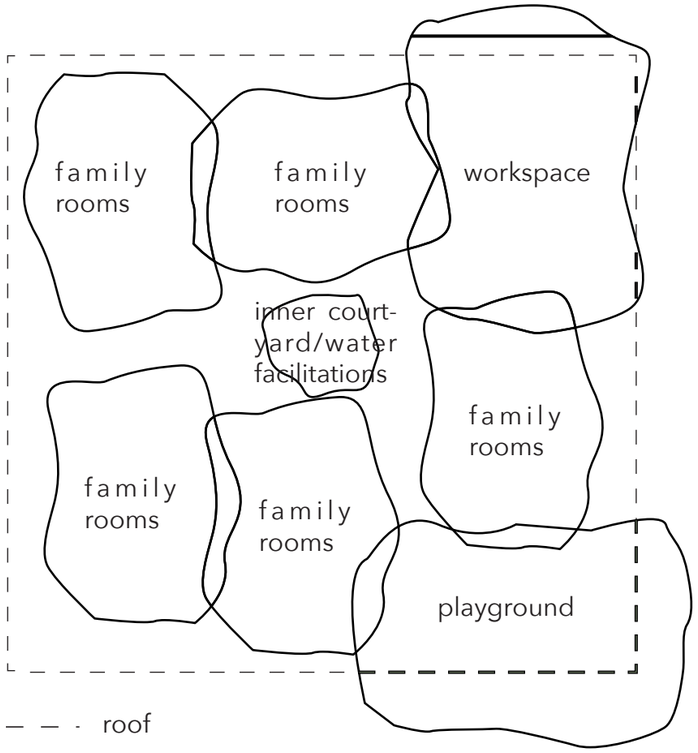


Figure 53. Conceptual floorplan (Own illu.)

Section

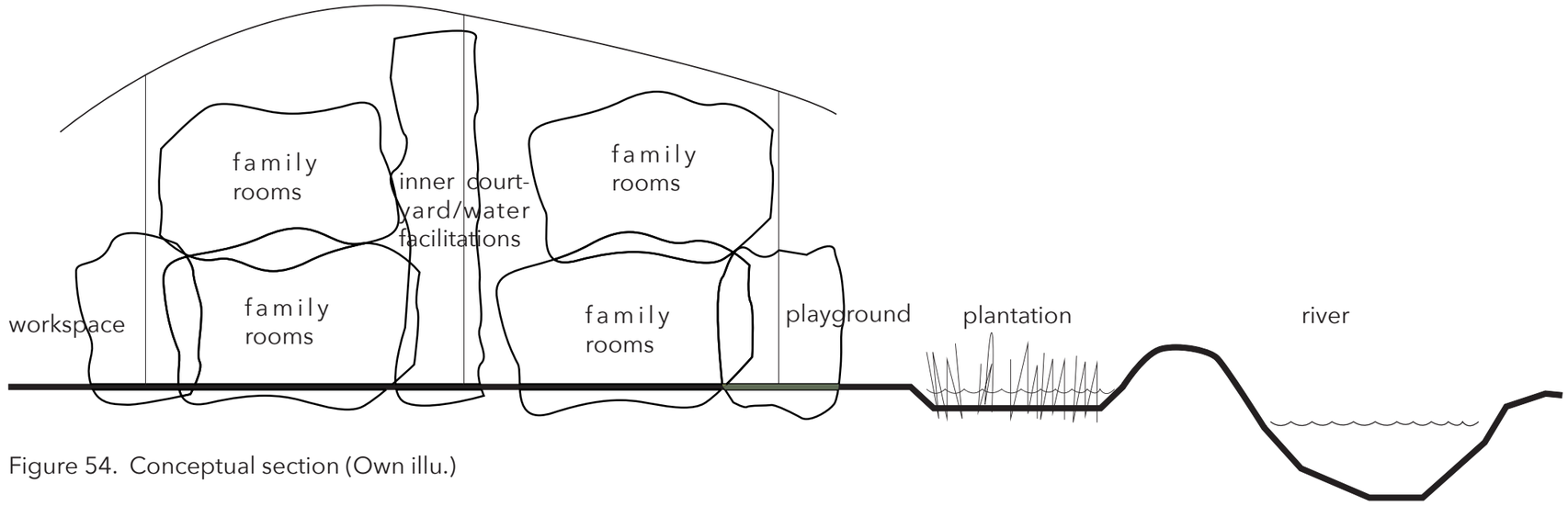


Figure 54. Conceptual section (Own illu.)

