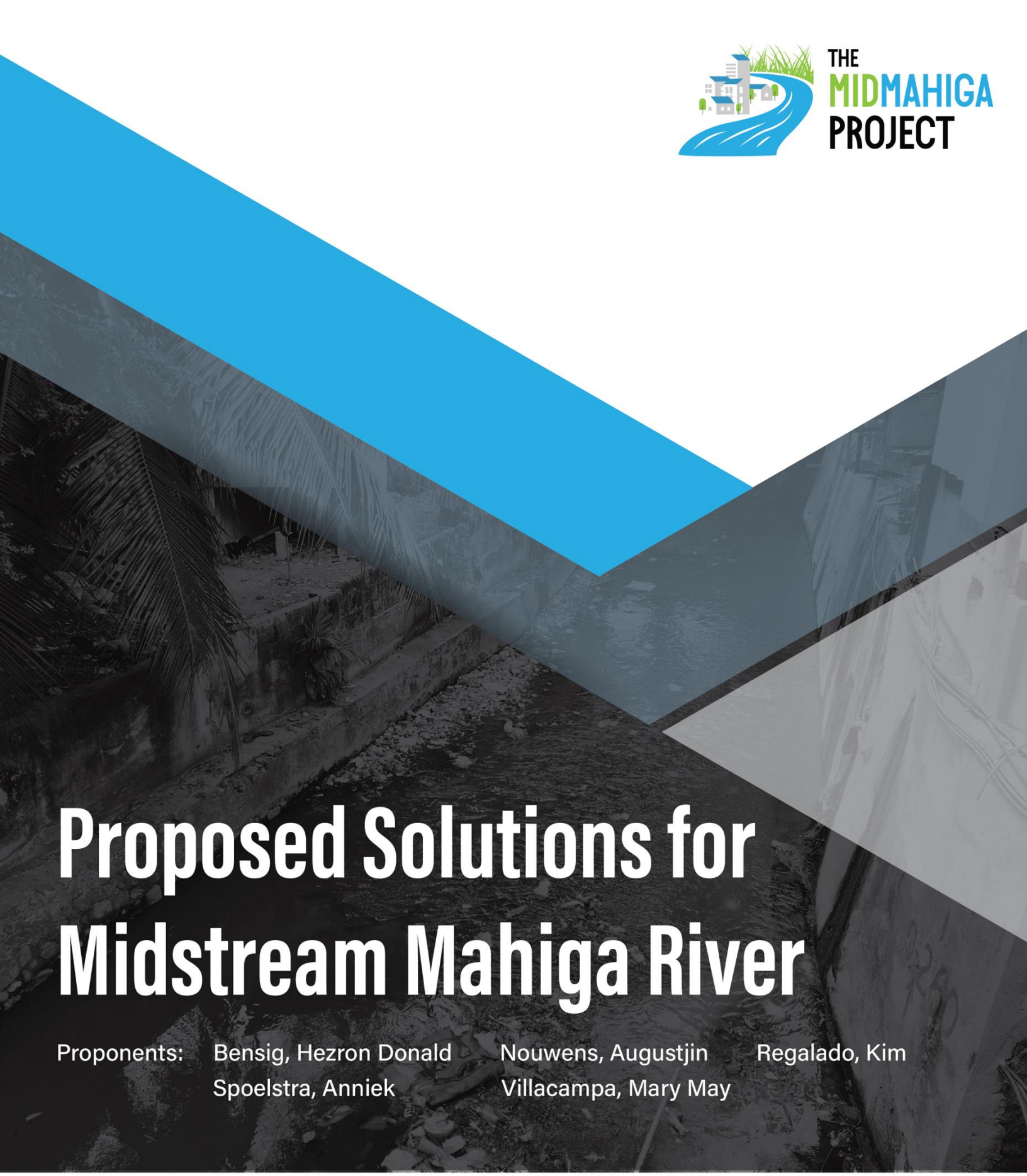
THE MIDMAHIGA PROJECT



# Proposed Solutions for Midstream Mahiga River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# CHAPTER 1
# INTRODUCTION

In the metro Cebu city there are a lot of rivers streaming through the city. It prevents clean water but at the moment they are polluted, that is a problem for the area. At the time buildings stand next to the rivers. So with heavy rainfall the water runs off to the river. The river gets shallower and the garbage also shallows the streaming area of the river. The focus in this report is on the Mahiga river.

Mahiga river is a prominent urban river with an upstream located at the Banilad mountains, down to Subangdako as its midstream and downstream at Mabolo Reclamation Area. The river starts in the mountains at a height of 356 metres. The river has a total length of 9.1 km which traverses six barangays from Cebu City to Mandaue City namely, Apas, Banilad both in Cebu and Mandaue City area, Kasambagan, Mabolo and Subangdako and this waterway ends up at the Mactan Channel. The river used to be a source of water for bathing and laundry of the local residents in the area. Due to the discharge of domestic wastewater and solid wastes, the river has become heavily polluted over the years. In 2018, the Mahiga River was considered to be biologically dead.


*Figure 1.1 The Mahiga Stream Between Cebu and Mandaue city*

A comprehensive rehabilitation program was implemented by the Department of Environmental and Natural Resources (DENR) in 2020 where a one-year memorandum of agreement was signed between the local government units of Mandaue City, Cebu City, 28 private companies, and six barangays where the river traverses to reduce the pollution in the Mahiga River and its tributaries under the Adopt-an-Estero/Water body Program. The local government units of Cebu City and Mandaue City continue to implement river rehabilitation activities to this day to clean up the Mahiga River.

## 1.1 BACKGROUND OF THE STUDY

Due to the arising pollution issues of several major rives in Cebu City and Mandaue City, several proposals have been planned to revive these bodies of water. TO help resolve and participate on this environmental concern, student from the Netherland and the Philippines are collaborating to resolve this long-drawn out issue. This project will be providing rehabilitation solution to the creeks and river of Cebu City and Mandaue City. Moreover, the project is divided into areas due to the large scope and its complexity. Specifically, the team will focus on the issues on pollution concerning the midstream section of the Mahiga River, encompassing Cebu City and Mandaue City. This project is conducted through a collaboration of Dutch student from the Rotterdam University of Applied Sciences and Hanze University, and Filipino students from the University of San Carlos. Lastly, this project is done in collaboration with the Cebu City Environment and Natural Resources Office (CENRO) and other participating LGU's (Cebu City and Mandaue City).

## 1.2 PROBLEM STATEMENT

The Mahiga Creek is one of the many small rivers that flow through Cebu City and Mandaue City. These small flows often have no clear origin and usually flow from a higher point to a lower point. The river originates at two points and converge in a larger river that ends in the Mactan Chanel. Several attempts have been made by the government to clean up the river, such as clean-up campaign, in which about 50 tons of waste was collected. Unfortunately, such measures since among of the main problems - illegal settlements and dumping of waste, have not been solved.

