Sustainable Port City

A Landscape Architectonic Intervention Towards Climate Change Adaptation
in the Port City Belawan North Sumatra-Indonesia

Sri Shindi Indira

Master Thesis Landscape Architecture
Wageningen University and Research Center
2012

... a deep respect for what designers have to deal with, which includes not only the technical aspect of design itself but also other factors such as envioronmental ramifications, observance of various regulations regarding safety and accessibility, consideration of cultural factors depending upon the expected users, not to mention cost and, last but not least, aesthetics.

Yuriko Saito, 2007

….we can realize only what we can imagine; but to realize what we imagine, we must convey those ideas to others as well as present them to ourselves.

Marc Treib, 2008

A man's feet should be planted in his country, but his eyes should survey the world.

George Santayana

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January, 2012

Date: Signature:

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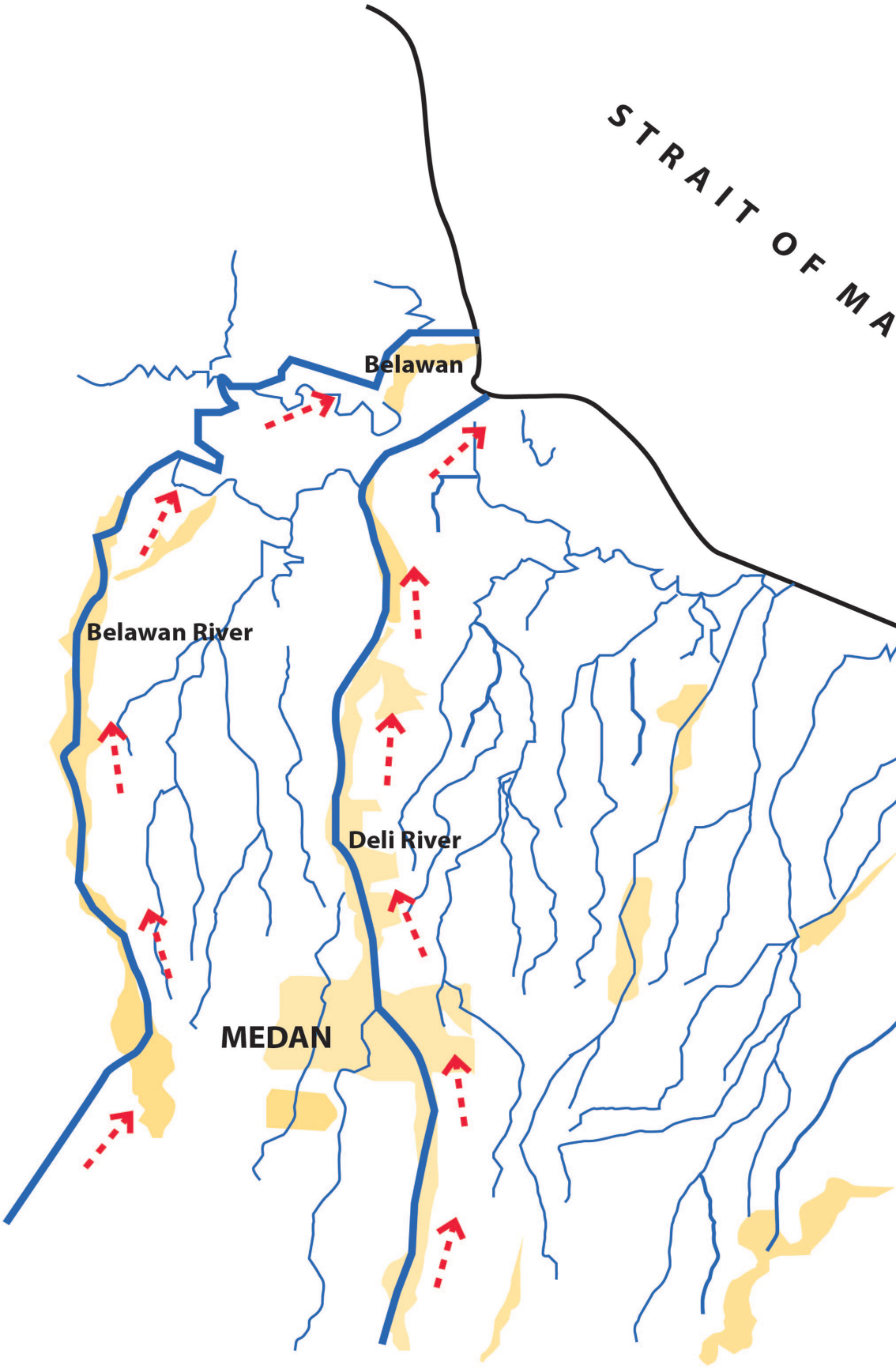
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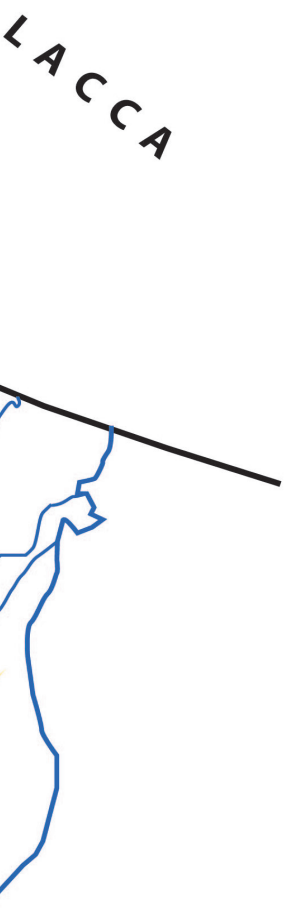
Foreword



I live in Medan, the capital city for North Sumatra where Belawan is one of the districts. I have witnessed flooded houses, inundation and children play in the inundated water. As an architect it triggers me to do something or to find solutions. Then I realised, what happened in Belawan is not merely technical issues but also the nature and environment. I want to understand more about these issues, then I found that landscape architecture covers it all.

Studying here, in the Netherlands is a dream comes true for me. I applied the program Landscape Architecture and Planning with big hope that later I will be able to contribute my knowledge and skill to the development of my home town, Medan. I've been working on my thesis since February 2011 and it has been quite some work and load. However, this thesis is worth doing as it will give a lot of meaning not only for Belawan but also for my own sake of learning.

Praise and gratitude to Allah SWT for bless and mercy that have been given to me to continue my study and passed many great lessons during my stay here in the Netherlands. Biggest appreciation to my parents and brothers, whom without their pray and supports I could never survive this fight.

Secondly, I would like to express my gratitude to Ingrid Duchhart for her patience and spirit during the thesis supervision. Her guidance has revealed my basic motivation to learn Landscape Architecture. With her step by step approach, she helps me to slowly switch the way of thinking as an engineer architect into a landscape architecture approach. Her supervision with critical points to address has been good inputs for the process and result of this thesis.

For the people of Belawan and Bagan Deli fisherman village, I would like to present this study and to thank them for the support and assistance during my fieldwork. I also would like to express my gratitude to them who help me during the discussion, consultancy and also data collection; the government of Medan, Faisal and his father from the Port Management, Yahya Darmawan and Benny Istanto for the GIS, Kiki Kartikasari for the climate change discussion, and Bambang I. Gunawan for the aquaculture knowledge and Faisal Razi for the geological data.

The most important also is to thank Stuned Nuffic and NESO Indonesia for the financial and consultancy support which allow me to study and gain knowledge as well as experience in the Netherlands. Moreover, I would like to express my gratitude to Pierre Pourchez, Wil G.K Tjoa and *Alle Beetjes Helpen* for their extra financial support during my study.

Last but not least is to express my gratitude and appreciation to friends in Medan and in the Netherlands. To Ika Asti, Kiki Kartikasari and Dila Andini without them I would have been a weak woman. Thank you to Ruth Dobbelsteen, Naiara Valcarlos Carrera, Qian Jieyan, Shristi Shrestha, Emilia Zemlak and Jaime Gomez De La Fuente without them Wageningen is simply an empty town.

Wageningen, 31 December 2011
Sri Shindi Indira

Summary

Chapter 1: Introduction

Belawan port is one of the most important ports in Indonesia. The growth of its population and expansion of the port facilities for industry has triggered the unbalance of the environment. Flood and inundation from the high tide and high precipitation have been major issues for the city that impacted in the welfare of the people and the continuity of the environment. Facing the climate that slowly changes into a massive impact in the next 50 to 100 years, Belawan is threatened with drowning. To analyse the problems and to find fit solutions for the sustainability of the port city, a landscape architectonic intervention is used. However, many aspects need to be considered in tackling the problems and designing proper intervention. The question is 'what is the best landscape architectonic intervention for Belawan that is adaptive to the climate change impact?'

Chapter 2: Research Design

The thesis is brought up with the idea to use landscape based approach in analysing the issues. The approach by landscape architectonic intervention contains aspects that focus on nature, ecology and its natural process in combination with their relationships with the people. The method is research by design. The research is started with fieldwork based to look at the problems occur by observation, drawing and sketching analysis in the field. During desktop study on data collected in the field, literature studies are conducted to get the ideas of possible and proper intervention. However, there is a gap in applying methods and theory that mostly from Western countries with different climatic characteristics to Indonesian tropical context. Sketching, drawing and modelling to test the possible solutions are done to adapt the methods with the condition and the characteristic of Belawan.

Chapter 3: Climate Change

Climate change is a global issue where the impact is slowly happened. However its impact can occur differently in the hemispheres. As an archipelagic country, Indonesia lies by the tropical climate with only two seasons of wet and dry. Moreover, Indonesia is also separated in islands and Sumatra where Belawan located is dealing with the impact of climate change slightly different from other islands in Indonesia. Thus, the climate change impact in Sumatra especially in and around Belawan is studied in more detail.

Chapter 4: Belawan Port City: The Challenge and Opportunity

Belawan as a port started since hundreds years ago. The geographical position made it a suitable location for ships to harbour. Thus, the historical aspects of Belawan contribute in the shaping of its landscape. Furthermore, Belawan is a delta that is very rich with biodiversities such as flora and fauna. The most important is mangrove habitat that actually becomes the unrevealed treasure for Belawan. Socially, the community is also various. They are categorized by the way they live; '*Rumah Batu*' or the concrete houses and "*Rumah Panggung*' or the pole houses.

Chapter 5: Problem Statement

The idea of this thesis is firstly comes up with the problems in Belawan. In this chapter I analyse the entire issues rose in Belawan during my fieldwork. By making problem trees I tracked back what the problems, the cause and the effect are. Not only that, sketching and drawing that show where the problems occur are also analysed in this chapter. Furthermore, as this is a landscape architecture thesis research, at the end of the chapter, I try to address the strategic focus for the design, first is to handle the storm water runoff because of the high precipitation and the second is to protect the land from high tide and sea level rise.

Chapter 6: Theoretical Studies

During the analytical process of the problems and contextual aspects, it reveals the necessary theory and methods to help in solving the problems. Theories such as how to construct wetlands as water retention, the rich benefit of mangrove ecosystem and also the methods of fish ponds in aquaculture to support not only for the economy of the community but also as coastal defence.

Chapter 7: Alternatives for Design Intervention

The theoretical studies and data analysis are used in shaping the alternatives for design intervention. Several studies on solving the inundation because of storm water run-off recommend an infiltration zone and also water retention to hold the water. Other solution is by constructing flood canal for flat dense urban area. To solve the high tide and sea level rise problems are by constructing dike, mangrove forest and also by local method of fishponds embankment. Those several alternatives are then chosen by means of methods that best fit with the condition of Belawan.

Chapter 8: Detail Design

The previous chapter provides alternatives of possible design intervention, in this chapter the chosen designs that best fit with Belawan are shown in detail. For the storm water runoff problems the combination of constructed wetlands and also individual house storm water infiltration is designed to reduce and to retain the storm water inundation. The mangrove forest conservation and the fishponds embankment become the natural and multi benefit coastal defence against the high tide and the projected sea level rise in the next 50 to 100 years.

Chapter 9: Conclusion

To conclude, studies that have been done cover almost all the problems in Belawan. By focus in landscape architectonic intervention for the climate adaptation, chosen intervention that best fit with Belawan is answering the question. Thus, the goal of this thesis is very simple, and the gap is already filled by adapting methods and theory with the local characteristics.

Bangau Putih bird at Mangrove Forest Belawan

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List of Abbrevation

BMKG: *Badan Meteorologi Klimatologi dan Geofisika* **(Meteorology, Climatology and Geophysics Agency)**

BPS : *Biro Pusat Statisti***k (Statistics Bureau)**

RDTR : *Rencana Detail Tata Ruang* (Spatial Detail Plan)

IPCC: Intergovernmental Panel on Climate Change

Chapter I. Introduction

The Archipelago

Figure 1.1 Indonesia consists of 17,508 islands and populate by 238 million
Sulawesi, Papua and also other smaller islands. With approximately 81,000 km long

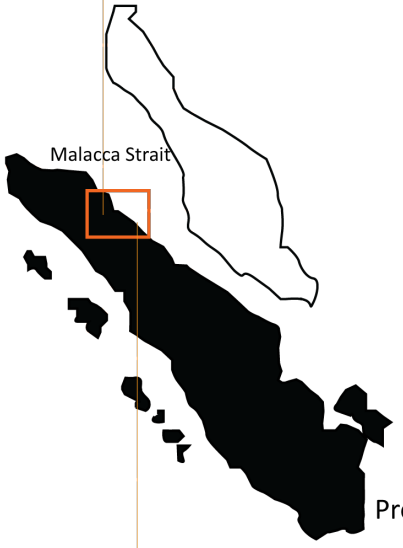
(Source: Indonesia Bureau of Statistic, 2010 &

of INDONESIA

people that spread mostly in bigger islands of Sumatra, Java, Kalimantan coast line, there more than 2 million people live in coastal area.

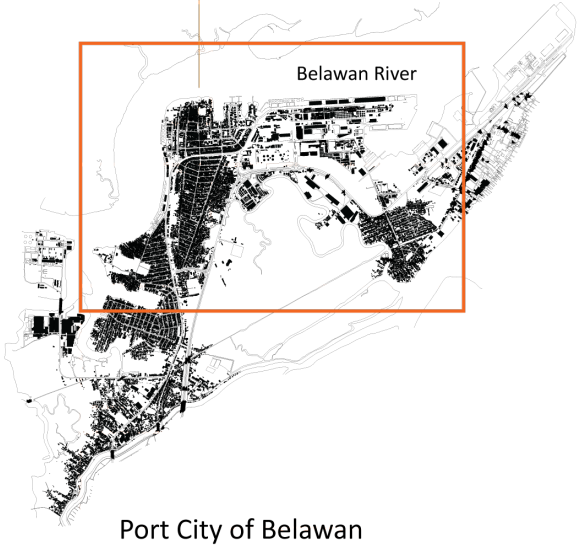
Indonesia Second National Communication, 2010)

Indonesia



Province of North Sumatra

City of Medan



Port City of Belawan

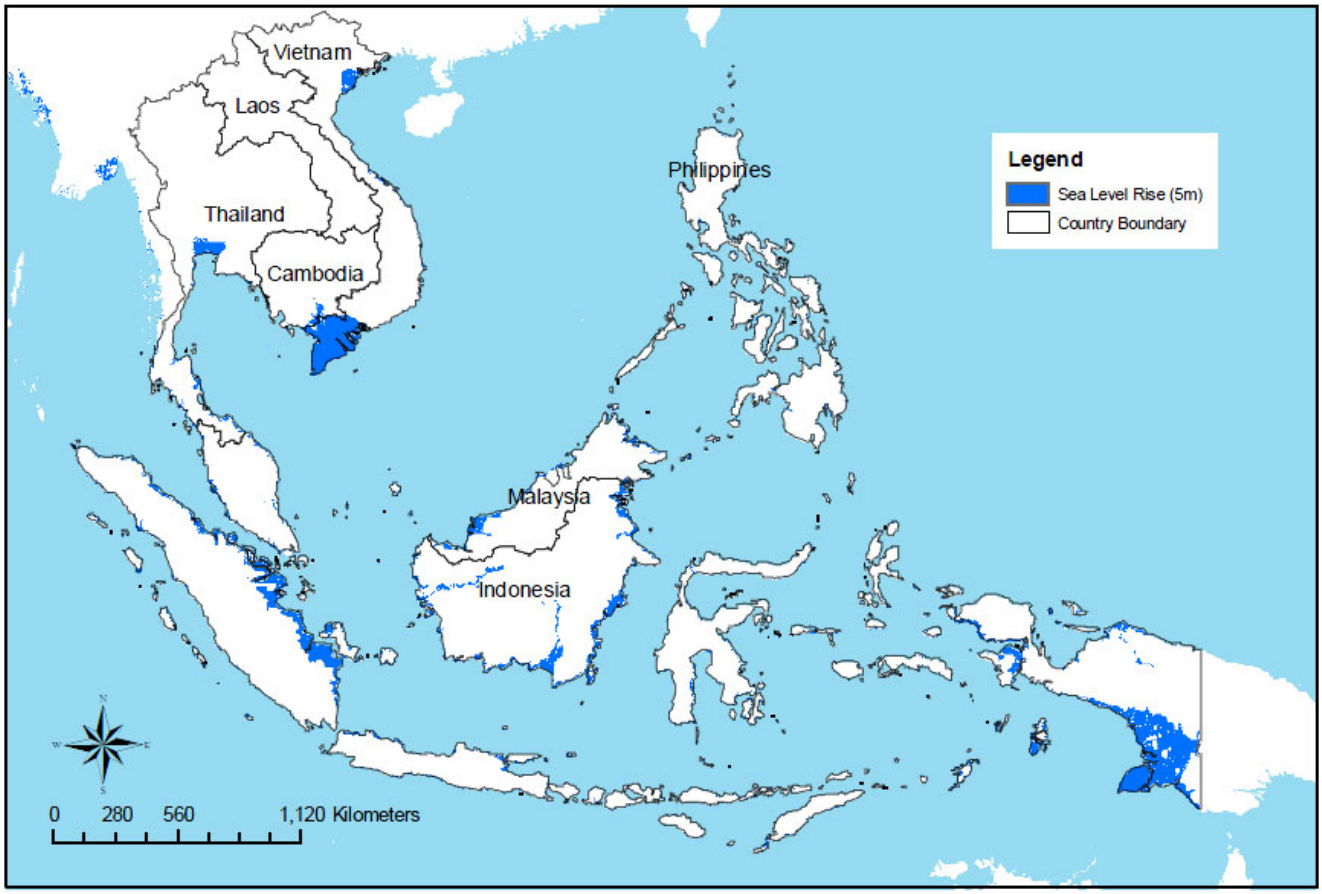


Figure 1.2 Sea Level Rise in South East Asia (Source: Climate Change Vulnerability Mapping for Southeast Asia)

I. Introduction

Indonesia as an archipelagic country is exposed to considerable impact of climate change on its coastal areas. Many big cities are located in coastal areas that are in the next 50 - 100 years threatened with drowning because of sea level rise. Big cities such as Jakarta, Semarang, Surabaya and Medan are already reported in the Indonesian Second National Communication under the United Nations Framework Convention on Climate Change (UNFCC) to face the problems. It is reported that for coastal and Outer Islands, the increase in sea level by about 25 to 50 cm in 2050 and 2100 as projected by many models will inundated many parts of the coastal cities of Indonesia. Land subsidence will exacerbate this, increasing the total area that will be inundated permanently which is between 25% and 50% of area in a number of sub-districts in coastal cities such as Semarang, Surabaya, Jakarta and Medan will be under water permanently (ISNC, 2010).