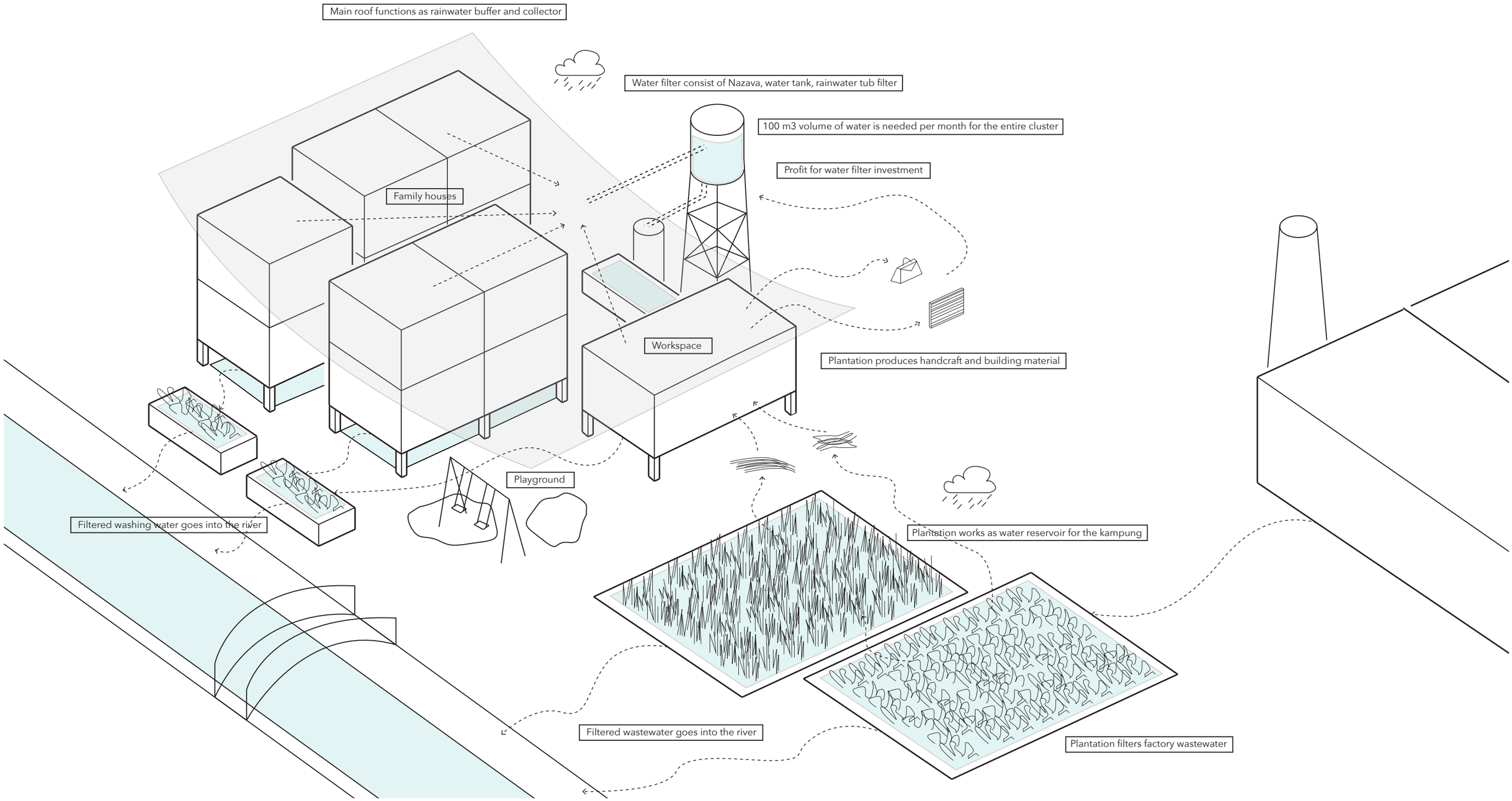
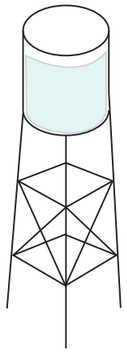


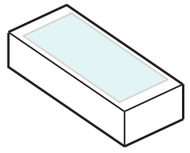
Figure 55. Integrated water system and housing cluster (Own illu.)