## 1.3 OBJECTIVES

Currently, the Mahiga creek has two major problems, and these are the high level of pollution in the water and the flooding that happens when it rains too hard or for too long. The aim of this project is to give this river a new life by coming with new innovations that can help solve the problem of the pollution and flooding. Specifically, this project aims to:

- Raise awareness among the residents of how one's action can cause the whole ecosystem and quality of life to fall apart. Hence encourage the residents to work together with the government so that they can improve the quality of life and ecosystem of the river.
- Present detailed solutions in two different infographics, that shows where in the river the solution should be applied,
- Identify the cost of the project and who are involved in the realization of this project.

## 1.4 GLOBAL QUESTIONS

To help resolve the issue and suggest solution, the following main questions wished to be addressed in this project:

1. How can the water quality of the Mahiga river be improved?
2. What is the behavior of the residents?
3. What is the role of the government in this project? How much can the government afford?
4. What solution can be applied here in the Mahiga creek to create a better-quality water?

# CHAPTER 2
# PROPOSED SOLUTIONS

In this chapter the solutions for the problems in the river will be explained. The group focused on different solutions which can be combined to a great solution for the entire midstream. We limited ourselves to a solution to raise social awareness as a social solution. For the technical solutions we took a look at a drainage outfall and a wastewater treatment system.


*Figure 2.1* *Core Concerns*

In a PowerPoint of the DENR these different concerns are given. We based the solutions on this model that has been given by the environmental bureau.

## 2.1 SOCIAL AWARENESS

The problems in the area can't be fixed in just one solution. That's why the solution for Social Awareness can be related with one of the other solutions. The goal with this solution is to prevent the residents to throw their waste in the river or on the streets. So, the environment gets cleaner and the river just exist with water and no plastic.

The problems in the Mahiga river are bigger than just the river its selves. It is also not possible to just solve them by yourself. With the social awareness solution, the idea is that the people start by themselves and inspire change for the whole community. Also, for the governments in the area it is important that they can start with preventing the river pollution. For example, make the problem signific for different groups in the area and to make the infrastructure of the water better. To relocate the informal settlers who live next to the rivers.

The solution is parted in two posters. One poster is for the government to spread among the public space and the public buildings. So not only the residents and informal settlers have the information but

other stakeholders also get the correct information. The other poster is a simple figure to show the residents the concerns and what they can do about it. This can prevent the river from further pollution.


*Figure 2.2 Sample Poster for Social Awareness*

In the poster above the poster is shown for the government in the area of the Mahiga stream. The information about the river is given and the current help from the government. Also, the government from Cebu and Mandaue city did some measures in the area already. The government organizes clean up days. So, they want to clean and prevent the area from more waste.

Further on the poster are solutions for pollution in the area, advice is placed on the poster to help and get a cleaner river.


*Figure 2.3* *Sample Poster for Social Awareness*

Above the posters for the residents. These are in English and in Visayan so everyone can understand the goal of the poster. It is simple to understand and can be an eyeopener for the residents.

## 2.2 CENTRALIZED TOILET ROOMS WITH RAINWATER HARVESTING SYSTEM

### 2.2.1. Design of the Solution

The river experiences a lot of problems and issues including flooding, solid waste, informal settlements, and poor water quality. According to the recent data gathered by DENR-Cebu, the fecal coliform content of the river is on its critical level with 18, 780, 367 MPN/100 ml.

The people living in the area have no proper sewage system or worst have no own toilet rooms in their houses. The river even served as their own toilet rooms and the one who received all the sewage from their own make-up septic tanks.

*Figure 2.4 Wastewater coming from household directly goes into the river*

In order to address the fecal coliform situation in the river, the team decided to propose this project which provides toilet rooms with proper sewage system to the community, this project is inspired by the Sani-Embankment project in Davao City. These toilet rooms will also have a rainwater harvesting system in which the rainwater harvested will be the source of water for the toilet rooms. Since, the sani-embankment project needs a large area to realize, the group decided to only provide Centralized toilet rooms with own rainwater collection system for the community.

The idea of this proposal came from two main facts gathered, the fecal coliform from the recent data from DENR- EMB is uncontrollably rising and the flooding in the area.

The flooding in the area as mentioned is also a major problem not just in the barangays nearby Mahiga but also the neighboring barangays. Together with these toilet rooms, rainwater harvesting system will also be installed. Rainwater Harvesting System is a technology that collects and stores rainwater for human use, instead of allowing it to run off and contribute to the flooding in the area, the rainwater will be of use. Rainwater harvesting systems range from simple rain barrels to more elaborate structures with pumps, tanks, and purification systems.

Private Establishments are also encouraged to install Rainwater Harvesting Systems in their own for them to help in mitigating the flood in the area given the large area they are occupying. However, further studies must be conducted to conclude if this rainwater harvesting system will be sustainable in the area.

Sufficient data such as, roof area, rainfall data, water demand, flood data etc. are needed to come up to a conclusion.