Belawan is a port city located in the northern part of Medan city. Belawan port is one of the most important ports in Indonesia juxtaposed with the Strait of Malacca. Located in the delta estuarine of two big rivers, Belawan is strategically functioned as a port since hundreds years ago. The richness of its mangrove biodiversity and the living culture of the local fishermen have made this port city blend harmoniously. However, recent development of port facilities expansion, mangrove deforestation for housing sector and the growth of the population cause destruction of coastal protection.

1.1 Issues in Belawan

What has happened in Belawan today? Mass media printed and electronic reported for at least twice a month about flooding and inundation because of the high tide of 30 -50 cm. It is said that the floods in Belawan is caused by two major factors, from nature and human. Human is the biggest contribution on the problems. There are many abundant domestic wastes in the sewage, mangrove deforestation, and the massive development. Moreover, the growth of its population and expansion of the port facilities for industry have triggered the unbalance of the environment. Flood and inundation from the high tide and high precipitation have been major issues for the city that impacted in the welfare of the people and the continuity of the environment.

As port city, Belawan is very rich with biodiversities such as flora and fauna. The most important is mangrove habitat that actually becomes the unrevealed treasure for Belawan. Socially, the community is also various.



They are categorized by the way they live; 'Rumah Batu' or the concrete houses and "Rumah Panggung' or the pole houses. The pole houses also face the problems, which they will need to be raised every time the sea level rise from its normal stated.

Facing the climate that slowly changes into a massive impact, Belawan is threatened with drowning. To be able to adapt with the situation in projected future Belawan needs to maintain the balance of its environment and welfare of the people. To analyse the problems and find fit solutions for the sustainability of the port city, a landscape architectonic intervention is used. However, there many aspects need to be considered in tackling the problems and designing proper intervention. The question is 'what is the best landscape architectonic intervention for Belawan that is adaptive to the climate change impact?'.

The thesis is brought up with the idea to used landscape based approach in analysing the issues. The approach by landscape architectonic intervention contains aspects that focus to nature, ecology and its natural process in combination with their relationships with the people. By using this approach, the research might give a different perspective and insight to existing climate adaptation options in the port city. Co-parallel with my main objective, I also hope that the study contributes to more significant role of landscape architecture in Indonesia.



I.2 Research Objective

Analysing the problems, there are many aspects need to be considered in solving them. Climate change adaptation has certain requirements based on the IPCC and also the Indonesian National Communication Report. However, landscape architecture based will look at this issue with its certain approach. By doing a landscape architectonic intervention the objective of this research is:

To find solution on current problems and also design a landscape architectonic intervention for Belawan that is adaptive to the climate change impact.

I.3 Research Question

Many coastal port cities deal with almost the same problem in Indonesia. Belawan has its urgent to study and there are several alternatives that can be addressed in solving the same issue and depending on its region characteristic. Thus, the suitable question for this research is

What is the best landscape architectonic intervention for Belawan that is adaptive to the climate change impact?

With sub questions:

1. What are the climate change impacts in Belawan?
2. What are the challenge and opportunity of Belawan that need to be consider in the development?
3. What are landscape architectonic interventions in small scale design solution?
4. How can the government and the local people help in deal ing with the climate change?



1.4 Worldview

Creswell (2009) chose the meaning of worldview from Guba (1990, p.17) as "a basic set of beliefs that guide action". According to him, worldviews are as general orientation about the world and the nature of research that a researcher holds. There are four different worldviews discussed by Creswell (2009): postpositivism, constructivism, advocacy/participatory and pragmatism.

Speaking about worldview in term of a researcher, then my world view in this thesis are Postpositivism, Constructivism, Advocacy and also Pragmatism. Why do I put myself on those fours views? It is because, as a Postpositivism in landscape architectonic approach is to study on technical method with physical measurement on how the landscape works and the design solution fit with natural science and then evaluate with the local characteristic landscape. As a Constructivist in this thesis, I study on the ethnography of the local people by looking on their culture, perception on aesthetics and historical background as the contributing factor to design solution. As an Advocacy/participatory worldview, I will put myself to use this thesis as suggestion and recommendation with a better solution and a better future for the community and government and where people can be involved in the implementation of the program suggested. I have separated myself in those worldviews in doing this thesis. However, as a landscape architectonic, I put myself mostly in the Pragmatism view, because the basis of this research is problems. That is how I started and how I oriented myself during the thesis, problem-centered.



1.5 Research Method

The method is research by design. The research is started with field-work based to look at the problems occur by observation, drawing and sketching analysis in the field. I look on how Belawan is organized and how it is related to the environment. Sketching is as a test to see if the design is fit the cultural and social setting. During desktop study on data collected in the field, literature studies are conducted to get the ideas of possible and proper intervention. However, there is gap in applying methods and theory that mostly from Western countries with different climatic characteristics to Indonesian tropical context. Sketching, drawing and modelling to test the possible solutions are done to adapt the methods with the condition and the characteristic of Belawan. These are the methods that fit with different steps.

I.6 Limitation

This research covers several fields in landscape architecture, soil science, water management, climate, and infrastructure engineering. One that cannot be denied is that richness and varieties of primary and secondary information are very important. However due to the experience and project in this fields, there are some limitation of information and data collection. Some information is generalized from the local mass media and interview with the local experts and government officers. Other limitation is that landscape architecture is a holistic approach where all aspects related to nature and natural processes have to be studied. However, due to limited data collected there are several educative guess and also assumption build in the design process.

Chapter II. Theoretical Background

2.1 Landscape Architectonic Research
2.2 The approach applies in Belawan

II. Theoretical Background

2.1 Landscape Architectonic Research

The thesis is brought up with the idea to used landscape based approach in analysing the issues. Landscape Architectonic approach is a study by looking at landscape and its context by means of nature and natural processes. However this is also a scientific thesis based research. Thus, landscape architectonic research is by combining the method of landscape architectonic analysis and solution and with scientific process.

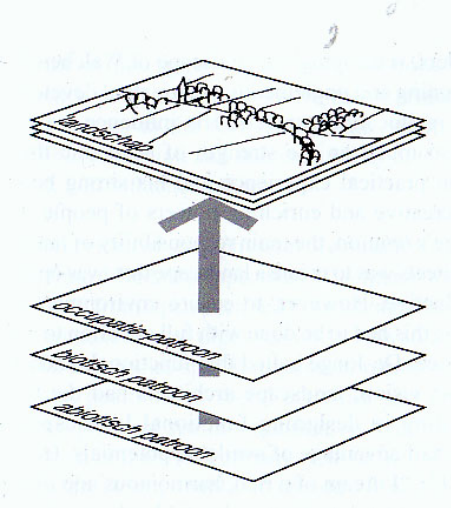
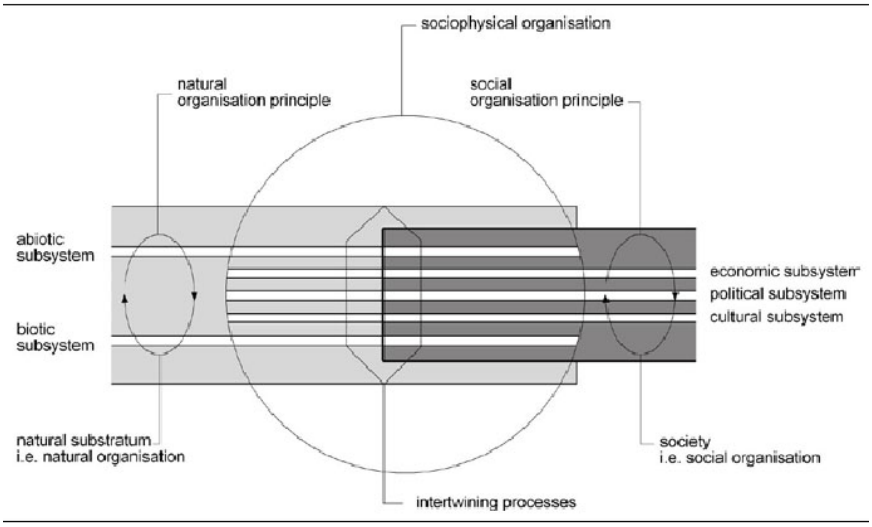


Figure 2.1 Landscape Triplex Model
(Source: Duchhart, 2007)

Triplex Model

The landscape approach in Wageningen was formed by Kerkstra and Vrijlandt. They developed triplex model that shows the interaction between man and nature in three layered model which are an anthropogenic, biotic and abiotic (Figure 2.1)(Duchhart, 2007). Thus, they defined Landscape as "the visible result on the surface of the earth of the interaction between man and nature" (Kerkstra and Vrijlandt, 1988 in Duchhart, 2007, p.16). This is the model that is developed base on the basic notion of human and nature relationship. However, today the world is changing. The way people engaging with nature are also changed and landscape is the visual result, a snapshot at a certain moment of time, of this continuing process of change (Kerkstra, Struik and Vrijlandt, 1976 in Brink and Seumeren, 2011).



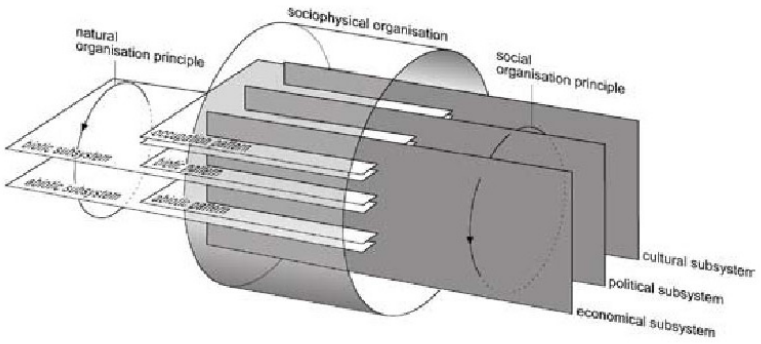


Figure 2.2 Sociophysical Organisation Model (Above) and Intertwining triplex and sociophysical organisation model (right) (Source: Duchhart, 2007)

Sociophysical Organisation Model

Speaking about the relationship between human and nature, Klefmann (1980) also discussed the issue of society that influence the landscape. By introducing Sociophysical organisation model, Klefmann tries to explain the system and process of the engagement in the social context (Figure 2.2). This is how Klefmann discussed more on the driving forces behind the landscape form which is the nature organisation and the social organization (Brink and Seumeren, 2011). Moreover, Klefmann links the interactive character of the design process to evaluate the imaginative future to their reality of the present (Duchhart, 2007).

Looking at the two models, Duchhart (2007) proposed modified the combination of two (Figure 2.2). Because the triplex model is strong in the description of the landscape in physical and tangible terms (pattern oriented), the socio-physical organization model focuses more on the driving forces behind the factors that form the landscape (process / system oriented) (Brink and Seumeren, 2011). Furthermore, Duchhart thinks that the modified combination of the two models will fill in the gap between now and the envisioned future.

Sustainable Development

"Sustainable Development is development that meets the need of the present without compromising the ability of future generations to meet their own needs." (Mc Carthy et al., 2001 in IPCC third assessment report, 2007).

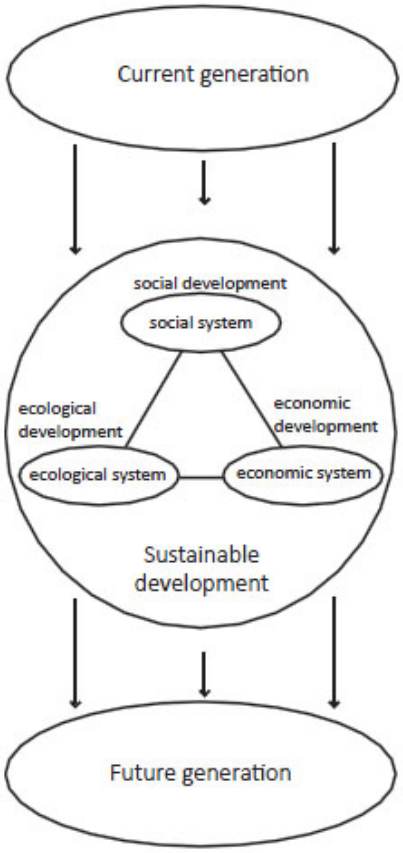


Figure 2.3 The three pillars of Sustainable Development based on Arndt, 2006 in Kupers, 2011)

Conclusion

To conclude, with this theory elaboration I will test if landscape architectonic intervention approach can help this research process by taking into account driving tangible and intangible factors. Thus, my hypothesis is:

Landscape architectonic approach may help to find solutions and also ways in dealing with the climate change adaptation.

2.2 The approach applies in Belawan

This research is solution based research where it is intended to function. By looking at spatial quality means the design has to work well, sustainable and also it has to fit with people expectation.

Landscape model for this thesis:

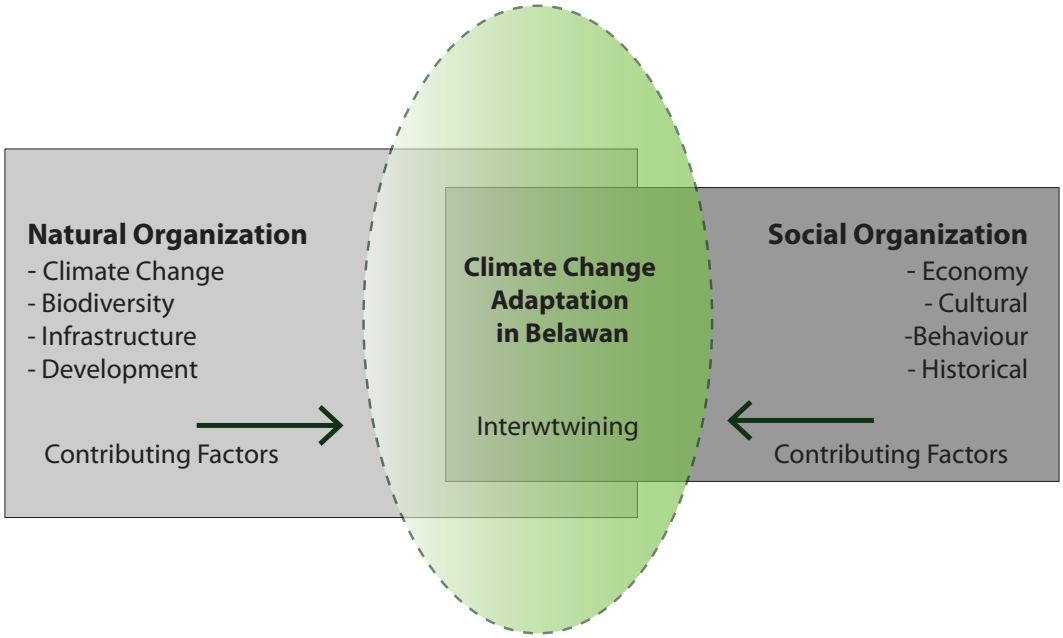


Figure 2.4 Landscape Model for Climate Change Adaptation in Belawan

This study is not only focusing on solutions but also on how to gain people appreciation to their environment. Appreciation leads into care and attention. In this way, people will take care of their environment and they will passing on to their generation so the wisdom will sustain. People appreciate aesthetic value by means of a certain aesthetical perception. By landscape architectonic approach, studies and analysis are not only done to physical setting problems but also to make aesthetically appreciate by means of beautification by local sense of beauty and order. This notion of aesthetic appreciation will not be studied in this thesis because it is a subjective matter and other kind of research itself. However, as Malay myself I will use my own perception and assumption based on my everyday observation to put this value in my design.