100 m3 volume of water is needed per month for the entire cluster

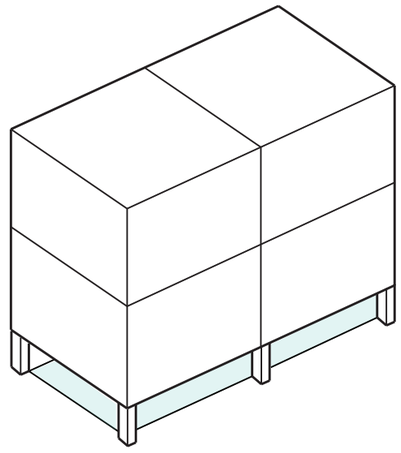


Water tank
that can save water until 30 m3
The water that is saved in this tank will be filtered by nazava to be able to consume

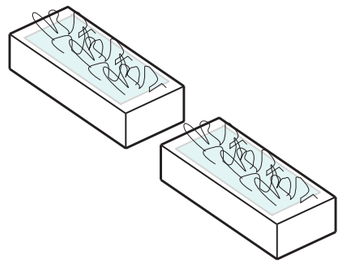
Nazava filter
Is capable to filter 500 L water/hour



Rainwater tub
Is capable to rainwater for bathing and washing usage
5m x 2m x 1m = 10 m3



Water reservoir
The rest of the water amount which is 40 m3 can be stored underneath the lifted houses.
If every two houses has 1 reservoir of 3m x 3m x 1m underneath them, then even 45m3 of water can be stored.



Plant tub
Is capable to filter grey water before going into the river
5m x 2m x 1m = 10 m3
Two tubs = 20 m3

Figure 56. Water system tools (Own illu.)

Conclusion

Cigondewah is a rapidly growing peri urban area that is depending on the textile industries in and around it. The unorganized density and the uncontrolled activities of the factories conduced six pain points for the area; the overexploited ecology, the polluted rice fields, clear water scarcity, the floodings, the lack of income and the unhygienic sewage system.

The intention of this paper is to understand these issues by investigating the current situation, the background of these issues and the potential solution for these issues. Relying on the fact that there is a demand for new housing projects and dealing with the six pain points, this paper answers this thematic research questions: How to use dwellings to facilitate the potential of rainwater as a new water resource in supporting the water management system that can improve the living and working of the kampung?

Firstly, the three case studies result in an understanding about the development of a water system by the growing population. The circular water system that could be found in a rural area will be difficult to maintain in the peri urban phase and cannot be found anymore in an urban situation. The structure and the elements of the water system change as the development is happening. The changing elements are the fishponds, the open land, the water resources and prices, the ecological value and the reaction on natural disasters that are happening these days.

Flooding is one of the natural disasters that often happen in Cigondewah. The second chapter of this paper reveals the explanation of how this can happens in Cigondewah. The influencing aspects are deforesting upstream, lack of water infrastructure, decreased open land, lack of drainage, groundwater extraction, and increased rainfall. To improve people's way of living, some alternatives can be made in dealing with these issues. The flooding relates to behaviors, which could be avoided, buffer, and use and store can be realized in three different scales that complement each other, household, community and public scale.
In the third chapter, the fact that Cigondewah has to have a new water resource, in order to be independent from the contaminated and overexploited water system, became clear. Fortunately there is plenty of rainfall to comply the water necessity of the entire Cigondewah. To realize this idea of using rainwater to improve the water system and different kind of water filters, which can be applied in different kind of scales as well, housing, community or scale, and filtering drinking water but also wastewater. Thus, improvement of people's financial situation and health can be achieved.

Because of the textile industrialization, the rice fields are threatened and badly polluted. The relation between ecology and economy are disconnected. Chapter IV gives an alternative in increasing the ecological value again in supporting the economy. Mendong and Eceng gondok are two potential plants that can filter wastewater and at the same time can be processed for a handcraft or even building material.

Additionally, houses are seen as a potential tool in dealing with the water issue. From this point of view, the roof becomes an important element in the design phase, and has therefore a few requirements such as: harvesting the water, buffering the runoff, dealing with the tropical climate, using local natural materials and should use low-tech building methods.
In conclusion the housing clusters or family kos-kosan (boarding houses) can be a potential to facilitate rainwater as a new water resource in supporting the water management system that can improve the live-work environment of kampung Cigondewah, by integrating solutions based on ecological an economical issues.

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Interview results

Kampung Cigondewah RW 2, Bandung

Figure 52. Ibu Lia and her son (Own illu.)