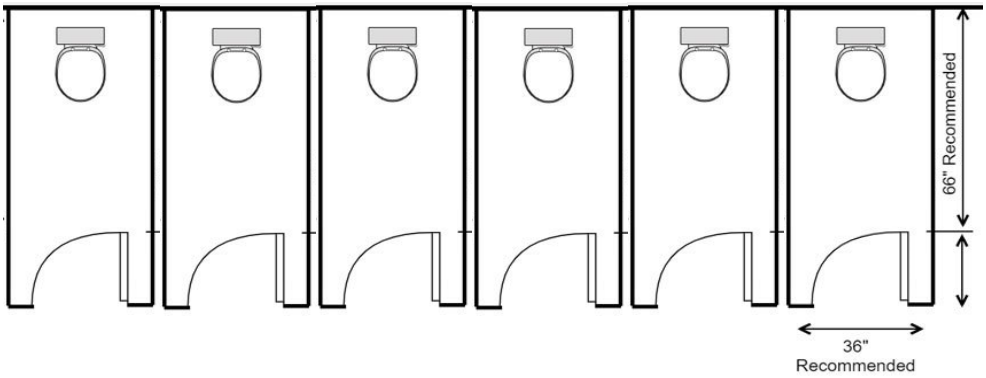



*Figure 2.5* *Floor Plan of the Centralized Toilet Room with Six Cubicles*

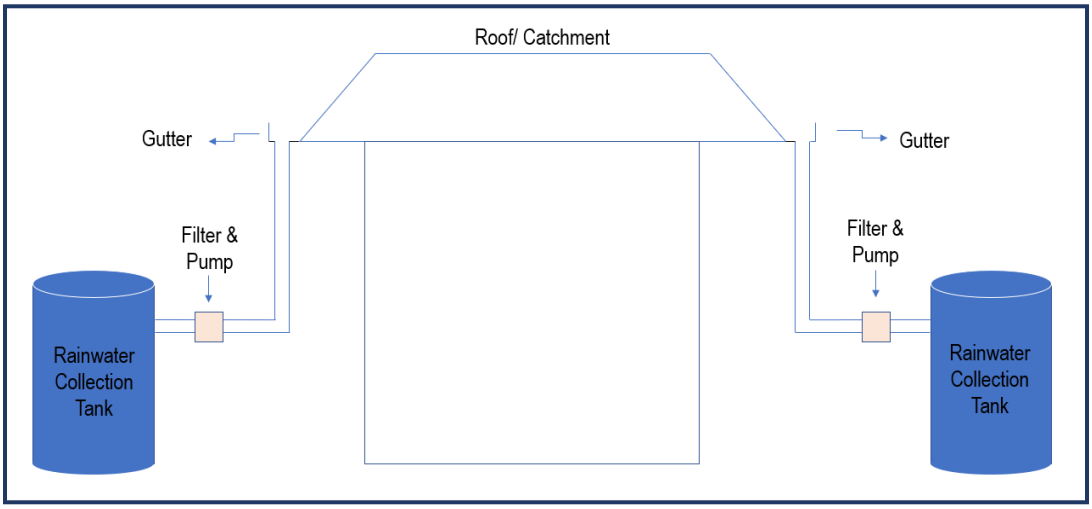



*Figure 2.6* *Schematic Diagram of Rainwater Harvesting System*

### 2.2.2. Location of the Analysis

#### 2.2.2.1 Location in the River where the Project will be Placed

The midstream section of Mahiga River crosses the barangays of Kasambagan and Banilad in Cebu City and Banilad in Mandaue City. As of 2015, Brgy. Kasambagan has a population of 8, 428, Banilad in Cebu City with 7,890 and Banilad in Mandaue City with 22, 771. With the Land cover map of these areas last 2015 (figure 4), retrieved from Geoportal Ph, these areas are built ups or an urban area where establishments and communities were situated.

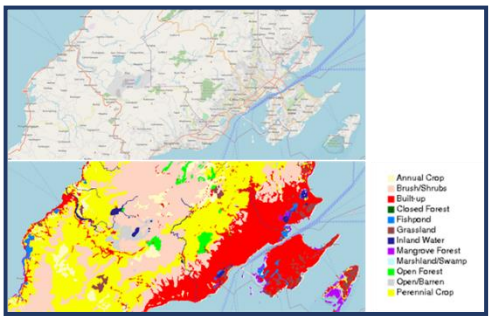



*Figure 2.7* *Land Cover Map of Brgy. Kasambagan & Brgy. Banilad*

Percentages of these population have no own toilet rooms and no proper septic tanks for their waste. This is why untreated wastewater pollute the river, not to mention other private establishment who disposes their untreated wastewater to the river.

The 2- km midstream of Mahiga river comprises the barangays of Kasambagan and Banilad in Mandaue and Cebu City. Four sets of toilet rooms and washrooms will be provided in each purok or in every 500-meter distance within the 2-km midstream.

### 2.2.3. Cost Benefit Analysis

#### 2.2.3.1. Cost of the Project

The factors affecting the cost of this project includes the construction materials, the excavation needed, and the survey done before realizing this project. The costing of this project is lesser than the Sani-Embankment project in Davao which costs 300M. The estimated cost of this project will be 6M-7M and with the installation of rainwater harvesting system which costs Php 400,000- 600,000 each depending on the tank size. So, the project will have a total estimated cost of 9M to 10M.

### 2.3.2 Funding of the Project

Cebu City and Mandaue City being the main affected areas for this environmental concern, both LGU's shall cooperate and agree with each other to initiate the funding of this project. Private partners or establishments in the nearby area can also be tapped in this project since this can greatly help the affected area.

## 2.4 Planning

### 2.4.1 Process of Implementation

Before the final planning, designing and construction of the said project, a survey of the community should be conducted on site and further studies should be conducted with regards to the sustainability of the project proposed.

Once this proposed plan is already backed up with sufficient data, final planning will now be done and orientation with local officials and the community should be done simultaneously.

## 2.5 Stakeholders Involved

This project is not just care of the LGU, private establishments, and the government but also a unified effort of all the residents. Since all are contributing to the problem and as part of the problematic system, taking part of the solution is necessary. At the end of the day, all the residents will all be benefiting with the project and in the long run, the good effects will spread like a wildfire, it just takes a single step.

## 2.6 Operation and Maintenance

### 2.6.1 Responsible Individuals

In the funding of the project, the LGUs and private establishments could take part in it. With the operation and maintenance of the proposed project, the community should have a system in which groups of people are assigned to maintain the cleanliness of the area. Furthermore, the maintenance of the toilet rooms, reports from the residents or site visit should be done in barangay levels.

## 2.3 PHYLOREMEDIATION

One of the main problems in the Mahiga River is the water quality. In a report by Pepito (2020), the physicochemical properties of the water in the river such as dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform were tested. Both the BOD and the fecal coliform test did not pass the criteria for good water quality according to Department of Environment and Natural Resources (DENR) standards.

The water quality problem may be remediated with the use of phytoremediation technology where plants are used to efficiently remove inorganic and organic pollutants in contaminated soil or water. This technology has been accepted in the past years as a more cost effective and noninvasive way to clean environmental contaminants (Pilon-Smits, 2005).

### 3.2.1. Design of Solution

There are a variety of plant species that can be used for phytoremediation. Several studies on wastewater treatment using water hyacinth (*Eichhornia crassipes)* have been published, however it is also considered to be the world's worst invasive plant species due to its fast-growing nature. It can form thick layers over the water which outcompetes native aquatic species, depleting the amount of dissolved oxygen in the water.

Water hyacinths can be planted in a controlled environment to avoid forming dense colonies. A study by Napaldet, J. & Buot, I. (2019) used water hyacinth, spiny amaranth (*Amaranthus spinosus),* Indian goosegrass (*Eleusine indica),* and elephant grass (*Pennisetum purpureum)* to treat the water quality of Balili River in Benguet, Philippines using a pilot-scale constructed wetland. The study shows 96-99.9% reduction in TSS, 87-95% in BOD, and 99% in total and fecal coliform.

#### 3.2.1.1. Wetland Plants

The plants to use for the constructed wetland are locally available plants in Mandaue City and Cebu City: water hyacinth (*Eichhornia crassipes),* spiny amaranth (*Amaranthus spinosus),* Indian goosegrass (*Eleusine indica),* and elephant grass (*Pennisetum purpureum)*. These plants are selected by their phytoremediation potential, dominance, high biomass, and deep root systems. Moreover, they are common plant weeds which makes the acquisition of such not a problem.