Chapter III. Climate Change

III. Climate Change

Climate change is not a new issue for us architects, landscape architects, urban designers and planners. In every project or design assignment we always have to take into account the impact of climate change as projection of no regret decision in the future. However, again, we have to define what climate change is in global overview and for this thesis is in Indonesia and specifically in Belawan North Sumatra

2.1 Global Overview

Intergovernmental Panel on Climate Change (IPCC) refers climate change as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC report, 2007). Other definition of climate change also derived from the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC report, 2007).

IPCC (2007) reported for the last twelve years (1905-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). This finding means that since 100 years ago there have been significant changes in the temperature of the earth. The temperature increase is widespread over the globe and is greater at higher northern latitude (IPCC, 2007). The warm temperature causes the melting of the ice scalp into glacier and influenced the rise of the sea level.

Chain reaction of this phenomenon implicates high global surface temperature and sea level rise. Increase on the surface temperature will be impacted on evaporation and leads to high precipitation.

According to the most recent estimates, the sea level is expected to rise by about 1 meter (3.28 feet) -- on average -- in the next 100 years. "But this average value doesn't really help coastal planners," says Detlef Stammer. an Oceanographer from Hamburg (Reuters, 2010)

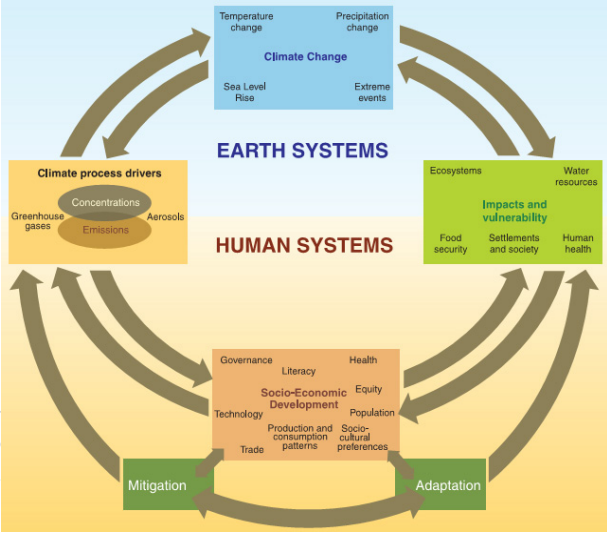


Figure 3.1 Schematic framework representing anthropogenic drivers, impacts of and responses to climate change, and their linkages. (IPCC report, 2007)

At continental, regional and ocean basin scales, numerous long term in other aspect of the climates have also been observed (IPCC, 2007). It is recorded on the report trends that show change in the amount of the precipitation. Significant change already happened in eastern parts of North and South America, northern Europe and northern and central Asia whereas precipitation declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia (IPCC, 2007).

There are other effects of regional climate changes on natural and human environment that are emerging and this due to adaptation and non-climatic drivers (IPCC, 2007). Sea level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas. IPCC reported regional impact on Asian countries such as the decrease of availability of freshwater in larger river basin, heavily populated coastal areas will be at greater risk due to increased flooding from the sea and rivers of the mega deltas. The impact also projected on the pressure of natural resource due to rapid urbanization, industrialization and economic development (IPCC report, 2007). The last but not least important is that the endemic morbidity and mortality because diseases that associated from floods and droughts.

In response to these issues, adaptation and mitigation options can be implemented over the next two to three decades, and their inter-relationship with sustainable development (IPCC report, 2007). As adaptation can reduce vulnerability in short and long term period of time, some developing countries need to apply this method in order to be able to deal with the climate change. However, the capacity to adapt and mitigate is dependent on socio-economic and environmental circumstances and the availability of information and technology (IPCC report, 2007). According to UNFCCC, developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt: socially, technologically and financially (UNFCCC, 2010).

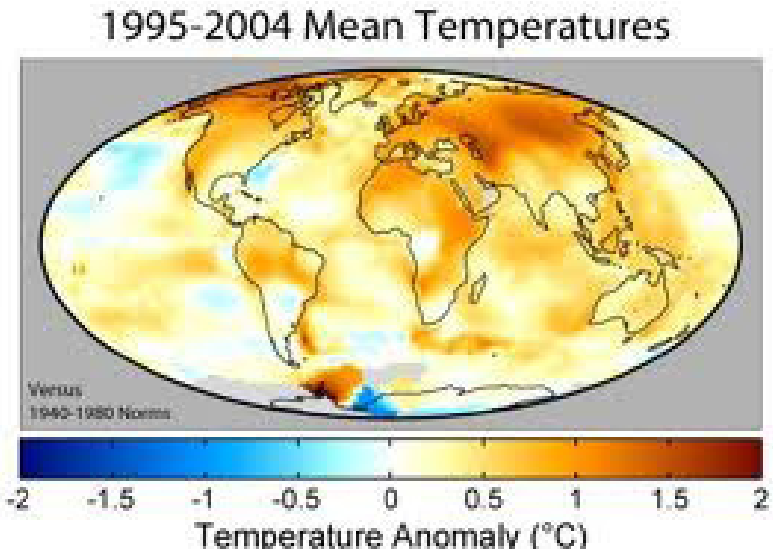


Figure 3.2 World Anomaly Temperature (Source: Internet Download, 2011)

Developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt: socially, technologically and financially (UNFCCC, 2010).

3.2 Climate Change Adaptation

Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern are likely to lead to severe water shortages and/or flooding. Increasing sea levels mean greater risk of storm surge, inundation and wave damage to coastlines, particularly in Small Island States and countries with low lying deltas. A rise in extreme events will have effects on health and lives as well as associated environmental and economic impacts.

Adaptation is processes through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. There are many options and opportunities to adapt. These ranges from technological options such as increased sea defenses or flood-proof houses on stilts, to behaviour change at the individual level, such as reducing water use in times of drought and using insecticide-sprayed mosquito nets. Other strategies include early warning systems for extreme events, better water management, and improved risk management, various insurance options and biodiversity conservation. Because of the speed at which change is happening due to global temperature rise, it is urgent that the vulnerability of developing countries to climate change is reduced and their capacity to adapt is increased and national adaptation plans are implemented.

"..like driving a car and face a car crash in front of you, mitigation functions as a break to stop the car and pull out of the crash. While ***adaptation functions as a safety bealt*** *which secure you from impact of the crash. Whether there is a car crash or not, safety bealt enables you to cope with any possibilities of adverse impact in driving a car.." (Translated from conversation with Kiki Kartikasari on Rizaldi Boer's explanation).*

Future vulnerability depends not only on climate change but also on the type of development path that is pursued. Thus adaptation should be implemented in the context of national and global sustainable development efforts. The international community is identifying resources, tools and approaches to support this effort. Sea level rise and changes in sea water temperature, salinity, wind speed and direction, strength of upwelling, mixing layer thickness and predator response to climate change have the potential to substantially alter fish breeding habitats and food supply for fish and ultimately the abundance of fish populations in Asian waters with associated effects on coastal economies (Cruz et al. 2007). Adaptation to climate change in developing countries is vital and has been highlighted by them as having a high or urgent priority.

However, developing countries have limitations in capacity making adaptation difficult. Limitations include both human capacity and financial resources. Outputs from the UNFCCC workshops and meeting highlighted that the most effective adaptation approaches for developing countries are those addressing a range of environmental stresses and factors. For example, in agriculture, reduced rainfall and higher evaporation may call for the extension of irrigation; and for coastal zones, sea level rise may necessitate improved coastal protection such as reforestation (UNFCC, 2010)

3.3 Climate Change in Indonesia

Indonesia as a maritime country is located between 60°8′ North and 11°15′ South latitude, and from 94°45′ to 141°05′ East longitude. It consists of five large islands (Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya) and approximately 13,667 small islands surrounded by South China Sea in the North and Indian Sea in the Southern part.

The archipelago of Indonesia is also face the threat of the climate variability and climate change. For the last four decades, climate related hazards and disaster have cause major loss of human lives and livelihoods in Indonesia. Floods and windstorms are counted as the most contributing hazards with the percentage of 70% of total disaster, and 30% for droughts, landslides, forest fires, heat waves and others. It is likely that global warming will lead to greater extreme of drying and heavy rainfall which will in turn lead to higher risk of climate hazards (Trenberth and Houghton, 1996; IPCC, 2007 as reported in Indonesian Country Report, 2007). According to a report from UN-OCHA (2006) indicates that Indonesia is one of the vulnerable countries to climate related hazards (Indonesian Country Report, 2007).

Base d on the country report (2007), type of climate hazards in Indonesia are floods, droughts, land slide and forest fires. Moreover, the report explained that Climate-related hazards in Indonesia are also caused by the location and movement of the tropical cyclones in the eastern south Indian Ocean (January to April) and the eastern Pacific Ocean (May to December). This variability will impact on the ocean surface temperature above 26.5°C and also to the Indonesia region commonly is local strong winds and heavy rainfall in the order of hours to days.

Synthesis Report: Indonesia Climate Change Sectoral Roadmap:
A. Surface Air Temperature Increase and Precipitation Change
B. Sea Surface Temperature Rise, Sea Level Rise and Extreme Climatic Events

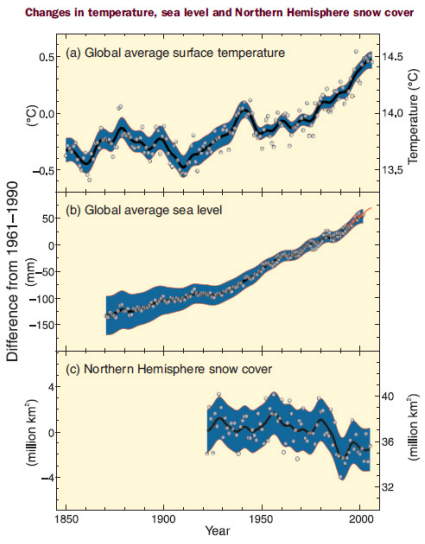


Figure 3.3 Changes in temperature, sea level and Northern Hemisphere snow cover (Source: IPCC Report, 2007)

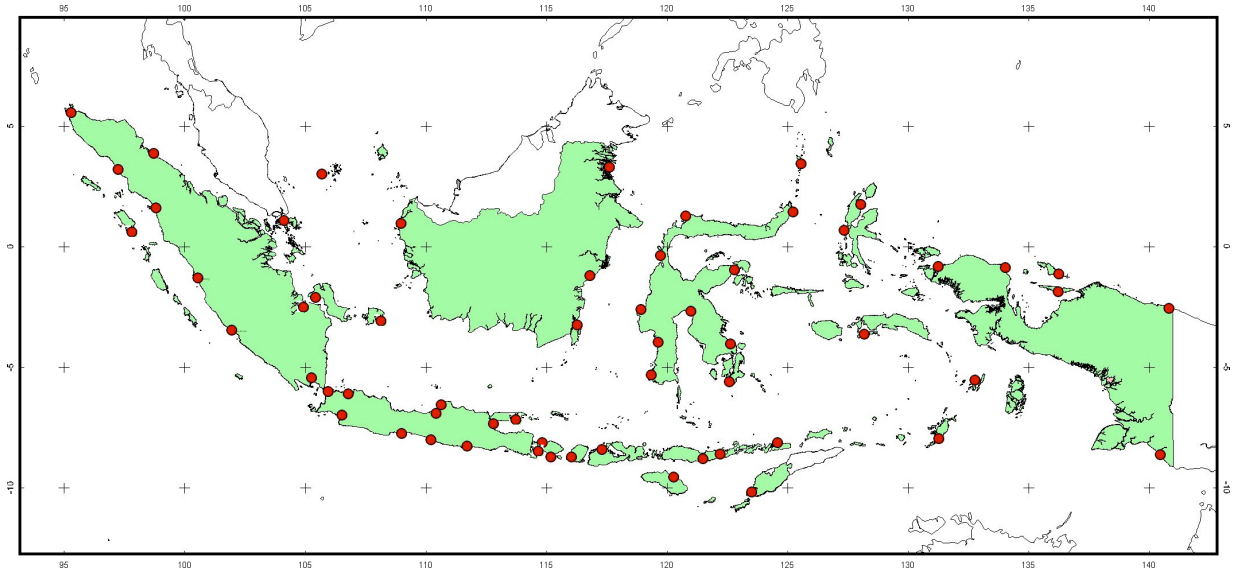


Figure 3. 4 Sea Leve Monitoring Stations in Indonesia (Source: Country Report, 2007)

Sea Level Rise.

The monitoring instruments spread in several stations have been installed to monitoring the sea level rise. The inundation of coastal areas during spring tide is called ROB. As an island country, Indonesia has a very long coast, i.e. about 81.000 km. In1997, it was reported that about two million people live in coastal areas with an elevation of between 0 and 2 m asl in combination with many industries and sectors operate in these coastal areas such as oil and gas exploration, transportations, fisheries (approximately 400,000 ha ponds), settlements, agriculture and tourisms (Country Report, 2007). Thus, the report explained that the increase in sea level will result in devastating impacts on socio-economic activities and sustainable development. With a sea level rise of about 1 m, it was estimated that about 405,000 ha of coastal land including small islands will be flooded. The impacts might be severe in certain coastal areas such as the north coast of Java, the east coast of Sumatra, and the south coast of Sulawesi (Subandono, 2002 cited in Country Report, 2007).

Sea level rise in combination with land subsidence due to over exploitation of ground water will definitely move the coastal line to the inland, with an associated higher risk of floods. For Sea level increase there will be rise in the period of 2030 for 0.65 cm, 2050 for 1.10 m, 2080 for 1.70 m and 2100 for 2.15 m. These rises will impact in the depletion and movement fishing stock away from Indonesian ocean.

Based on Indonesian Climate Change Sectoral Roadmap (ICCSR) synthesis report the climate change hazards is identified in the surface air temperature increase and precipitation change, sea surface temperature rise, sea level rise and extreme climate events. The hazards will result into condition of water shortage, flood, drought, coastal inundation, sea surface temperature.

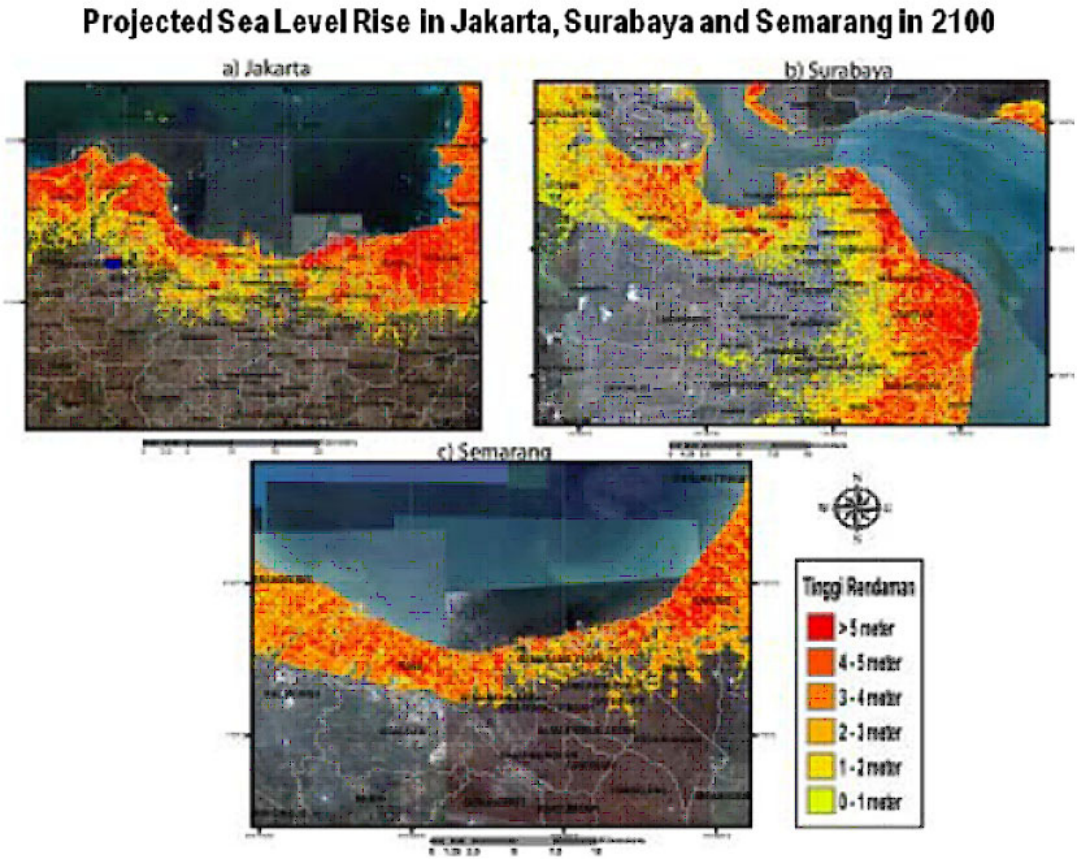


Figure 3. 5 Projected Sea Level Rise in Coastal Cities in Indonesia (Source: ISNC, 2010)

The Climate Change impact in Coastal Cities in Indonesia

The impacts of climate change on coastal areas can be divided into two categories: biophysical and socio-economic impacts. Biophysical impacts include (IPCC, 2005): (i) increased coastal erosion, (ii) inhibition of primary production processes, (iii) increased flood frequency, (iv) increased intensity of flood events caused by storm-surge, (v) saltwater intrusion into estuaries and aquifers, (vi) changes in the quality of surface water and groundwater characteristics, (vii) changes in the distribution of pathogenic micro organisms and (viii) increasing sea surface temperatures. Economic and social impacts include (i) increasing number of homes lost and coastal habitats, (ii) increased risk of flooding and the number of lives potentially lost, (iii) damage to buildings and other infrastructure, and coastal protection, (iv) increased risk of disease outbreaks, (v) loss of resources that can be replaced (vi) loss of tourism, recreation and transportation, (vii) loss of cultural assets and historical values and (viii) impacts on inland fisheries and agriculture due to declining quality of soil and water as a result of saltwater intrusion (ISNC, 2010).