1. - Name: Ibu Lia, 29 years old.
- Drinking water source and quality: Using water from the mosque that has a deep well going into the ground and saved the water in a tank. The costs divers per month depends on the usage, can be about Rp.30.000-50.000. The collected groundwater water will be cooked and consumed. They think the water will be clean enough to consume if they cook it.
- Cooking water: same as drinking water
- Washing bathing water: Private well that is used for this particular family. If it rains a lot the water is clean, otherwise the water is yellow and it smells. They often feel itches on their skin. There is always enough water but the quality is not so good.
- Rainwater usage: They use rainwater to wash their clothes that they harvest in a bucket. Besides that they never heard about Nazava, only Pure It filter from television. The reason that they don't use Pure It is the high costs of this filter system. Besides that they do not trust a filter only and thinks that they have to cook it again after filtering it.
- Other water usage: Extra water usage for cooking some snacks and making some drinks for the shop.
- Flooding: There are often flooding, the big once comes four times a year. This flooding comes from Cimahi they said. The flooding height is as high as our knee if we stand next to the security gazebo. Their houses are lower than the ground level of the gazebo. So when flooding comes, their houses will be flooded and they have to evacuate their stuff to the security gazebo. Luckily the flood will not last long, it will come at one time and will go again.
- Extra information: She is originally from Garut and used to work for Kahatex, but then married a man from Cigondewah and is now a mother of two children. They live in RT 5 next to the rice fields and next to the security gazebo. She and her family live in the first floor. While the ground floor is used by her mother and sister in law and also for a small shop that sells a few drinks and snacks. Because of the bad water quality of the well, the fact that they see he waste water from the factory is being used for the rice fields next to their house (schema), and the environment that become worst she really want to move out from Cigondewah. The problem is that her husband that does not want that because he does not want to leave his home, where he originally comes from. Her husband works as a textile distributor in and outside Cigondewah. On the other side of the pathway that goes through the rice fields there is convection and a yarn factory. These factories produce a lot of air pollution. This caused lung diseases for almost every child in that RT 5. Their children already got this disease since their young age. Their youngest child got it when she was just 3 months old.
- Sanitation: No septic tanks. The sewage will directly go into the river.
- What about the rumor of Kahatex giving free water facilitation to Kampung Cigondewah?
That is not true. This does not go inside the kampung itself she said. They sometimes give some bonus (money), food or water, but only for the people that are living along the main road, in front of Kahatex. We only get the waste.
- What about the role of the government in developing the living situation of Kampung Cigondewah?
The government does not know anything. As you can see the dam of the river often breaks because of the heavy flooding, she said. This makes them always worried and scared that the flooding will come every time it begins to rain.

Figure 53. Ibu Lia, her son and her neighbor (Own illu.)

2. - Name: Ibu Desy
- Drinking water source and quality: Ibu Desy buys drinking water in gallons that costs Rp.17.000. In one month her family needs 4 gallons. For drinking water they use water from the gallons, while drinking coffee or tea they use water from the groundwater collection from Pak RW that costs Rp.3000/m3. The reason behind this is that they have to cook the water eventually to make tea and coffee so why not using the groundwater because it is cheaper. The total water usage per month for 3 families that lives in the kos-kosan is Rp100.000.
- Cooking water: PAM from Pak RW
- Washing bathing water: Water from the well that has good quality. The water is looks clear. And the well is never dry.
- Rainwater usage: They don't use rainwater. They know about Pure It but do not use it because of the same reasons as Ibu Lia.
- Flooding: she lives at the end of the street where Ibu Lira lives
- Extra information: She is a mother of two who lives in a kos-kosan. She is originally from Cigondewah, also her husband. The reason that she lives in a kos-kosan is the will to live by their selves. Even though her parents lives e few house next to the kos-kosan and has enough space for her family, she prefers to live independent in a small kos-kosan room from 3x4.

3. - Name: Ibu kos-kosan owner
- Drinking water source and quality: Aqua, everybody buys their own drinking water. (Rp.17.000 per gallon)
- Cooking water: The workers that live in the kos-kosan
- Washing bathing water: Water comes from the well that is located next to the rooms. She said that the water quality are pretty good, but she was telling that the well next to her well is not clean, and the quality is bad and is definitely not hers. The water is pumped up with Jet Pump.
- Rainwater usage: She doesn't use rainwater at all.
- Extra information: she owns a few kos-kosan rooms that are located in a small alley in front of other kos-kosan with 1 m or less distance. This makes the kos-kosan pretty dark and humid. The rent for one room is Rp.400.000 and every room has its own bathroom.

Figure 54. Ibu Lira and her husband (Own illu.)

Kampung Cigondewah RW 12, Bandung

Figure 55. Ibu Siti and her husband (Own illu.)