*Figure 2.8 Spiny Amaranth (Amaranthus spinosus).*

*Figure 2.9. Indian goosegrass (Eleusine indica)*

*Figure 2.10 1* Figure 3. Elephant grass (*Pennisetum purpureum)*

*Figure 2.11. Water hyacinth (Eichhornia crassipes)*

### 2.2.1.2. Constructed Wetland

Constructed wetlands use the natural processes involving an artificial wetland vegetation to treat industrial or municipal wastewater, greywater, or stormwater runoff. It consists of a shallow depression in the ground where the flow of water is controlled to spread evenly among the wetland plants. The wetland plants filter suspended solids and absorb organic materials as nutrients (National Small Flows Clearinghouse, n.d.).

The main components of a constructed wetland wastewater treatment system include a septic tank, which provides primary treatment by removing the settling solids and floating solids from wastewater, and a constructed wasteland for secondary treatment. This paper introduces the design of a horizontal flow constructed wasteland (HFCW) where a multilayered substrate is to be structured for an efficient hydraulic performance and pollution removal.

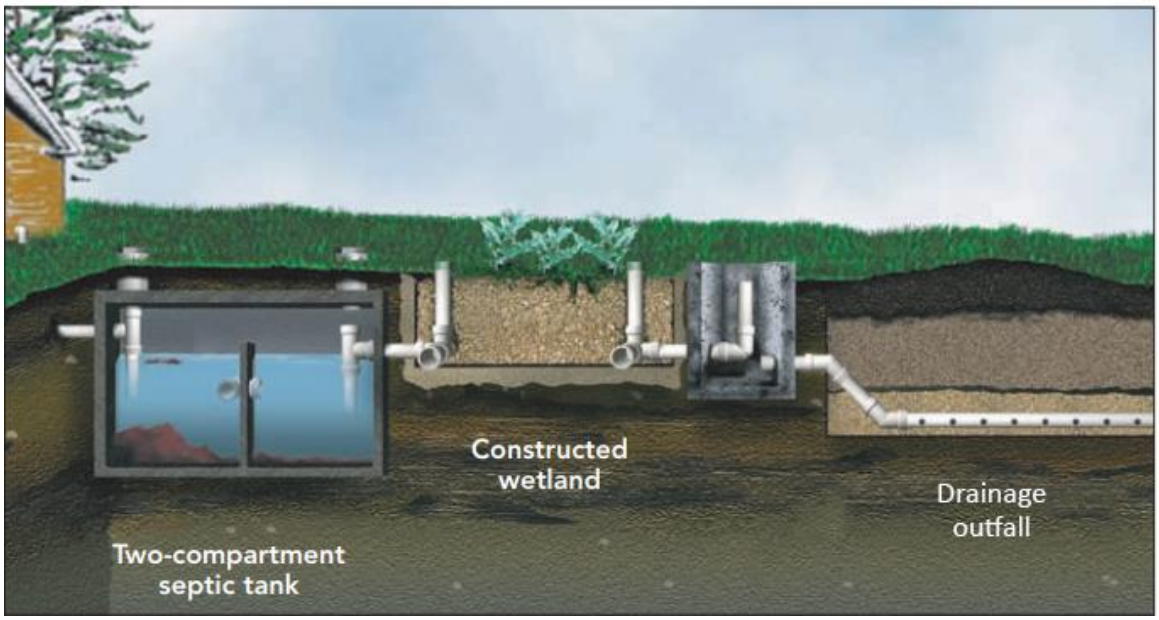



*Figure 2.12* *Constructed Wetland System*

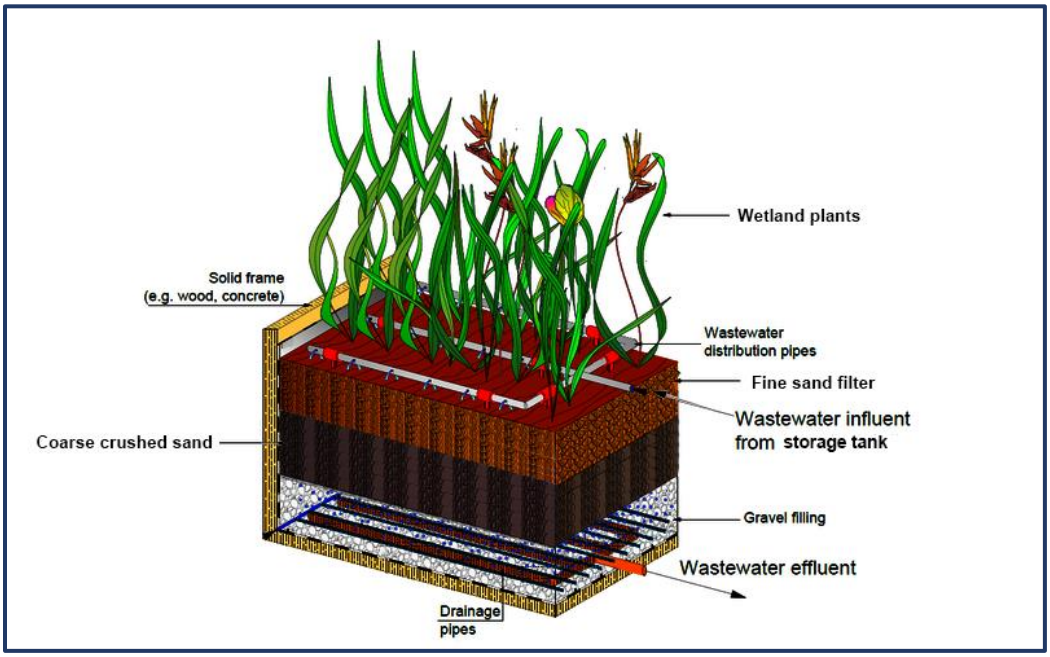



*Figure 2.13.* *Horizontal flow constructed wasteland design.*
*Adopted from Napaldet, J. & Buot, I. (2019).*

The design for HFCW is to be adopted from the study of Napaldet, J. & Buot, I. (2019), the wetland measures 2 m long x 1.2 m wide x 0.8 m deep with the main substrate zone. It consists of three layers namely fine river sand, coarse-crushed sand and 3/4'"-size gravel. Each layer is 20-cm deep for a

total of 60 cm depth and is arranged at increasing particle size at greater depth. The 3/4'"-size gravel formed the bottom layer, followed by coarse-crushed sand and fine river sand on top. Influent distribution zone and the effluent collection zone is also installed having identical dimensions of 20 cm x 120 cm x 60 cm (length x width x height) and consist of 1"-size gravel. The water level in the HFCW should be kept 2 inches below the surface to control or eliminate odor.

From Figure 4, the domestic wastewater will be stored in a septic tank for primary treatment and flow into the HFCW for a secondary treatment. A five-day hydraulic retention time (HRT) treatment is to be adopted before treated water is discharged in the local drainage outfall. However, the dimensions of the HFCW can vary as the relationship between the amount of water stored and the HRT determines how much surface area the system needs.