Distribution of floods based on the scenario of sea level rise + high tide: 0.25+2.69 m (A) and 1.0+2.69 m (B).

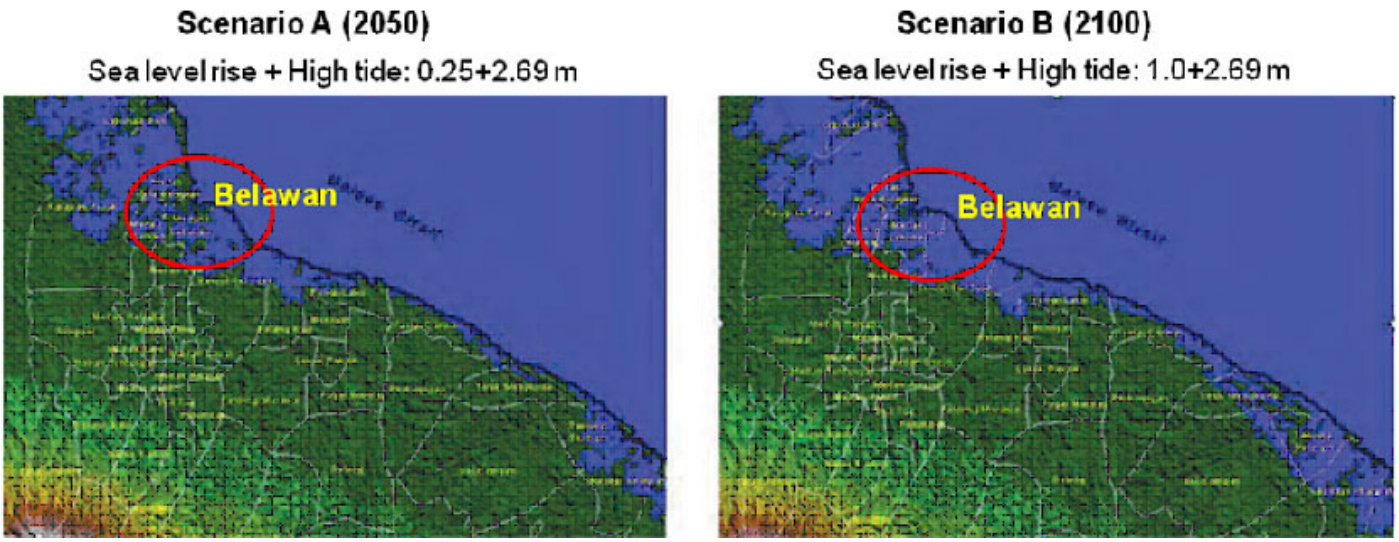


Figure 3. 6 Distribution of flood in North East Coast Sumatra (Source: Hariati et al.,2009 – ISNC Report 2010))

One of the priority areas to deal with high risk water sector is North Sumatra. For coastal and Outer Islands, the increase in sea level by about 25 to 50 cm in 2050 and 2100 as projected by many models will inundated many parts of the coastal cities of Indonesia. Land subsidence will exacerbate this, increasing the total area that will be inundated permanently. Between 25% and 50% of area in a number of sub-districts in coastal cities such as Semarang, Surabaya, Jakarta and Medan will be under water permanently (ISNC, 2010).

Flood

It is reported that Sumatra has the largest vulnerable areas. The contributing factors are for extreme rainfall of up to 400/mm/month and overloaded surface water sources/water reservoir such as river, ponds and dams. The rainfall in general is important to note that the trend of rainfall change maybe quite different, not only seasonal but also month to month. In Sumatra rainfall patterns over central and Northern part of Sumatra has been increasing to 10-50 mm since the period of 1960 – 1990. For the period of 2010 – 2020 significant increases in the rainfall are from December until March. Overlarge period of rainfall over Sumatra expected to increase for almost all seasons until 2020. During the period of 2020 – 2050, it has been projected that the increase of the rainfall pattern does not show significant number. However, for the period of 2070 – 2100 there will be large changes and it is projected that higher CO2 emission (ISNC, 2010).


Figure 3. 7 (Left) Flood in Jakarta; (Right) Flood in Surabaya (Source: Internet Download, 2011)

Climate Change Adaptation in Indonesia

Van Drunen 2009 said on climate change adaption is a 'no regret' decision. Adaptation refers to strategies that act to reduce the adverse impacts of climate change and also to make benefit from it. The occurrences of extreme climate events have caused serious impact in many sectors. Current capacity to anticipate to such events is still low. In the future the intensity and the frequency of these extreme climate events may increase. If the capacity to adapt to such changes will not develop from now, Indonesia may not be able to achieve sustainable development. Plans for adaptation to climate change need to be developed. Planned adaptation to the future climate will be based on current individual, community and institutional activities that, in part, have been developed as a response to current climate (Jones et al., 2004 cited in Country Report, 2007).

As developing country, Indonesia has several limitations in funding in the frame of climate change anticipation as well as developing and disseminating environmentally friendly technology. Therefore, the problems of technology transfer and funding are two issues that should receive support from international community. Additional important activities, which will ensure success of mitigation and adaptation program, are awareness, education, empowerment and capacity building (ISNC, 2010).

According to the report there are some of adaptation measures done in the cities (among other places) to cope with flooding from sea level rise, tides and extreme waves include:

1. Development of dike equipped with polder system to protect area behind the dike (Figure 3.6);
2. Mangrove rehabilitation in an effort to increase soil surface and reduce wave energy destruction so that the rate of erosion can be reduced; and
3. Practicing fish culture using sylvof shery.

Figure 3. 8 Construction of a dike to reduce fl ooding from high tides and extreme waves in East Harbour of Muara Bary, Jakarta. (Source: Media Indonesia, 2007 in ISNC)

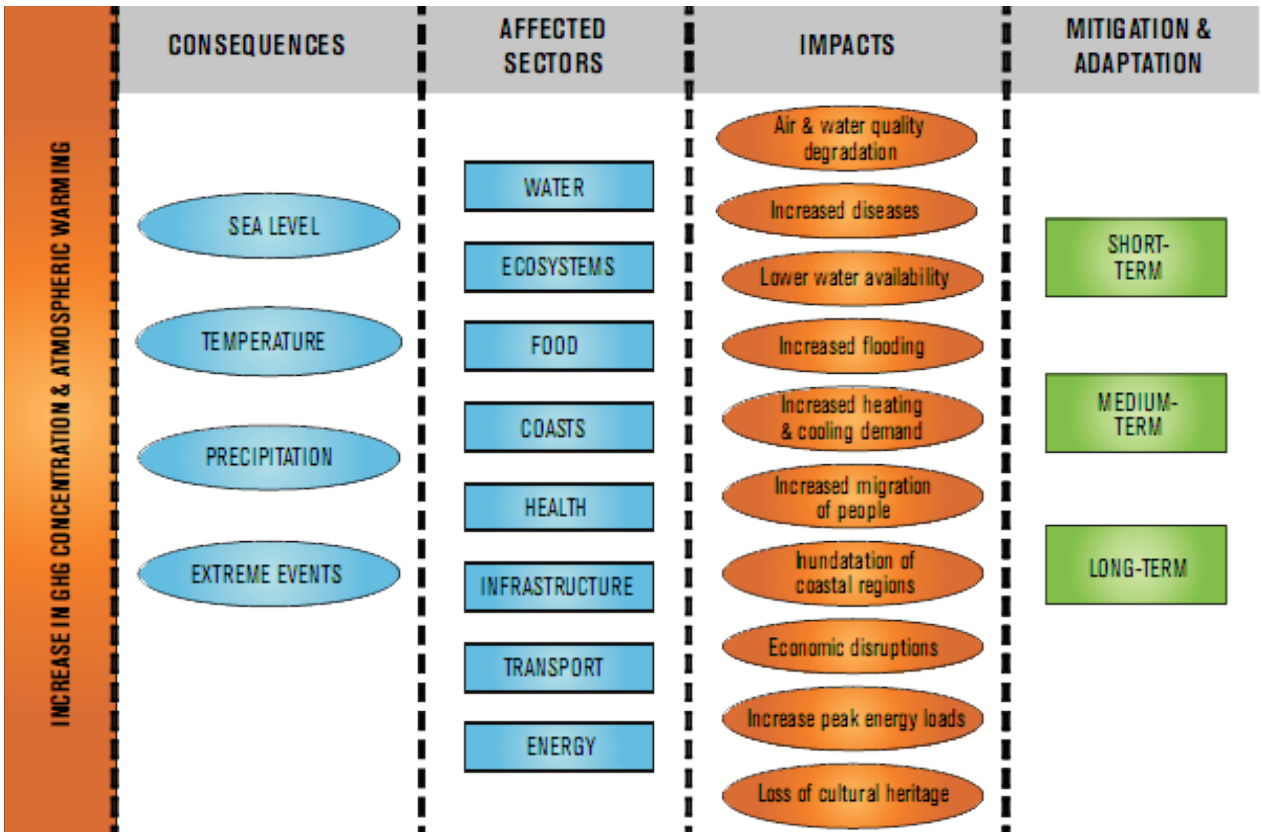


Table 3.1 Government Response Scheme on Climate Change (Source: ISNC, 2010)




Figure 3. 9 (Above left) Flood in housing area; (Above right) flood in low lying area; (bottom left) flood in city; (bottom right) flood in fishermen village (Source: Author)

3.4 Climate Change Impact in Belawan

Climate change is also impacted in Belawan. Not only from the sea level rise, and the changing pattern of the high tide but also at the high precipitation level. High surface temperature trigerred into fast evaporation, especially in coastal city.

The topography of Medan as is undulating with an altitude around 2.5 above sea level. Due to the topography, this region is not vulnerable to flooding due to sea level rise equal to one meter or less. Sea level in Belawan is projected to have a significant rise in 2050 for 0.25 cm and 2100 for 1 m. According to studied from Heriati et. al (2009), the probability of coastal areas affected by flooding due to sea level rise alone (Scenario 1) is low even with sea level rise up to 1 m. However, when combined with high tide (2.69 m), a significant area will be inundated. The extent of water flooding inland due to sea level rise and high tide is varied depending on the topographic of the area. Because of the nature of the floods in this region are only temporary, the damage to infrastructure is small, but if the flood affected the functions of wetlands and ponds, damage will be high and lead to large economic losses.

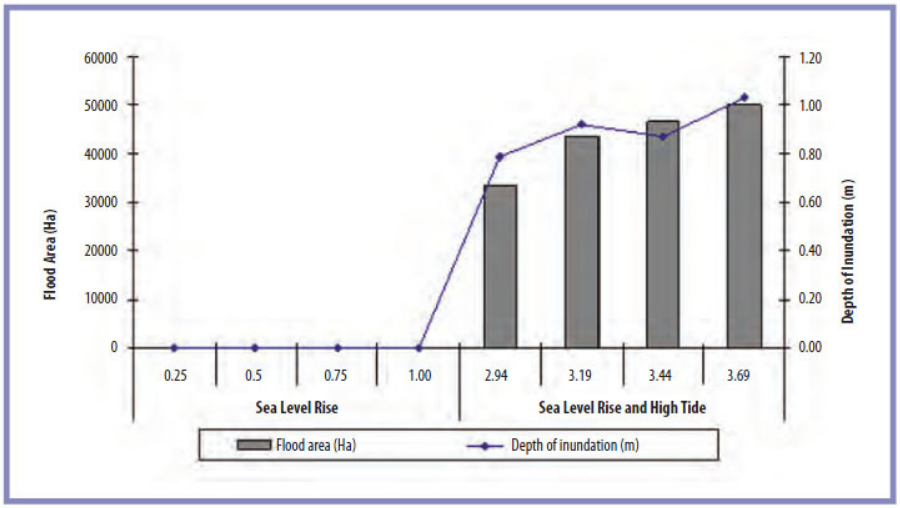


Figure 3.10 Distribution breadth and depth of inundation due to sea level rise and high tide of Medan andsurrounding areas (Hariati et al., 2009 in ISNC 2010)

Scenario		Population (x 1000)	Economic Loss (billion IDR)				
			Settlement	Rice	Ponds	Harbor/Airport	Total
SLR + Tides + Waves (m)	2.94	368	0.00	29.24	17.50	0.00	46.74
	3.19	588	0.00	40.41	21.06	0.00	61.48
	3.44	761	0.00	43.23	21.95	0.00	65.19
	3.69	998	0.00	46.02	22.73	0.00	68.75

Table 3.2 Impact of sea level rise and high tide on population and land use in Medan (Hariati et al., 2009 in ISNC, 2010)

Hariati (2009) has been studied on the region around Medan and surround Belawan area (Deli Serdang District) that the main land use types situated below an elevation of 100 m a.s.l. are ponds, dry land farming and settlements. The size of settlements in Medan are most likely to be affected by flooding are 320-770 ha, and this will threaten the residents who live in the area. Hariati et al also reported that with sea level rise of 2.94 meters (0.25+2.69 m), the total population aff ected by the temporary flood is approximately 370,000 people; when sea level rise increases by 3.69 meters, the population aff ected increases to 1 million people. Furthermore she continues the sea level rise of 2.94 meters, the total area of wetland ponds aff ected by flooding is almost 18,000ha, equivalent to an economic loss of approximately47 billion IDR. With sea level rise of3.69 meters, the amount of economic loss increases to approximately 69 billion IDR (Table 3.2) (Hariati et al, 2009 in ISNC, 2010).

Figure 3.11-a Weak Coastal Protection

Figure 3.11-b Low Lying sea bed in the fishermen village

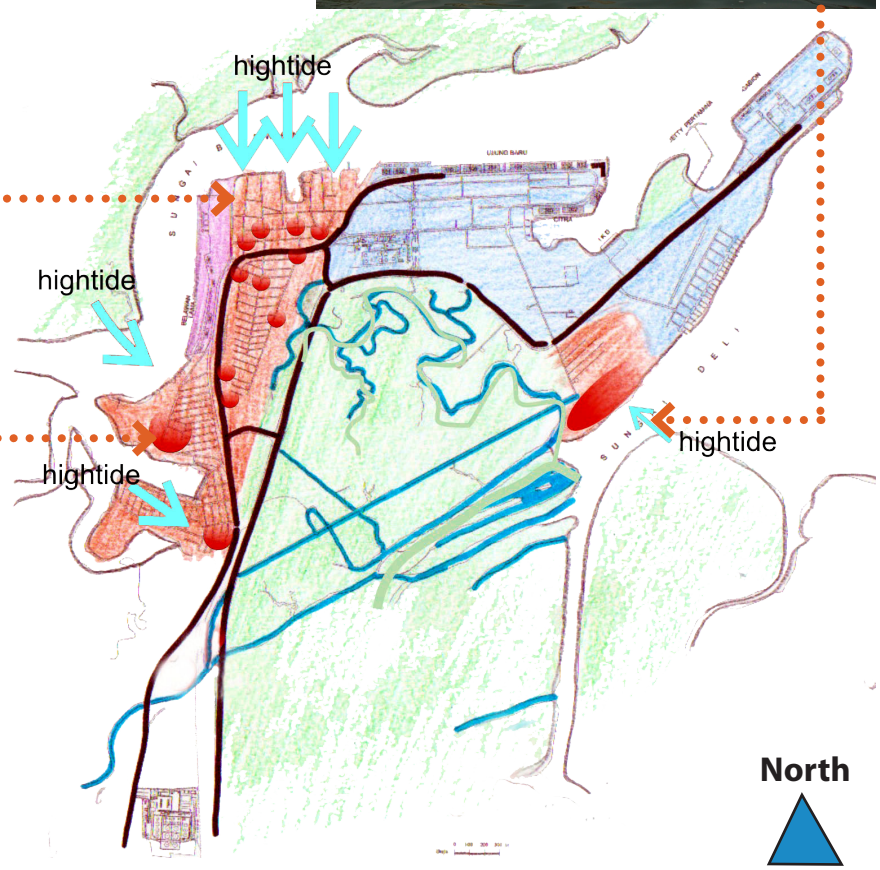


Figure 3.11 Potential opening to the high tide

Sea Level Rise Impact in Belawan

High tide in Belawan occur two times a day, there are two tides that reach the greatest amplitude, the spring tides or in local language called Perdani tide, occur when the earth, sun and the moon are in the straight line (i.e. about the times of the new moon and the full moon); the second is Neap tides or also called Dead tide by the local people, or the smallest amplitude, occur when the sun is opposed (is the right angles) to the gravitational pull of the moon, and it happens about the times of the first and last quarters of the moon.

During the high tide, there are opening at the tip of the island that easily for the tide to flow in (FIgure 3.11). From the Northern part of the island, the tide can flow in because there is now significant protection (FIgure 3.11-a). High tide also comes from the low lying sea bed of the fishermen village inwards (Figure 3.11-b).