4. - Name: Ibu Lira Herniawati
- Drinking water source and quality: She buys her drinking water; she said a gallon of water costs Rp.4000. In one week her family uses approximately 3 gallons, so Rp.17.000/week.
- Cooking water: The water that is used for cooking is the same they use for drinking. So the price above is already included with the cooking.
- Washing bathing water: For this need they use the water form the well. This well of 10 meters deep is once built by someone in the kampong but is now used for many houses around this well. The quality of the water from the well is bad. The water is constantly yellow and it smells. Next to the well there is a tub where the water is filtered with waste textile. This is done so the yellow substantial can be separated from the water.
- Rainwater usage: They never use rainwater
- Flooding: often happens, skin itches and diarrhea.
- Extra information: Ibu Lira is originally from Garut but already lives there for a long time with her husband that works in convection outside of Cigondewah. She herself does not work; she just stays home taking care of the children. She said she really wanted to work but doesn't have the skill. She said that people from outside Cigondewah that moves here take all the good work. This is because people from outside Cigondewah mostly finished the SMA degree that is needed for the factory work, while the originally inhabitant of Cigondewah doesn't have the money to be educated until SMA.

5. Name: A couple named Siti and Eden that lives in a kos-kosan room in RW 12 near the bridge.
- Drinking water source and quality: They buy their own drinking water; the price is Rp.5000/gallon. They consume 2 gallons/week.
- Washing bathing water: The kos-kosan has its own well that they use to wash clothes and to bath.
- Rainwater usage: not using rainwater
- Flooding: flooding often happens. The last flooding also broke the river dam. But the kos-kosan itself has 2 stores, so maybe it helps.
- Extra information: This couple comes originally from Garut. Siti works in Kahatex and Eden works in a plastic factory outside Cigondewah. The kos-kosan room that they live in costs Rp.450.000/month this is including the well water that each person uses. The two man that sit next to them also live in the kos-kosan and works in Kahatex. They tell us a little bit about the situation in Kahatex factory. She said that the climate inside is warm, a lot of dust, and a lot of noise. But for the noise they each get equipment for that.
- Sanitation: There are 4 toilets in total that is used by 12 rooms. Two families use two rooms and the rest are still single.

Kampung Taman Sari, Bandung

Figure 56. Ibu Euis and her husband (Own illu.)

Figure 56. Ibu Li (Own illu.)

1. - Name: Ibu Euis and Pak Bambang (house are located on the upside of the kampong near to the main street)
- Drinking water source and quality: Boiling water from the well, 2 m deep. The water from the well is being tested by the Puskesmas once in a few months. In 1976 they had a spring near their house but now it is already polluted that's why they change to the well. They said the rest of the neighborhood buy clean water from PAM, refill filtered water for Rp. 6000 or aqua for Rp. 12.000-14.000
- Cooking water: groundwell
- Washing bathing water: groundwell
- Rainwater usage: They don't use rainwater because it contains salt and it feels slippery on the skin.
- Other water usage: This family also has 2 extra persons living with them in the kos-kosan that also make use of the groundwell. Besides the kos-kosan she also uses 1000 l water/day for the laundry business that they have.
- Flooding: There are no flooding, the water goes to Saluran Cikapundung, to other places.
- Extra information: The mayor of Bandung, Ridwan Kamil is planning on a row house and a water park on the riverside called Taman air Tirta wening.
- Total usage: This family uses 500 l water from the groundwell per 2 two days. The water will be pumped up to the tank.
- Sanitation: There is closed sewage with big pipes that is under the ground and goes in to the Cikapundung River. The open ditches that we see are to collect and channeling the water to the river.

2. - Name: Ibu Li (house are located on the riverside)
- Drinking water source and quality: PAM that costs more than Rp.100.000 per month. This costs includes drinking, cooking, washing, bathing. Sometimes they also use aqua to drink. The groundwell water is already heavily polluted, it has a black color and it smells badly. One groundwell used to be facilitating 4 families.
- Cooking water: PAM
- Washing bathing water: PAM
- Rainwater usage: No using rainwater
- Other water usage: -
- Flooding: There are no open ditches to accept the rainwater and all the path-ways are covered with concrete so no absorption. With also the situation of the neighborhood that is lower than the rest of the kampung this neighborhood gets all the water from the upper neighborhood. Flooding often happens, water goes inside their houses.
- Extra information: Dengue disease often happens, but the government helps a lot by sending help from Puskesmas
- Sanitation: There is closed sewage with big pipes that is under the ground and goes in to the Cikapundung River.

3. - Name: Ibu Etti
- Drinking water source and quality: Filtering the rainwater with Nazava filter. Now she doesn't need to buy aqua anymore.
- Cooking water: Filtered water
- Washing bathing water: PAM
- Rainwater usage: To drink and to cook
- Flooding: same as Ibu Li
- Sanitation: same as Ibu Li