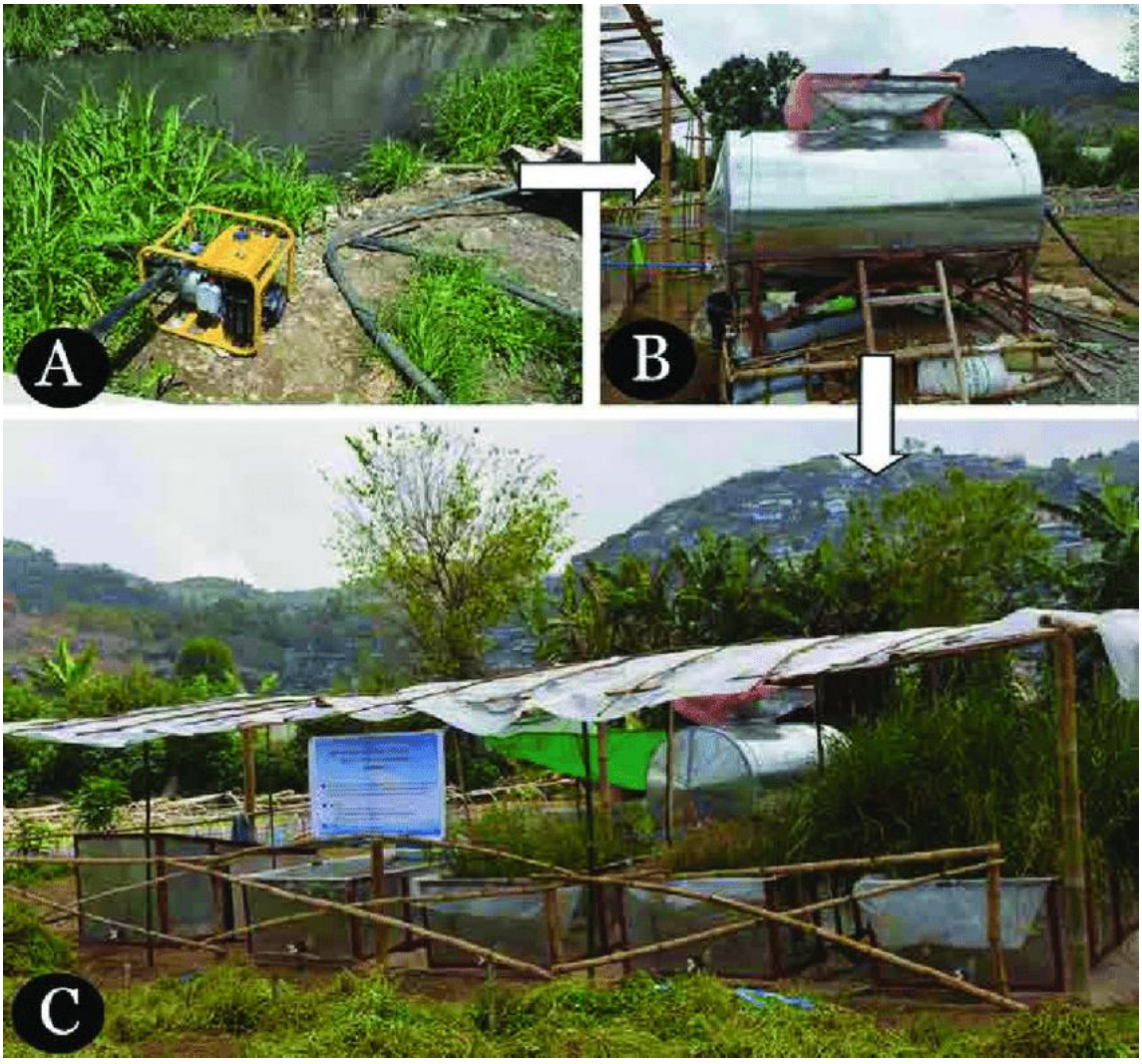



*Figure 2.14. Setup of a constructed wetland system in Balili River, Benguet. Photo by Napaldet, J. & Buot, I. (2019).*

Figure 2.14 shows a constructed wetland system in Balili River, Benguet. The CW system is in a controlled environment to test each plant's efficacy of reducing water pollution. However, the proponents of this paper suggests the use of concrete blocks (as shown in Figure 2.15) to avoid corrosion problems and to make the design more sustainable.

*Figure 2.15.* A constructed wetland made with concrete blocks. Photo by WWF-China/Chen Chan.

### 2.2.2.1. Constructed Floating Wetland

A further treatment of the water quality is to be done in the Mahiga River by the use of a constructed floating wetland (CFW). The CWF is to be made with PVC pipes to provide buoyancy and have the plant shoots grow above the water and plant roots underwater. The CFW is to have a dimension of 1 m x 1 m to consider the varying width of the Mahiga River.

*Figure 2.16.* Design of constructed floating wetland adopted from Chen, Z. & Costa, O. (2020).

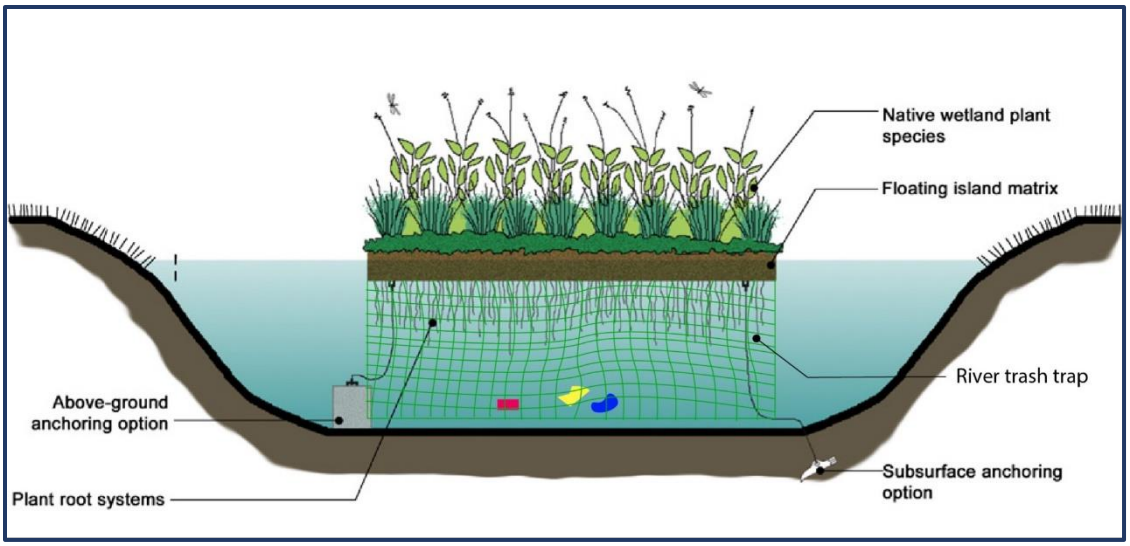



*Figure 2.17. Schematic diagram of constructed floating wetland adopted from Tanner, C. et. al. (2011)*

The CFW is anchored to the river bed to prevent getting washed away by strong currents. A trash trap is also attached in the CFW to capture the garbage before it flows further down the river. The trash trap is detachable for easy emptying and maintenance.