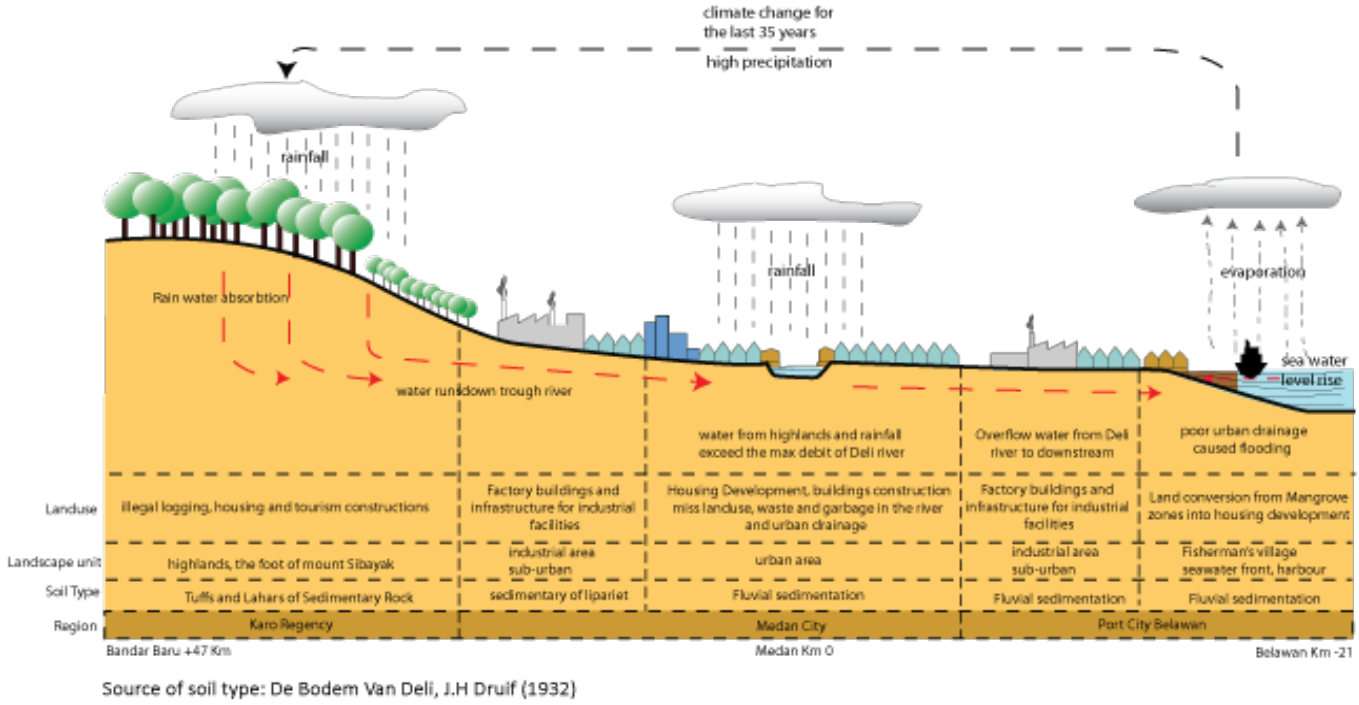


Figure 3. 12 Cycle of evaporation process from Medan to Belawan

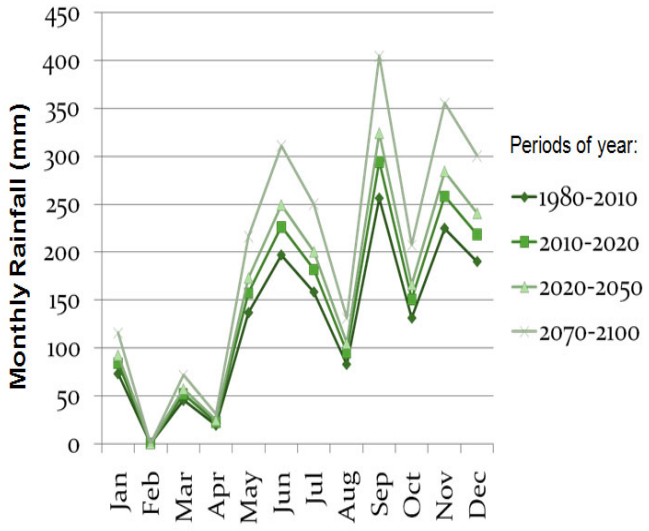


Figure 3. 13 Graphic of monthly rainfall in North Sumatra (Adapted from BMKG and ISNC report, 2011)

High Precipitation Level in Belawan

For the last 30 years, there has been rised of the precipitatoin mm according to Belawan station. It is recorded since 1980 the rise mainly during June, September and November and January (Figure 3.11). The graphic shows the adaptation measure of increasing monthly rainfall for 30-40% until 2050.. In the period of 2070-2100 there will be significant risedduring June, September, November . The peak rainfall will be during September.

The rainfall is caused by high surface temperature in the sea and evaporate to the clouds. Hardest rainfall will be in the mountain area (Figure 3.12). Belawan is located at the estuarine of the two rives. Thus, the impilcation from the rainfall from river upstream will also show significant impact to the over flow from the rivers.

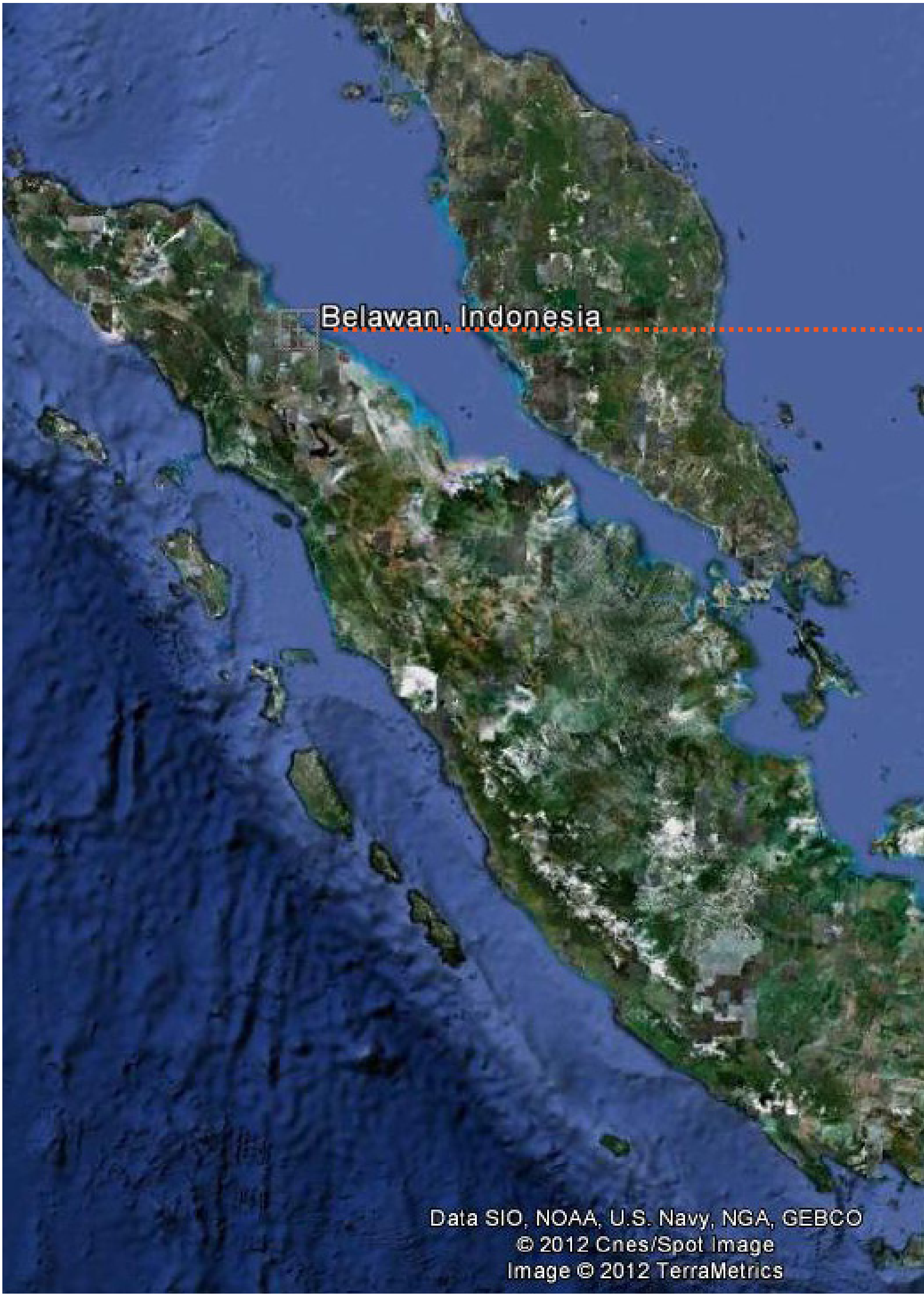
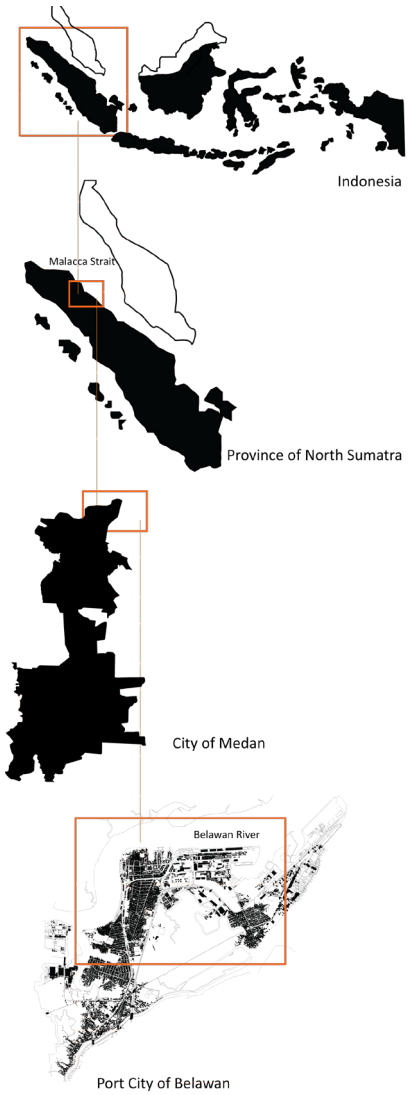

Belawan, Indonesia
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
Image © 2012 TerraMetrics

Figure 4.1 Aerial Map of Belawan (Source: Google Earth, 2011)

IV. Belawan Port City

Belawan is part of Medan city the capital of North Sumatra province and geographically coordinated in Latitude: 03" 48', South - Longitude: 98" 43', East (Figure 4.1). In the northern side, Belawan is adjacent with Malacca Strait and located at the estuarine of Belawan and Deli River with distance of 23 km from Medan city center. This is the advantage of Belawan to be a port and used to be the most important port in the Eastern Coast of Sumatra to export tobacco. Belawan port is the busiest port outside Java because its geographic location at the western gate of Indonesia.

Statistically, the district own 9,88% area of Medan which is 2,625 Ha. However, according to satelite imagery and using photo interpretation of 2005 the area is 3,186 Ha (*RDTR BelawanDistrict, 2010*) that consists of 2,514.30 Ha land and 671.80 Ha water.



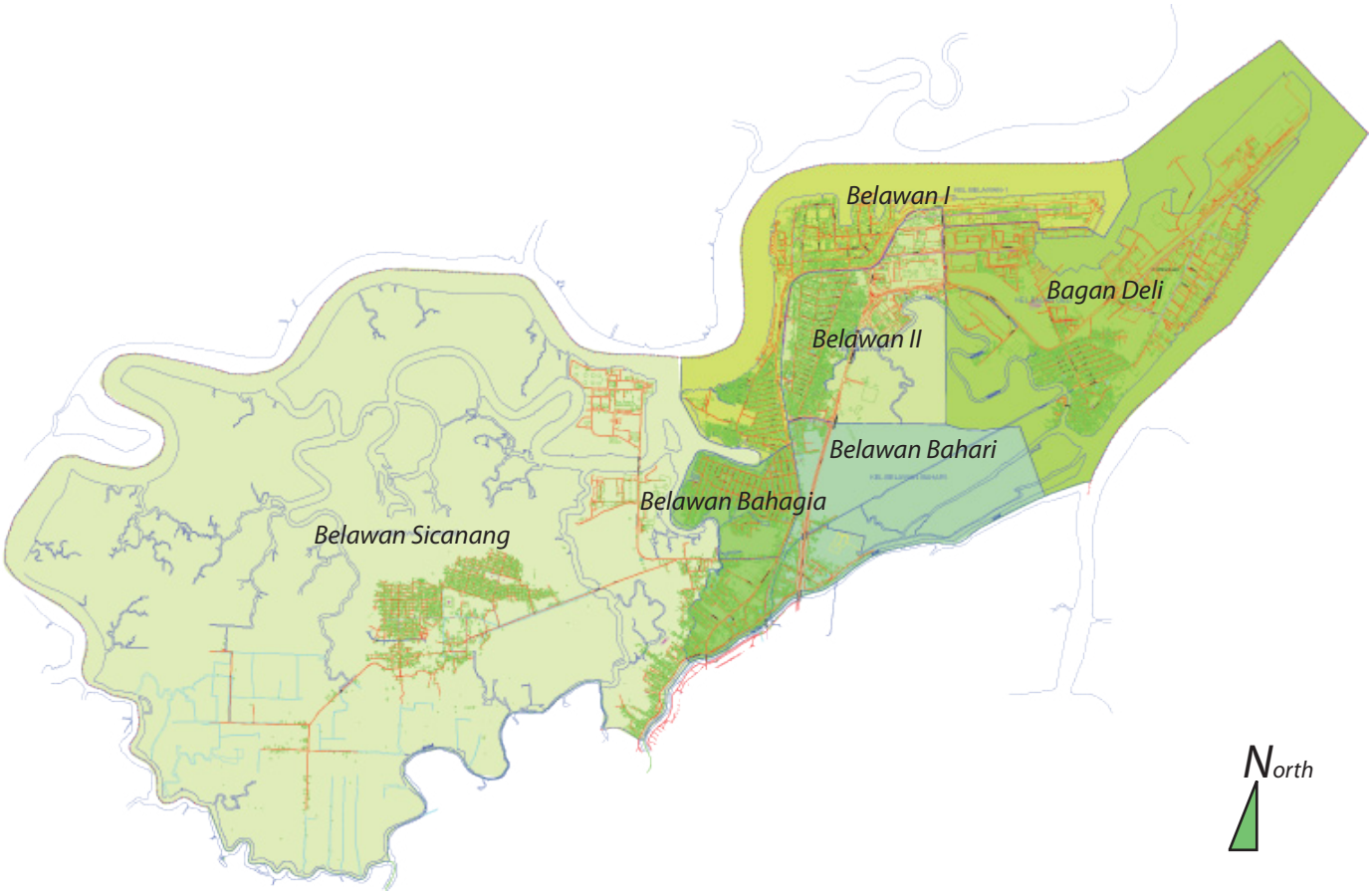


Figure 4.2 Map of Belawan Sub District (Source: Adapted from Regional Map of Medan city

The administratic Belawan is divided in six sub districts; Belawan I, Belawan II, Belawan Bahagia, Belawan Bahari, Belawan Sicanang and Bagan Deli (Figure 4.2). The people occupations are as fisherman, government officer, port labor, enterpreuener, etc. The city is developing faster as the growth of the population that rises into 95,506 people for the last 10 years.

In this chapter will be discussed the history behind the morphology of the landscape and the port city. Moreover, Belawan is consider to have opportunity to develop even bigger, by taking into account the challenge and opportunity of the nature, people, culture and biodiversity have to offer.

Figure 4.3 Tobacco Leaves from Deli (Source: Download from Internet, 2011)

Figure 4.4 Labuhan, government center of the first Sultanate of Deli (Source: http://melayuonline.com/ind/history/dig/367/kesultanan-deli)

4.1 The History of Belawan

The development of this port city has a strong relationship with the history of Medan and that is how this story will be started.

Medan used to be known as Tanah Deli (Deli land) with 4000 ha swampy area covering the land. There are several rivers that passing the land and empties to Malacca Strait. Two of them are Sei Deli and Sei Belawan. Many years later, Tanah Deli developed in to a small village called Medan surrounded by a tobacco plantation. The tobacco planting firstly initiated by a Dutch planter, Jacob Nienhuys in 1893 and in which six year later become a plantation company called Deli Maatschappij.

Deli tobacco leaves was famous not only in the neighbourhoods but also in Europe. The export of tobacco was transported by shipping from Medan to Sei Deli River estuarine and ship to Europe. Sei Deli estuarine was the small island called Belawan and because of this export activity it became a small port. Slowly, the plantation becomes a trigger of vast development of Medan and Belawan was the important port to export tobacco to Europe.

Figure 4.5(left) Map of Belawan Island in 1876 and (right) Map of Belawan Port in 1920.
(Source: Collection of WUR Library)

The distance from Medan to Belawan is 23 km because of the intensity of the transportation, Deli Maatschappij built a railway network with a company Deli Spoorweg Maatschappij to connect the two cities (Medan Beeld van Een Stad, 1997).

Belawan used to be a small island and named after the river Sei Belawan. The island was ruled by a kingdom called the Sultanate of Labuhan (Figure 4.4). After the railway construction, many people move back and forth from Medan to Belawand they started to see opportunity to live in this rich estuarine. Because of the growth of population and the demand of place to live, people started to built their houses along Sei Deli River, and become fishermen. Expansion and reclamation of the land through time since early 19 century shaped the morphology of the land into what it is now (Figure 4.5).

1876

In this early year, Belawan was a separated island from the main land. Based on the old map from WUR library special collection, the island called Kepala Angin. There was a small fisherman village at one part of the coast. It was consist of swamp and surrounded by mangrove forest ecosystem. This era was before tobacco to be the famous for the outer world. Not later until 1893 a young Dutch came over to planting tobacco and initiated a plantation company, Deli Maatschappij. The plantation had triggered development of harbour become bigger port to facilitate the need to storage the product

1920

Few years later after fast growth of the plantation in Medan, the port was expanded to provide demands of more storage facilities. The port activities became attraction for people to come, work and live there. They started to build houses around the fisherman village along Deli River. These were some of the factors that helped to shape the landscape into more massive with reclamation and siltation under the pole houses along the river. Another factor was the railway construction that was first initiated in 1920. The construction worked forced the island to join with the mainland.

1970

For nearly 50 years, the development of Belawan as not only port but also bigger industrial area and also city for people to live. After the declaration of independence in 1945, this port has developed its economy rapidly with post activities. The built of storage facilities and more over the housing sectors were spread like mushroom along the river. These construction badly implicated mangrove deforestation and also the build of illegal fish ponds. The city planning agency decided to make regulation to protect the nature by short term and long term development of Belawan.

2010

Today, as economy and technology are getting more sophisticated, the necessity to construct and build infrastructure can be done in short time. The expansion of the port dock for storage extended towards Malacca strait. Each year, because of the siltation in the shipping line, the port has to dredge the sea ground along the line. For the last 20-30 years, the construction of highway, factories and also housing sectors are changing the landscape massively. To transport goods and trailers, big trucks and cars are intensely made the connection road become busier with traffic. Moreover, mangrove deforestation for housing area causes the reducing of fish species stock for fishermen. The balancing of the environment is distorted because less infiltration area for storm water that caused into inundation and flooding.

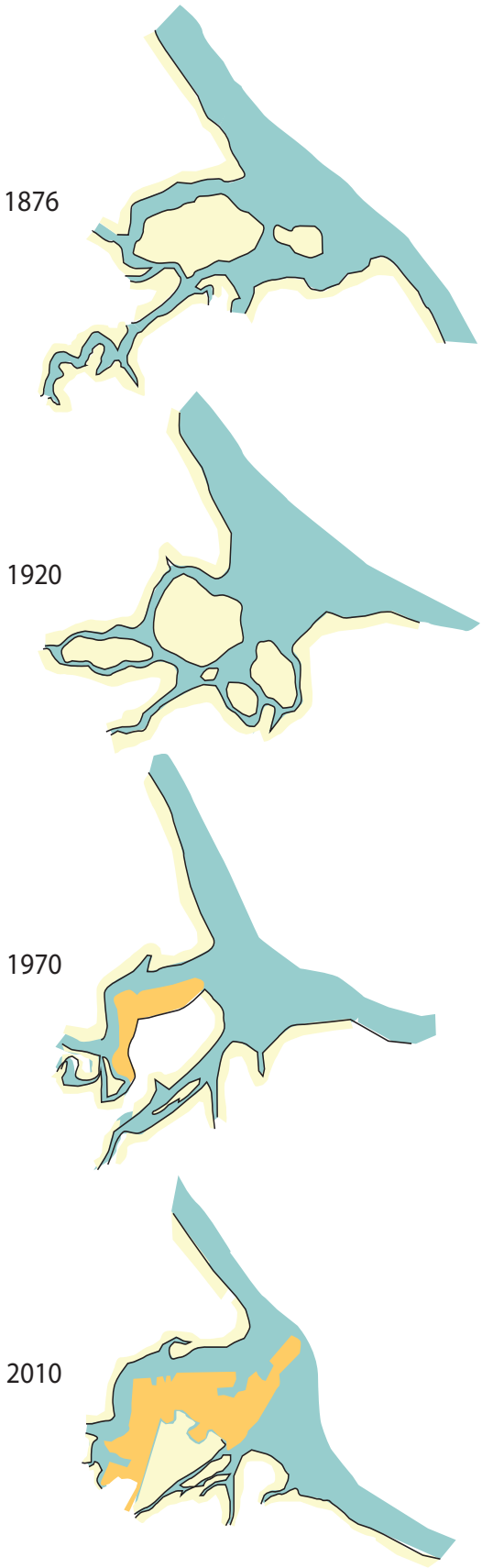


Figure 4.6 Morphology of Belawan Island
(Source: Author)

Figure 4.7 Port Belawan welcome dock (Source: Wisata Melayu.com)

4.2 The Port of Belawan

According to several resources, the port was initially built in 1890, to provide a location where tobacco could be transferred directly to the ships. The harbour expanded in 1907 with the construction of a new section intended for Chinese and indigenous traders, reserving the existing port for European shipping. In the early twentieth century the port's business expanded and 1920s more berthing facilities built. A major restructuring in 1985 saw the construction of a container terminal; it almost immediately captured about one-fifth of Indonesia's containerized exports (Port Belawan Webpage, 2007).

Today the port of Belawan develops rapidly with activities everyday including operational activity such as loading and unloading which has important economic impact for the city of Medan. The port itself has the facilities for storage 76 m2. For the outdoor container storage the area reach 136 m2. According to Parmono (2009), the calculation for the facilities provides the exporter and importer in Medan or Sumatra enough space to cover the needs for container storage. Not only for container or goods, the port also functioned as passengers port as the gate to transport passengers from Belawan to other part of the island or to Java. The activities within the port for domestic or international connection have made Medan as one of the most important city in the west (Pramono, 2009).

Figure 4.8 Port Belawan containers dock (Source: Port Belawan Webpage, 2011)

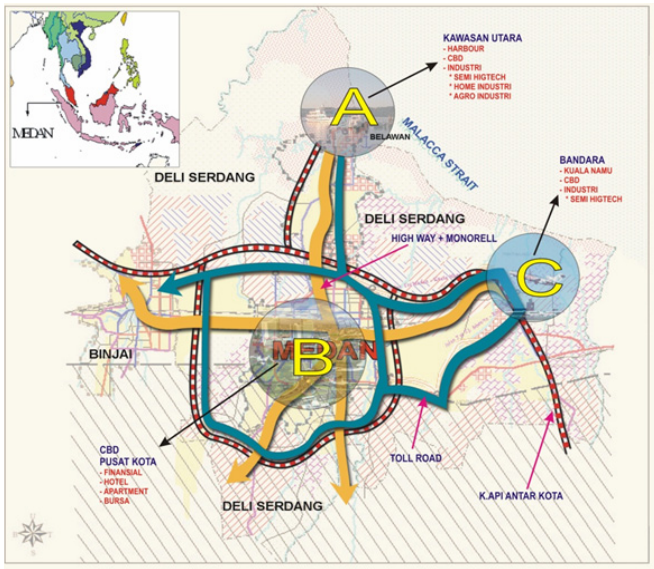


Figure 4.9 Medan Long Term Development Planning (Source: Medan Regional Development Planning Agency, 2008)

As a sub-district, Belawan is considered to be the focus development of Medan city. Hence, the planning department has made Belawan as Northern Medan Development (Figure 4.8). The port expansion, industrial area, and also the marine tourism are main sector to be opened for investment. These are supported by the richness of its nature and region.

To support the need for investment, the port management has made plan of expansion for facilities of more physical intervention. The development has to be sustainable in a way to keep the balance with the natural environment.

Figure 4.10 Landscape unit of Belawan

4.3 The Landscape of Belawan

As part of Medan municipality, Belawan located in the northern part as a delta in juxtaposed with Malacca Strait. The elevation is relatively flat that spanned from Belawan to Medan. That is why Medan was named *Median* by the Arabic traders means flat ground. The distance from Belawan to Medan is 23 km. The average ground level from the sea water surface is 5 m until Medan city center.

The landscape of Belawan coastal consists of several land units that can be distinguished, starting from the coast inward to the land (Figure 4.10). The low lying depression swamp of mangrove forest along the coast and fish ponds. In main island consists of dock construction of the port. In the city the ground is relatively flat and along the fishermen village is the low lying sea bed.

Figure 4.11 (above left) City center of Belawan; (above right) fish ponds; (Bottom Right) Port Docks; (Bottom Left) Low lying sea bed (Source: author).

Water Influences

Located in between the river and the sea current, the low lying mangrove forest is influence by the saline sea water and the fresh water from the river that makes brackish water (Figure 4.12). The fresh water comes from up stream of Deli River where it meets in the estuarine with the saline water from Malacca Strait. From other side of the island, dominant influence comes from Malacca Strait to Belawan River because of the bigger opening.

With these two side influences, the chance of current flow to the island during the high tide is very significant. Especially from the side of Belawan River because it has direct access to main land of dense build area. However, some parts are already protected by the port dock construction.

From Deli River side, the main island protected by the low lying mangrove forest. However, during the high tide, sea water that flow to the creeck system towards the island will give high water level in the creek that may cause flood to the island.

Figure 4.12 Water Current influences in Belawan

Tide System

Looking at Belawan water flow which influences by the surface current at Strait Malacca around Sumatra island (Figure 4.13). In the larger scale can be explained that the tide in Sumatra occur twice a day, this because of the pull of the moon and to a lesser extent the sun (Whitten, Damanik et al. 1987).

Furthermore, Damanik and Whitten explained that In the open ocean the amplitude (height) of the tides is not more than about 0.5 m but in shallow seas around Sumatra it is commonly up to 3 m. They also explained that there are two tides that reach the greatest amplitude, the spring tides or in local language called Perdani tide, occur when the earth, sun and the moon are in the straight line (i.e. about the times of the new moon and the full moon); the second is Neap tides, or the smallest amplitude, occur when the sun is opposed (is the right angles) to the gravitational pull of the moon, and it happens about the times of the first and last quarters of the moon.

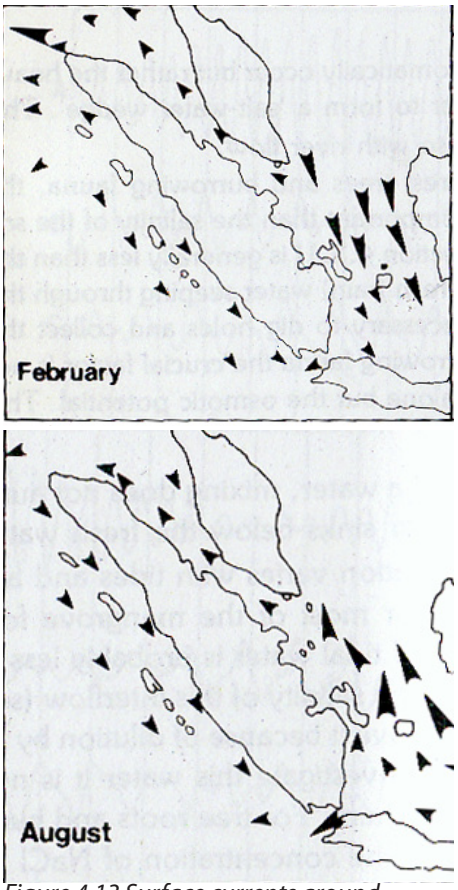


Figure 4.13 Surface currents around Sumatra during February and August. (Source: The Ecology of Sumatra, Whitten, Damanik et al. 1987)

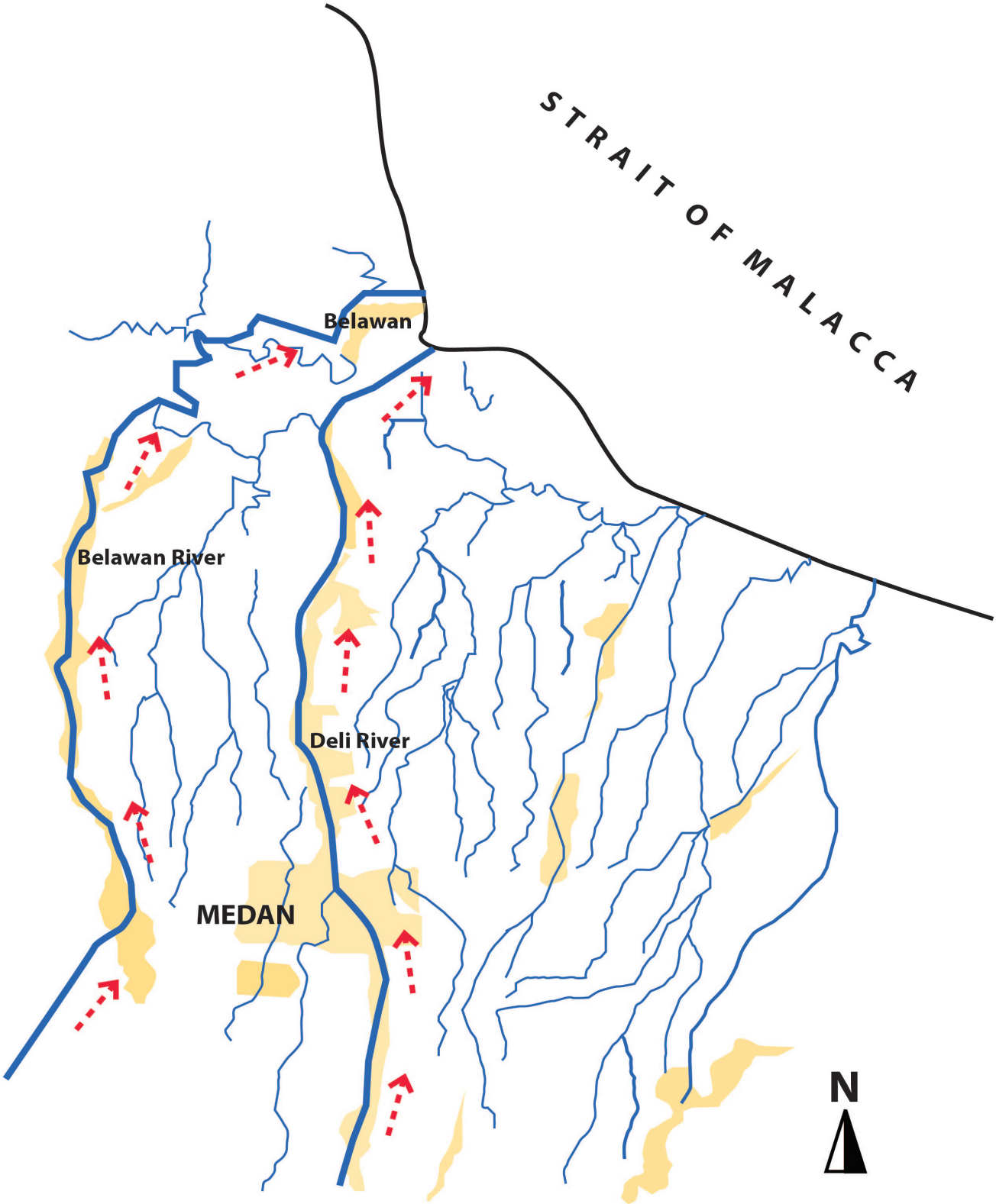


Figure 4.14 Flow of two Deli River and Belawan River from upstrem to downstream estuarine Belawan

Figure 4.15 (Left) Deli River; (Right) Belawan River (Source: Author)

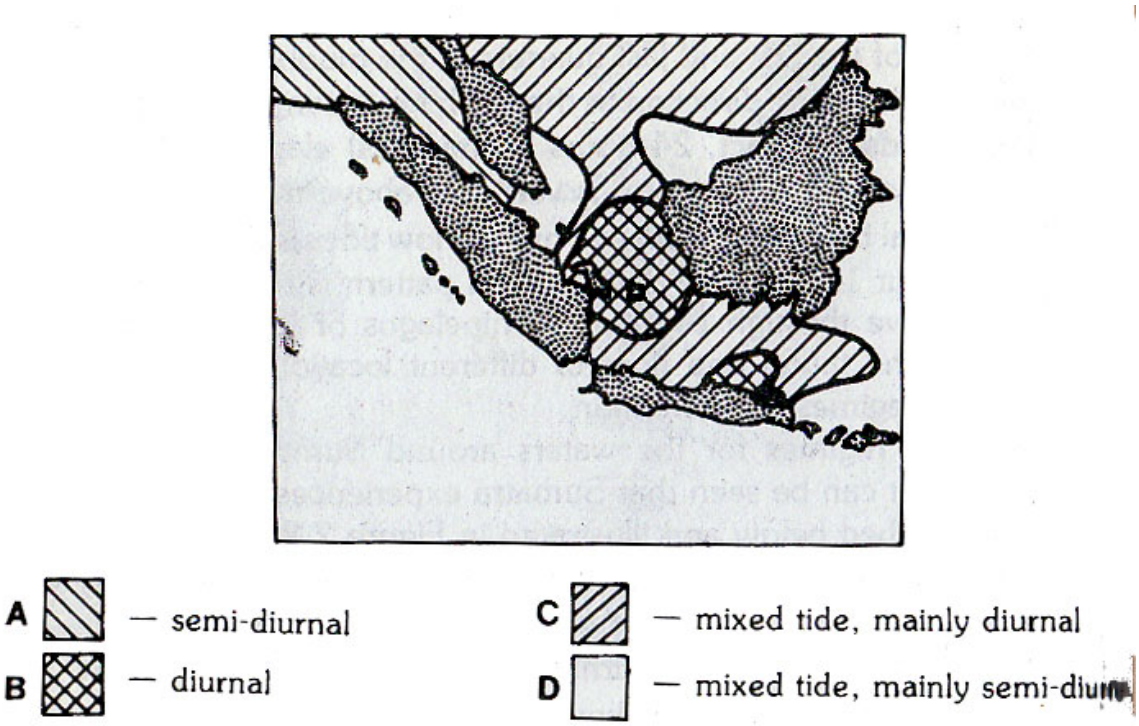


Figure 4.16 Distribution of tidal types around Sumatra. (Source: The Ecology of Sumatra, Whitten, Damanik et al. 1987)

Sumatra regions experiences four types of tide:

• Semi-diurnal tide – two high waters and two low waters daily with similar amplitudes;

• Mixed – tide, mainly semi-diurnal-two high waters and tow low waters daily with different amplitudes;

• Mixed tide, only one high water and one low water daily.