### 2.2.2. Location Analysis

#### 2.2.2.1. Horizontal Flow Constructed Wetland (HFCW)

The HFCW is to be placed at an area close to drainage outfalls along the Mahiga River. The wastewater will be diverted into a septic tank for primary treatment and will pass through the HFCW before it will be discharged to the river. Each barangay or purok has at least 1 drainage outfall and it is recommended to have the HFCW at each area.

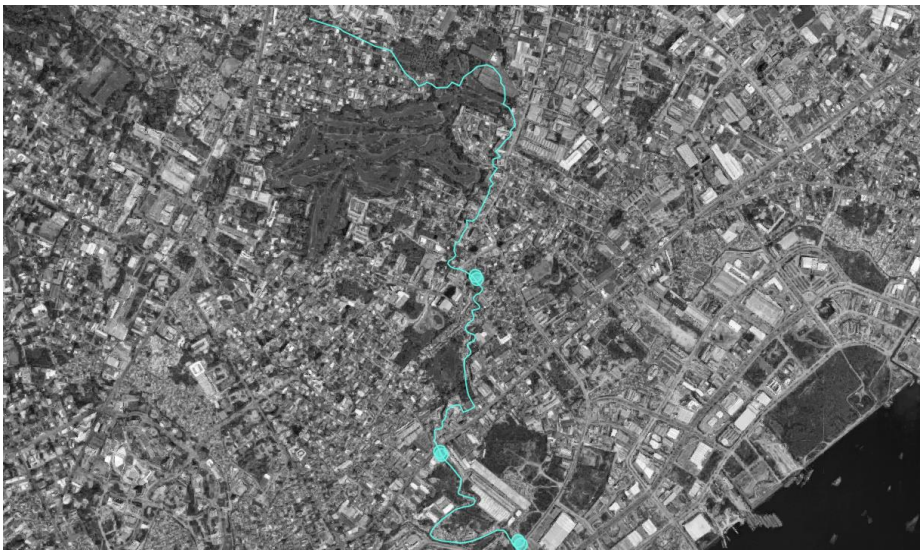


*Figure 2.18. Location of drainage outfalls identified by Mandaue City government. The area has more drainage outfalls that are not indicated in the figure due to lack of data.*

#### 2.2.2.2. Constructed Floating Wetland (CFW)

The CFW is to be placed at the Mahiga River, spaced at least 5 meters apart to avoid obstruction of the water flow but still able to have the phytoremediation process.

*Figure 2.19. Recommended spacing for the constructed floating wetland.*

### 2.3.3. Cost Benefit Analysis

#### 2.3.3.1. Cost of the Project

The project under consideration would provide an alternative method for domestic wastewater treatment in the communities along the Mahiga River. While it would provide an effective way to improve the water quality, it also acts as a project to beautify the river and revive and encourage the growth of local flora and fauna.

| Particulars | Total |
|---|---|
| Horizontal Flow Constructed Wetland (per 5 units) | |
| Concrete frame | Php 16,500 |
| Distribution & drainage pipes | Php 10,000 |
| Aggregate filter | Php 7,000 |
| 1000-L Settling & storage tank | Php 15,000 |
| TOTAL | Php 48,500 |

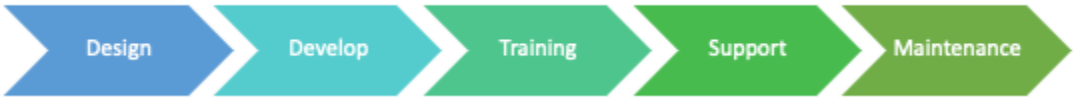
| Constructed Floating Wetland (per 1 unit) | |
|---|---|
| PVC frame | Php 2,000 |
| Floating island matrix | Php 800 |
| Trash trap | Php 300 |
| TOTAL | Php 3,100 |

Considering the 2-kilometer length of the midstream of Mahiga River, the total cost for the CFW would be Php 1,240,000. This will cover the whole span of the midstream where CFWs are spaced 5 meters apart. Assuming that there are a total of 8 drainage outfalls in Brgy. Kasambagan and Brgy. Subangdaku, the cost for the HFCW would be Php 388,000. This cost does not include the land space for the HFCW treatment system.

#### 2.3.3.2 Funding of the Project

The MidMahiga Project applies the principle of co-financing the proposed constructed wasteland wastewater treatment system between the different government bodies involved in this project. It will include cooperation and funding between the local governments of Cebu City, Mandaue City, and the Department of Environment and Natural Resources - Environmental Management Bureau Region 7 (DENR-EMB 7). It is therefore important that the proposed organizations and offices make some contributions towards the operational costs of the project. Moreover, fundraising activities are encouraged to provide further funding in the maintenance of the project. Fundraising activities such as "Run for River" have been used in the past, such as in Pasig River, which provided not only funding for the clean-up and rehabilitation, but also raised awareness in the community.

### 2.3.4. Process of Implementation




The implementation of this project starts with design where a design appropriate for the site area would be made. The design is not only limited to the technical specifications of the CW wastewater treatment system, however it also includes the design of project goals, strategy, and budget. The second stage of the process of implementation is the development of the project where resources would be gathered, including manpower and materials, for the construction of the CW. The next stage includes training of people involved in the operation and maintenance of the project. After which, the support of the community is needed for the success of the project. Lastly, maintenance of the CW is needed for a long service life and sustainability of the project.

### 2.3.5. Stakeholders Involved

The main stakeholders involved in this project are the local government units of Mandaue City and Cebu City, and the DENR-EMB 7. Moreover, its secondary stakeholders are the barangays along the Mahiga River, namely Brgy. Kasambagan and Brgy. Subangdaku, the business establishments that discharge their wastewater on the river, and the local community along the river.

### 2.3.6. Operation and Maintenance

#### 2.3.6.1. Responsible Individuals

The LGU Mandaue City and Cebu City as well as the DENR-EMB 7 are responsible for the development of the project. For the operation and maintenance of the constructed wetlands, this will be done by the Barangay Environmental Officers (BEO). Maintenance of the CFW can also be done by the local residents in the area.

#### 2.3.6.2. Maintenance Activities

Maintenance activities of the project include weekly collection of garbage from the trash traps as well as maintenance of the wetland plants in the CFW are to be done by the. The HFCW should be inspected every six months which includes cleaning pipes and filters, pulling out undesirable plants, and replanting if necessary. Septic tanks should also be inspected every three to five years, depending on the tank size. Pumps and pipes associated with the system should be checked for any leakage.

## 2.4 WASTEWATER TREATMENT PLANT

The main function of a wastewater treatment is to speed up the natural process by which water is purified. Wastewater treatment mainly includes three treatment processes: primary (which focuses on the settlement and removal of larger wastes), secondary (which uses biological process to further purify the wastewater) and tertiary (which include disinfection of water from remaining contaminants. The detailed process is discussed in the later section.