(Source: Whitten and Damanik, 1987)

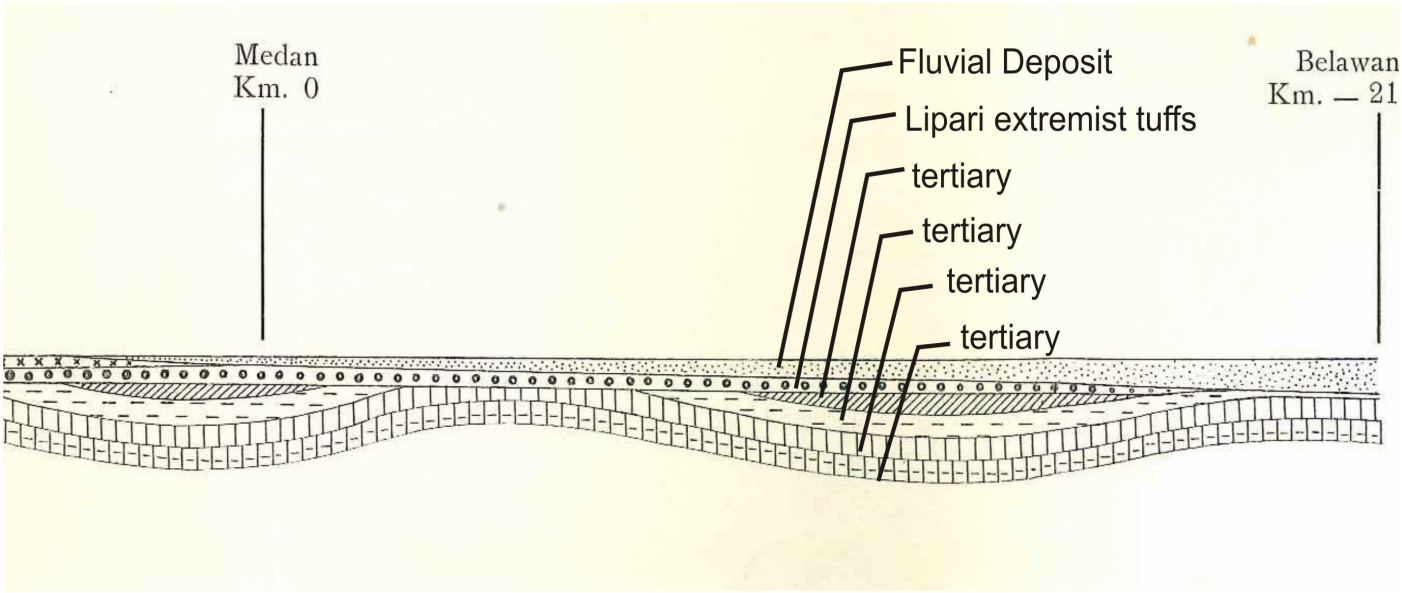


Figure 4.17 (Left) Soil layer from Belawan to Medan (Source: De Bodem van Deli , 1932)

Soil

The eastern fringe of Sumatra and the land either side of the major rivers are dominated by alluvial hydromorphic soils or grey hydromorphic soils (Whitten and Damanik, 1987). However, according to Duif (1932) in his book *De Bodem of Deli,* the soil type of Belawan to Medan is Fluvial Deposit, because the land is formed by deposit of rivers and streams.

Fluvial is used in geography and Earth science to refer to the processes associated with rivers and streams and the deposits and landforms created by them. When the stream or rivers are associated with glaciers, ice sheets, or ice caps, the term glaciofluvial or fluvioglacial is used (Wikipedia, 2012).

The characteristics are fine, brown to reddish brown and loamy. For the fluvial soil found in the upper rolling area, the soil texture is coarse and sandy (www.onep.go.th). Because of its sandy texture, it is easier for water to inflitrate. However, most of the mainland is covered by concrete construction. There are necessity to have more open space for water infiltration.

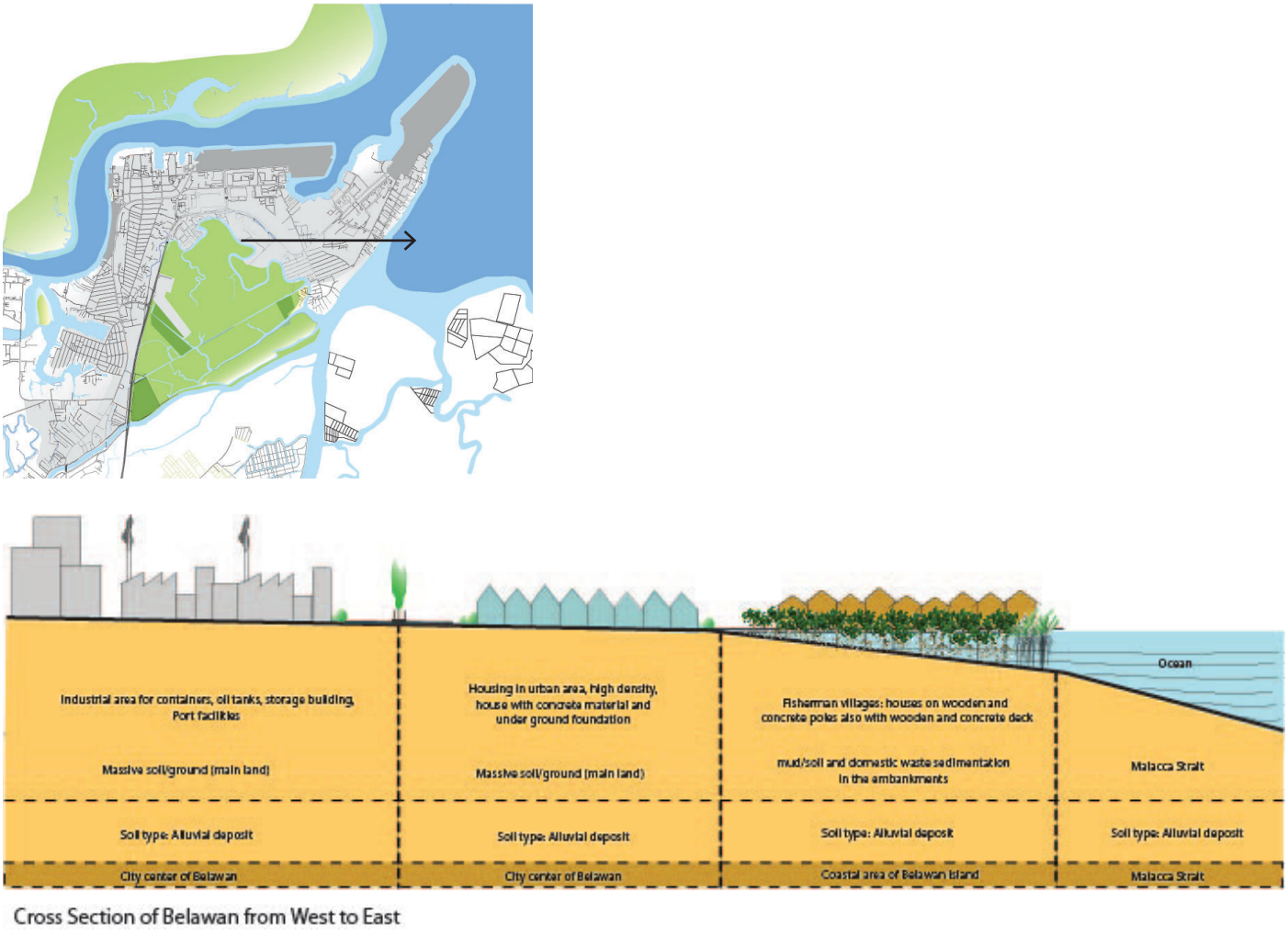


Figure 4.18 Cross Section of Belawan from West to East (see keymap above).

Landuse in Belawa

Landuse in Belawan divided in several zones; Industrial area, port facilities, housing area, pole houses of fishermen village and fish ponds located in the low lying mangrove forest (Figure 4.18). Industrial area and port facilities used for containers, oil tanks, storage buildings, and the management building separated in different building complex. In the city center of Belawan consists of shop houses, housing area, government offices., and old railway. There are several open green space manage by the local government and also the port management.

At the riparian low lying sea bed, there are fishermen pole houses at the side of Deli River and also Belawan River. However, most of low lying mangrove forest located in the Deli river side of the island.




Figure 4.19 (Above left) The port dock; (Above Right) Pole houses; (Bottom Left) Concrete houses; (Bottom Right) City center

4.4 Social,Cultural and Biodiversity

The population of Belawan is 95 thousand people with different ethnic backgrounds, Malay; Bataknese, Javanese, etc. Mostly people living in the North Eastern coastal area is dominated by Malay as most of the fishermen in Belawan. Malay people have a certain culture to appreciate arts and pleasure. They enjoy everyday live by entertaining themselves like singing, dancing and playing. Malay people also enjoy beauty, beauty or aesthetic appreciation. Based on my own observation and also as Malay myself, we see beauty in the shape of neatness, cleanness and also colours. However, through time of changing and globalisation, sophisticated technology has become our extra value to appreciate aesthetic. For example, on my observation on fishermen in Belawan , they prefer to watch TV, listening to music, and playing on their gadgets instead of sitting in the park or walking in the woods.

Figure 4.20 Biodiversity in Belawan

Biodiversity

Belawan and its surrounding are rich of flora and fauna. The richness and fertile ecosystem become favorite place for migrating wildlife and also marine species.

There are several marine species in Belawan such as; Shrimps, Crabs, Krapu fish, etc. These fish are normally used for the aquaculture in brackishwater fishponds. Other type of marine species are mostly in the mangrove forest to take the benefit of food resource from mangrove tree.

Mangroves ecosystems in Belawan is the main biodiversity. It contributes symbiosis mutualism for the fauna and also for the food chain. There are several types of Mangrove in Belawan. Mangrove tree in Belawan is also used by the local people for fire wood and the ecosystem are used to gain nutrient for food for their fish breeding in the magrove forest fish ponds.

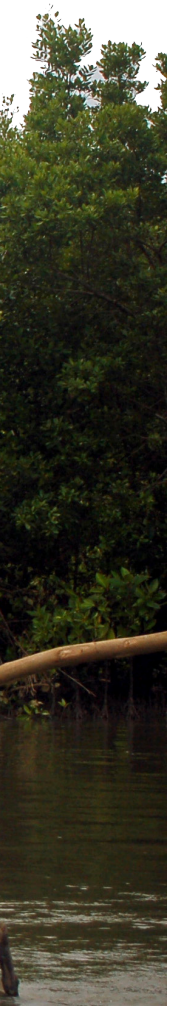


Figure 4.21 (above left) Nhypa; (above right) roots for fire wood; (Bottom right) the flowers; (Bottom left) Bakau minyak.

Types of Mangrove in Belawan are in (Indonesian names):
- Nypha
- Bakau minyak
- Bakau Api-api

Mangrove forest in Belawan is beneficial not only for the people but also for protecting the land from high tide and tidal power. Mangrove is a unique inter-tidal wetland ecosystem found in the sheltered tropical and subtropical shores and riverine areas. Mangrove plays an important role in storm protection, and this protection depended on the quality of the mangrove habitat (Azlan 2008). Mangrove forest is one of the many types of forests in Sumatra that exist in almost of the shores and some in river entrances or around offshore islands (Whitten, Damanik et al. 1987). Moreover, it is studied that mangrove forest forms a protective and productive margin to much of Sumatra's coastline. Degraded habitats or habitats with mangrove associate species instead of true mangrove species did not provide adequate protection. To some extend mangrove forest can reduce wave energy (Azlan 2008).

Chapter V. Problem Statement

5.1 Problem Analysis
5.2 Problem focus

Figure 5.1 Inundation after heavy rain in the city (Source: Medantime, 2010)

V. Problem Statement

In this chapter the problems occur in Belawan will be analysed and at the end of the chapter design focus will be chosen by sorting out the problems. The idea of this thesis was firstly comes up with the problems in Belawan. During fieldwork, I have observed and collected information related to the problems happened in Belawan. By making problem trees I tracked back what the problems, the cause and the effect are. Not only that, sketching and drawing that show where the problems occur are also analysed in this chapter. Furthermore, as this is a landscape architecture thesis research, at the end of the chapter, I try to address the strategic focus for the design, first is to handle the storm water runoff because of the high precipitation and the second is to protect the land from high tide and sea level rise.

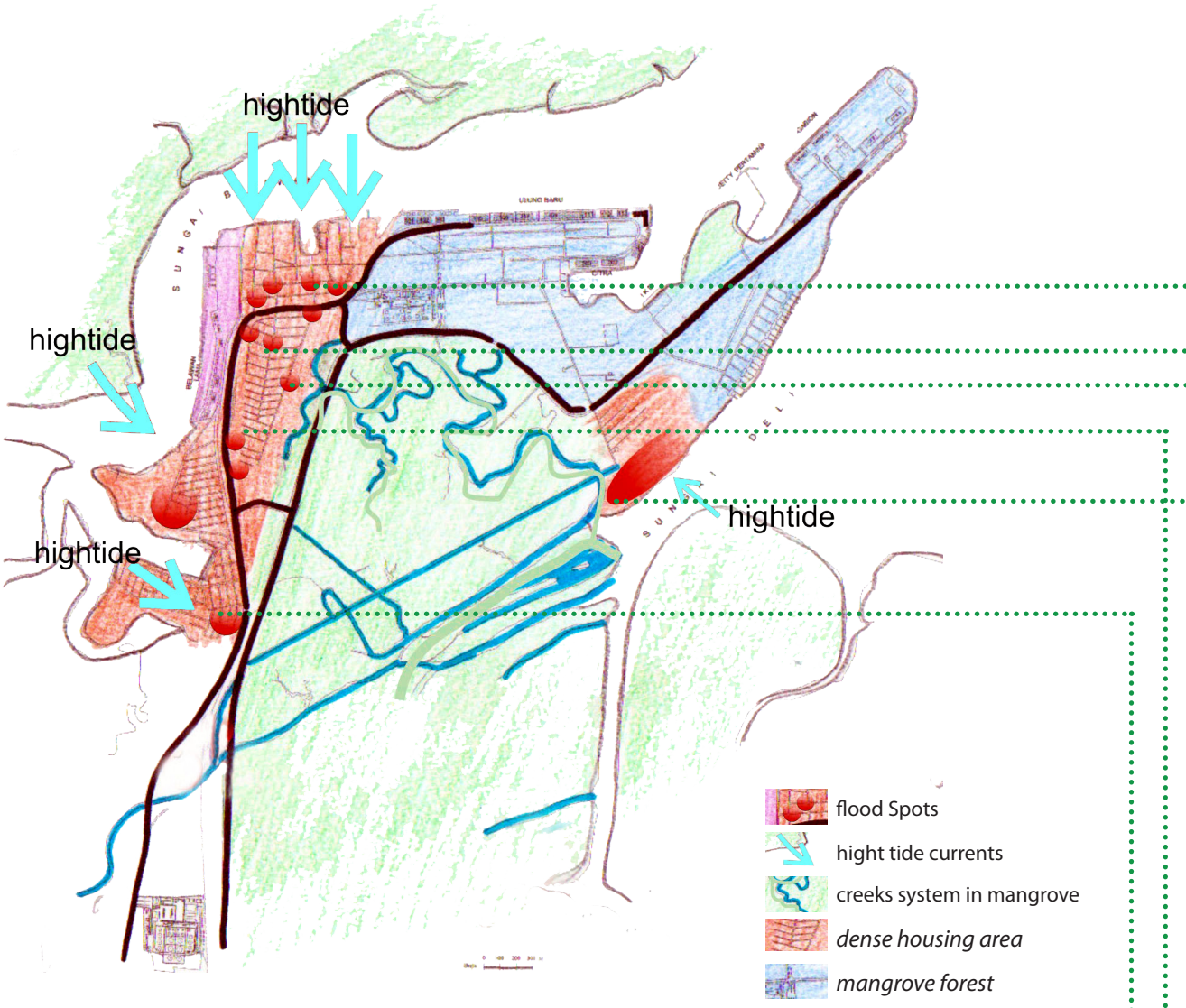
Figure 5.2 Sewage condition in one of the corner in Belawan (Source: Author, 2011)

5.1 Problem Analysis

5.1.1 Flood and Inundation

Flooding is threatened as the basic issue to start this thesis. Belawan has been flooded and inundated for almost 2-3 times a month since the growing of the population few years back. However, the term flooding and inundation will be defined and explained.

According to Merriam-Webster Dictionary, 'flood' as noun refer to a rising and over-flowing of a body of water especially onto normally dry land; also : a condition of overflowing<rivers in flood>. In other reference from Kansas Water Science Center, 'flood' is an overflow or inundation that comes from a river or other body of water and causes or threatens damage.