Aside from water discharged from sanitary pipes from residential and commercial buildings, waste water also includes storm run-off, and even harmful substances that may be washed off from roads, parking lots and roof tops which can contaminate and contribute to the pollution on the natural bod of water.

### 2.4.1. Design of the Solution

Prior to the operation of a Wastewater Treatment Plant, a proper sewerage system has to be constructed that would collet wastewater from residences, commercial buildings and run-off from roads and concrete pavements. These sewage systems shall be directly connected to the wastewater treatment plant where these wastewaters are treated prior to disposal on the river and into the ocean. Once sewerage has been addressed in these areas, then the operation of the plan can go as planned. Presented below is the detailed process of how a wastewater treatment plant works:

### Pre-treatment Process

The process of wastewater treatment starts from the sewage system of the areas that deposits wastewater in to the treatment plant. Prior to treatment, this wastewater is filtered using Bar Screens to remove large solid substance, such as cans, papers, plastics and other large materials that could clog ang damage the pumps in the plant. This will result to water containing smaller particles such as sand and pebble and sludge. Then, it goes to the primary treatment.

### Primary Treatment Process

The filtered fluid then slowly flows to the Grit Chambers, so that sand and pebbles will be allowed to settle at the bottom slowly. Then, it flows through the Sedimentation Tank wherein wastes such as feces are allowed to settle. Also, waste such as soap, oil and debris are allowed to rise to the top of water. The solid waste that settles at the bottom is called the sludge, which is removed through scraping, and is performed every a few days. Then, the material that floats is called the slum, which is removed using a skimmer. And then come the water which is now clarified. Clarified water is then processed for secondary treatment.

### Secondary Treatment Process

The clarified water is then fed to the Aeration Tank, wherein organic wastes are removed. This is done by transferring the clarified water in an aeration tank where air blows bubble air. It helps the aerobic bacteria to grow and feed on organic contaminants such as food, feces and etc. Then, the water goes to the clarifier, wherein the activated sludge is allowed to settle through gravity. The activated sludge produced in the clarifier, along with the sludge produced in the sedimentation tank goes to the Digester, wherein it is allowed to decompose by anaerobic bacteria. These gases can be used to produce fuel and electricity. Then, the dried sludge is taken to the Sand Drying Bed, which can be used as a fertilizer or as a compost.

### Tertiary Treatment Process

Once all the contaminants, and solid waste from the water, the water quality could still be not 100% guaranteed as safe, especially for drinking, as it may still contain bacteria and other harmful microbiological organism. To ensure safety of the water from these organisms, it undergoes the last step of chlorination, wherein the water is treated with chlorine.

This entire process of treating wastes water may take up to 24 hrs. to 36 hrs. from the moment the wastewater enters the treatment facility and the moment it is chlorinated. This treated water can then be delivered into the river or, can even be stored, process and recycled for commercial use, as at this stage, this treated water is already safe for human usage.

For a detailed process of the plant operation, and operational chart is provided in the succeeding page.

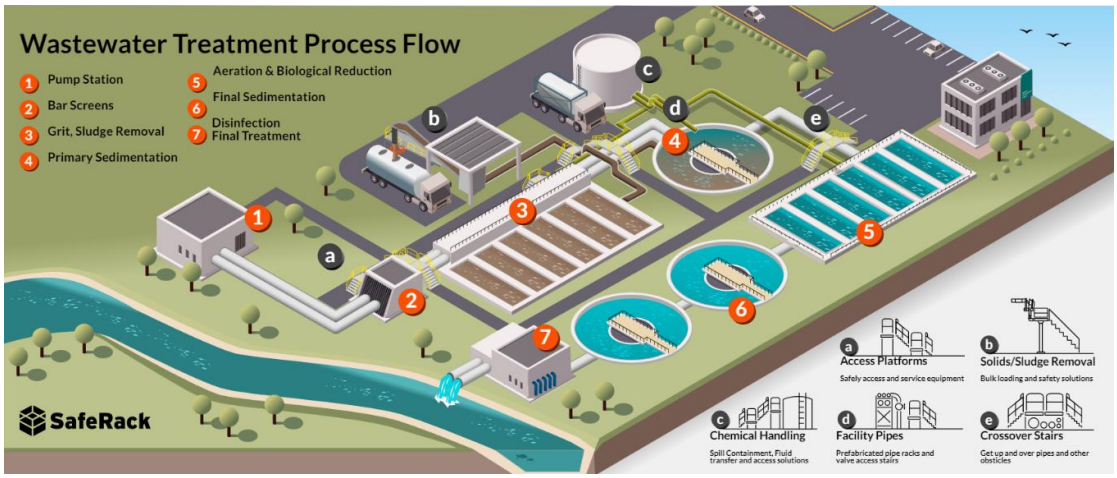



*Figure 2.20. Wastewater Treatment Plan*

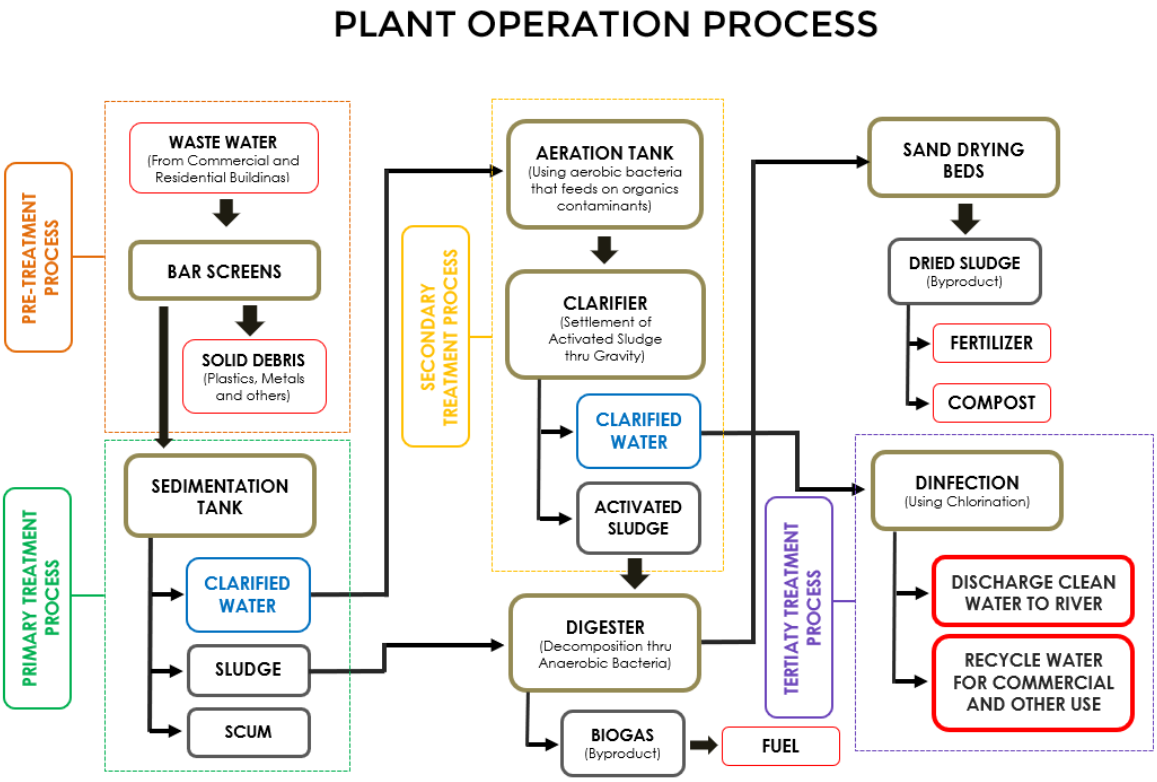



*Figure 2.21. Detailed Plant Operation Process*

## 3.2 Location Analysis

### 3.2.1. Location in the River Where the Project Will Be Placed

Currently, the side of the Mahiga River has been densely occupied by a larger number of informal settlers, and even commercial buildings operating without the proper sanitary permits.

In order to visualize the construction of this plant, the best option is to build it on areas occupied by illegal settlers. As shown in the map, the green portion are the side of the river occupied by illegal settlers.

As identified in the map, the chosen area is the deemed to be the most qualified area in terms of land area. Due to the limitations, no survey has been conducted onsite. Further, no data can be gathered on the land area of the location. Hence, further study on the identified area shall be conducted prior to planning of the plant construction.

Due to the construction of this plant, relocation of these illegal settlers is another challenge for the local government as well as construction heads. Hence, proper relocation is a must before initiation of the plant construction.


*Figure 22. Map of Illegal Settlers and Recommended Plant Site*

## 3.3. Cost Benefit Analysis

### 3.3.1. Factors to Be Considered in Costing a WWTS

In building a wastewater treatment facility, two main factors drive the cost. This includes:

(1) The water quality of the plant's effluent to be treated (such levels of contaminants)
(2) The local maximum and average monthly discharge limits to the environment
(3) The amount of water that needs to be processed per day and the speed of processing (which requires the peak gallons per minute). [1]

Once these factors have been identified, then, construction costs estimation can begin.

### 3.3.1. Cost of the Project

Constructing a new Wastewater Treatment System is indeed an expensive project to execute. For most industrial applications, a 1500,000 GPD capacity of Wastewater Treatment Plan would cost an estimated **$500,000 to $1.5 million** inclusive of all necessary design, engineering, equipment, installation, and startup, or approximately **Php 25,000,000.00 to Php 150,000,000.00.** This does not include the flow rate, effluent quality standards, which may cause the budget to rise, if necessary. [2]

### 3.3.3. Funding of the Project

#### 3.3.3.1. Cebu City and Mandaue City LGU

Cebu City and Mandaue City being the main affected areas for this environmental concern, both LGU's shall cooperate and agree with each other to initiate the funding of this project.

#### 3.3.3.2. DPWH and National Funding

DPWH being engineering and construction arm of the government, and being the main public agency directly responsible for the planning, design, construction and maintenance of infrastructure, especially the national highways, flood control and water resource development system, and other public works in accordance with the national development objective [3], shall be the direct government partner for the execution of this project, through national funding, if possible.

## 3.4. Planning

### 3.4.1. Process of Implementation

Prior to planning and construction of the Wastewater Treatment Plant, several preliminary actions has to be performed. It has to be considered that there are two main problems, that would disable the immediate construction of the plant: (1) poor to no available water sewage system available that can be directly connected to the plant for water treatment; and (2) large number of informal settlers that needs to be properly relocated. Hence, the construction of this Wastewater Treatment Facility shall not proceed

Once the identified problems have been resolved, then the implementation of constructing the plant shall proceed. It shall begin by creating an agreement between the two LGU's of Cebu City and Mandaue City for a coordination partnership on the construction of the project, as both cities are to benefit from it.

After the agreement shall follow the recommending the project to the DPWH for funding partnership of the project. This project shall be funded both by the LGU's of Cebu City and Mandaue City, along with DPWH. On cases that there is a lack of budget partnership and negotiations with private companies shall be executed, and necessary contracts and agreements of operations shall follow.

Once the source of funding is identified, bidding for qualified contractor shall follow.

## 3.5. Stakeholders Involved

### 3.5.1. MCWD

Metropolitan Cebu Water District (MCWD) being the main agency responsible for the viable utility to provide adequate, safe, potable and affordable water and an effective sewerage system for Metro Cebu, [4] shall be the main stakeholder and the responsible management for the operation and maintenance of this Wastewater Treatment Plant.

# CHAPTER 3
# CONLUSION

## 3.1. CONCLUSION

The Mahiga river have major problems namely, untreated wastewater present in the river, water quality and other problems that needs to be addressed. The solutions discussed like the wastewater treatment plant, centralized toilet rooms with rainwater harvesting system, phytoremediation and social awareness show both long term and short-term solutions. The wastewater treatment plant will not just benefit the people nearby the river but also the people in the whole province since it will provide wastewater treatment which the cities did not have yet. The centralized toilet rooms with rainwater harvesting system are proposed in order to address the lack to no household toilet room of the people living in the area and open defecation in the river that affects its water quality. The rainwater harvesting system installed will be the source of water for the toilet rooms. In dry seasons, where there is no rain expected, the phytoremediation solution proposed also can help. Phytoremediation can address the water quality situation in the river and also can help the livelihood and benefit the residents directly. All these proposed solutions need pilot studies to test its feasibility and sustainability for Mahiga.

The implementation of this project would only be considered a success if both the government and the other stakeholders take action to achieve its goals. The government has to raise the social awareness regarding the importance of the project and the other stakeholders, especially the residents in the area, should also do their part in supporting and maintaining the projects.

## 3.2. RECCOMENDATION

1. There has been no study conducted yet as to the amount of water discharged around the Mahiga River. So, it is recommended that prior to implementation, a research study be conducted to answer the questions concerning costing a Wastewater Treatment Plant: The water quality of the plant's effluent to be treated (such levels of contaminants); (2) The local maximum and average monthly discharge limits to the environment; and (3) The amount of water that needs to be processed per day and the speed of processing (which requires the peak gallons per minute).

2. Survey on the identified area (land area) if it is sufficient for the plant site are requirement.

3. It is recommended to have the constructed wetland maintained properly to avoid the plants for invading the existing plant colonies in the area. Controlling the growth of water hyacinth is very important so as to not pose a problem in the natural ecosystem of the river. Furthermore, other aquatic plants that are locally available are encouraged for use in the constructed floating wetland system.

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