Drawing 5.1 High Tide flood

In the other type of word, 'flooding' according to www.thefreedictionary.com is the submerging of land under water, esp. due to heavy rain, a lake or river overflowing, etc. While the term 'inundation' as a noun means the rising of a body of water and its over-flowing onto normally dry land; "plains fertilized by annual inundations".

There are several issues to address as the effect of flooding and inundation; health; quality of the environment; welfare and economy. The problem will be analysing by studying the map, sketches and also data collected from interview and government record.

Belawan is divided into four different types of spatial used; the port facilities complex, dense concrete housing area, pole houses of fishermen village and the mangrove for-est. The main problem in Belawan is flood and inundation. According to government record on hazards mapping, there are several spots of monthly flood and inundation (Figure 5.3). Most of flooding because of the heavy rain is on the dense housing area. While inundation spreads in mostly coastal part especially in the pole houses of fisher-men village.

Figure 5.3 Inundation in city center

Figure 5.4 Inundation in old railway

Figure 5.5 Inundation in housing area

Figure 5.6 Inundation in fisherman village

Figure 5.7 Inundation in old railway

Figure 58 Inundation in housing area

Figure 5.9 One of the corner in Belawan during low tide (Source: Author)a

5.1.2 The causes of the flood and Inundation

Climate change has contributed to the problems happened in Belawan indirectly. Due to the rise of the precipitation level, current drainage system is not able to hold the surface run off. Moreover, poor maintenance causes siltation of mud and domestic waste in the sewage. It has been projected that in 50-100 years sea level will rise significantly due to climate change. Thus, force to protect the land from sea water has to be taking into account in the development.

As one of the important ports in Indonesia, Belawan has to keep up with demand of storage and supporting facilities. Hence, development and expansion of facilities are included in the future planning of the Belawan port. With limited space available, port expansion tends to look for empty space and put aside ecological balance. Deforestation of mangroves forest is one of the negative impacts of the development of the port.

With population of more than 95 thousand people, Belawan face the high demands for housing. Most of house ownership in regional districts is based on land ownership. Thus, more and more houses are built individually without following a certain rules and regulation. These are some of the main cause of flood and inundation where drainage system is not able to convey the surface runoff and less infiltration area because of densely build area.

Figure 5.10 Mangrove tree in eroded earth dike (Source: Author)

5.1.3 The effects from the flood and Inundation

Flood and inundation cause major issues in several sectors such as; health, quality of environment, welfare, and economy. Inundation in dense area happened 2-3 times a month, and it will remain for 4-6 hours each time (Figure 5.). In the pole house zone inundation mixed with mud siltation and domestic waste stuck under the house in between the pole. Inundation can cause the growth of germ, bacteria and mosquitoes. These will lead to health problem and diseases such as, Malaria and Dengue fever.

In dense housing area, inundation damage plants, grass and in larger context flood causes unbalance to the ecology. Aesthetically it will damage the face of the city and the quality of the environment. Dry mud after the inundation in fishermen village give unpleasant view with the combination of domestic waste stuck under the house.

Flooding that happened routinely are mostly early in the morning, and it during the office hour. Thus, this problem influences the everyday activities to go to work and also to school. As for the fishermen, inundation in the riparian area becomes the obstacle for local fishermen to sail in nearby mangrove zones. Over flow in mangrove zone will be difficult for bigger boat to see the depth of the water.

Due to obstacle from flood during people everyday activities, there are some delays in transporting goods, fishermen activities and also the some loses on house industry and local shops. This is impacted in the economy of not only the local people but also to the export import activities.


Belawa


n, Indonesia

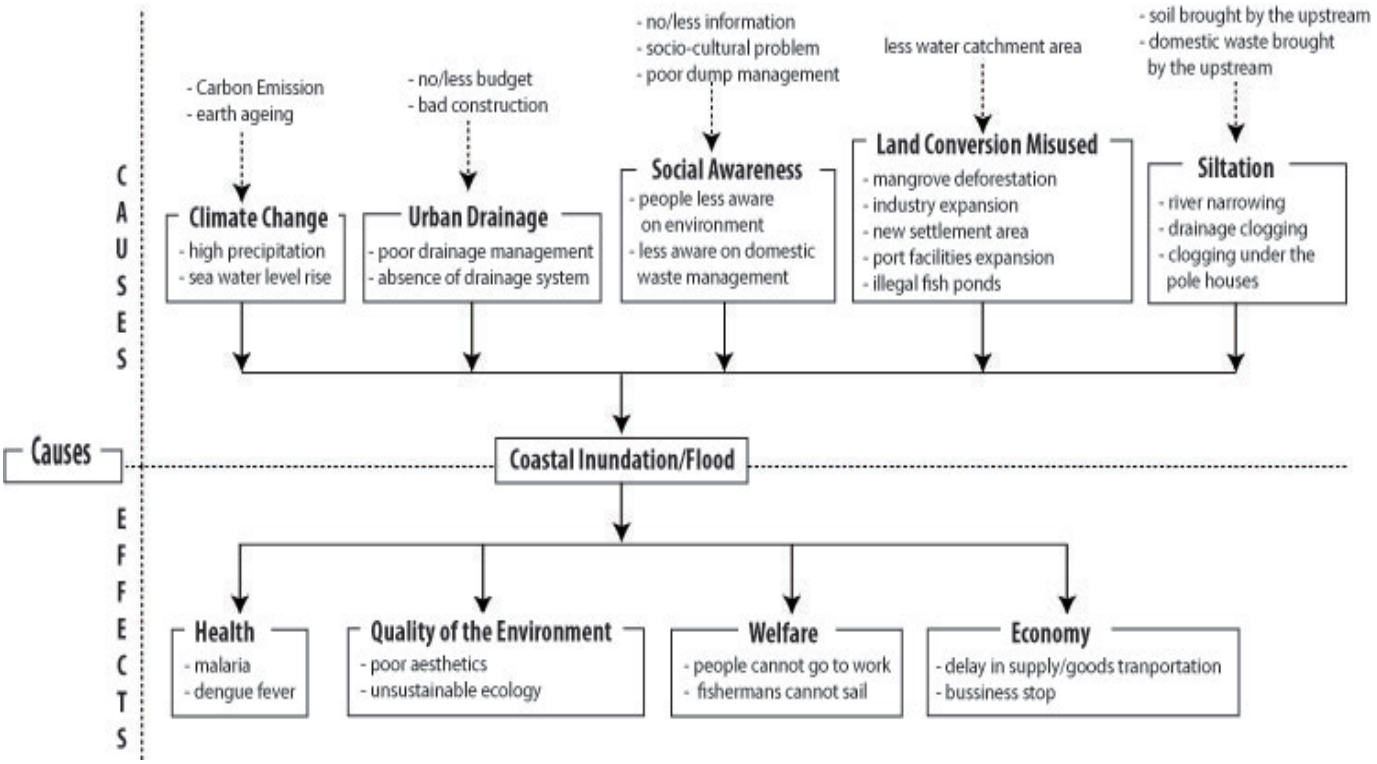


Figure 5. Problem Analysis of Causes and Effects

5.2 Problem Focus

As landscape architect, problem focus of this thesis research is to solve problems related to landscape architectonic intervention. The intervention is by means of how the landscape system works and causes the unbalance in the environment. Nevertheless, recommendation of program and planning will be suggested for government to be included in their program plan. The problems are divided in two focuses; the focus to solve the current problems, and the projection of future problems that might occur due to climate change.

The current problems:
1. Flood and inundation in the relative flat ground dense housing area, due to current drainage system is not able to hold and convey the surface runoff.
2. Flood and inundation from the high tide due to less protective coastal defense.
3. Domestic siltation in the pole houses

The projected future problems:
1. Flood and inundation due to the rise of the precipitation level
2. Flood and inundation due to sea water level rise.

Chapter VI. Theoretical Studies

6. 1 Constructed Wetlands
6.2 Mangroves
6.3 Aquaculture: Fish Ponds

Figure 6.1 Constructed Wetlands in urban area (Source: Internet Download, 2011)

VI. Theoretical Studies

6.1 Constructed Wetlands

Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971) defined Wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters (Scholz, 2006). Another, more succinct definition from Smith (1980) is that wetlands are a half-way world between terrestrial and aquatic ecosystems and exhibit some of the characteristics of each". Wetlands have many function and benefit for biodiversity and also ecological balance. Wetlands serve as a wildlife conservation resource, and can also be seen as natural recreational areas for the local community (Hawke and José, 1996 in Scholz, 2006).

Constructed wetlands are specially designed with a certain engineering system to be able to serve more effective function. This water ecosystem is functioned in three aspects; for the improvement of the quality of the water environment, protection of banks or sides of rivers and lakes; conservation of bio-communities (Liu 2008). In other words wetlands also functions as water purification system such as sewage treatment, urban runoff treatment, waste water treatment, etc.

Figure 6.2 Natural Wetlands in Belawan (Source: Author)

Sewage Treatment

Sewers or pipe is treatment works that convey waste dispose from domestic households and industry, and the arrangement of sewers is known as the sewerage system, thus everything that flows in the sewers is sewage (Scholz, 2006). There are two separate sewerage systems; one is for the foul sewer and the second for the surface water. The flow in a sewer can be estimated with Eq. the following formula:

$$DWF = PQ + I + E$$

Where,

DWF = averaged total flow in 24 h (dry weather flow) (QT/24);

P = population;

Q = mean domestic water consumption;

I = rate of infiltration;

E = industrial effluent discharge to the pipe; and

QT = total volume of flow in a 24-h period

Source: Scholz, 2006 – Wetland Systems to Control Urban Runoff

In the treatment principles, raw sewage contains 99.9% water and 0.1% solids. That is why the sewage needs to treat by separating the solids from the water (Scholz, 2006).

Scholz explained mentioned three methods to remove contaminant during the sewage treatment; either physical, chemical or biological in nature. The physical operations such as screening, filtration and sedimentation; chemical operations depend on the chemical properties and can be done by coagulation, precipitation and ion exchange; and the biological process that utilize biochemical and/or biological reactions such as percolating filters and activated sludge (Scholz, 2006).

For the Engineering classification of sewage treatment stages, Scholz (2006) argued that engineers tend to describe sewage treatment based on stages of treatment as follow:

• Preliminary treatment (physical); e.g., screening and grit removal;
• Primary treatment (physical and/or chemical); e.g., sedimentation and flotation; Sewage treatment.
• Secondary treatment (biological and/or chemical); e.g., constructed wetlands, biological filters and the activated sludge process; and
• Tertiary treatment (physical and/or chemical and/or biological); e.g., polishing wetlands, micro-straining, grass plots and lime precipitation).

According to Scholz, wetland systems can be designed for each engineering stage, and for sludgetreatment. But then he argued that constructed treatment wetlands are usually applied for secondary or tertiary treatment stages. For Wetlands thatintegrated in sustainable urban drainage systems (SUDS) Scholz argued that it is frequently used for preliminary and primary treatment purposes. As for urban runoff, it requires full treatment of combined sewer systems and minor storms.

Urban runoff flows to a watercourse exerts a polluting load on that water body with micro-organism present in the natural water and the wastewater breakdown (stabilize) the organic matter (Scholz, 2006).

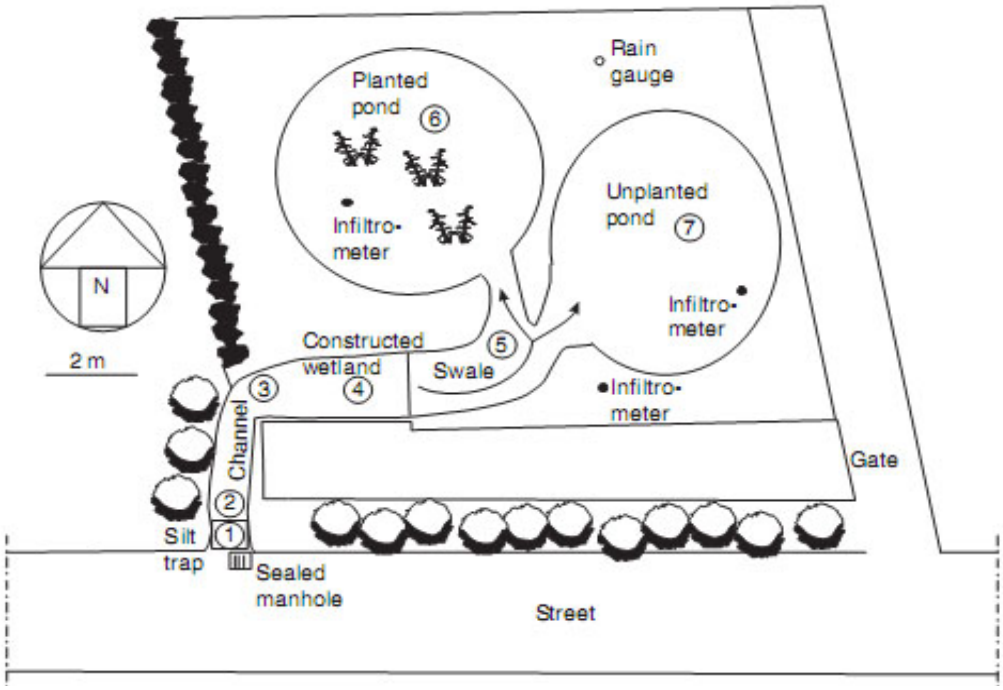


Figure 6.3 Design of a case study of road runoff (Scholz, 2006)

Urban Runoff Treament

Storm water runoff urban areas have been recognized as a major contributor to pollution of the corresponding receiving urban watercourses (Scholz, 2006). Pollutants consist in the urban runoff such as BOD, SS, heavy metals, de-icing salts, hydrocarbons and faecal coliforms (Scholz and Martin, 1998a; Scholz, 2004b as mentioned in Scholz, 2006). Urban runoff comes from rainfall from street and also roof.

Scholz also provide information about sustainable roof runoff drainage as a deliberation of the sustainable urban drainage system (SUDS) technology. He said that conventional stormwater and urban drainage systems are designed to dispose off rainfall runoff as quickly as possible. He suggests that combined attenuation pond and infiltration basin systems can be applied as cost-effective 'end of pipe' drainage solutions for local source control; for instance collection of roof drainage. Scholz quotes on Butler and Davies (2000) that runoff from roofs is a major contributor to the quantity of the surface water requiring disposal and this is a particularly beneficial approach, where suitable ground conditions prevail.

The SUDS is based on a combined wetland and infiltration pond design. The explanation is that the rainwater runoff from the road flows directly into a silt trap (Scholz and Zettel, 2004 cite on Scholz, 2006) (Figure 6.3). Water from the silt trap overflows via a gravel ditch into a constructed wetland, this wetland also serves the purpose of below ground storage tank. When the wetland attenuation system is full, the storage water flows over a dry stonewall into a swale and finally into the infiltration ponds.

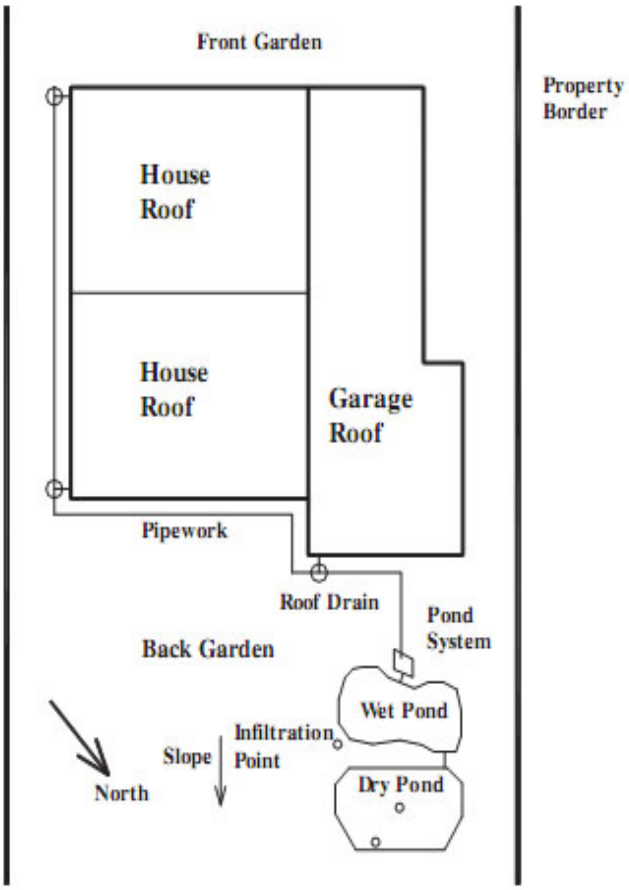


Figure 6.4 Design of a case study of roof runoff (Scholz, 2006)

Scholz gives a case study on applying SUDS by using the system of combining attenuation and infiltration basin design. The explanation is that the runoff from the roofs of one house (tandem garage attached) was drained directly into a silt trap, which fulfilled the purpose of a small sedimentation tank. The attenuation pond structure that overflows will be transferred to a vegetated infiltration basin structure. The ponds and the basin were planted with common aquatic plants.

Scholz quotes that flood protection management and recreational value can be improved by integrating infiltration pond design and operation (in contrast to conventional drainage) into the urban planning and development processes (Scholz quoting on Campbell and Ogden, 1999; Scholz, 2003). While the recreational activities may include watching birds and ornamental fish such as C. auratus, walking, fishing, boating, holding picnics and teaching children about aquatic ecology (Scholz quoting on Galuzzi and Pflaum, 1996). The last he concludes that stormwater can be reused for watering gardens and flushing toilets as part of an urban water resources protection strategy. Scholz also explains prevention of flooding in urban areas caused by inadequate drainage systems has become a significant problem.

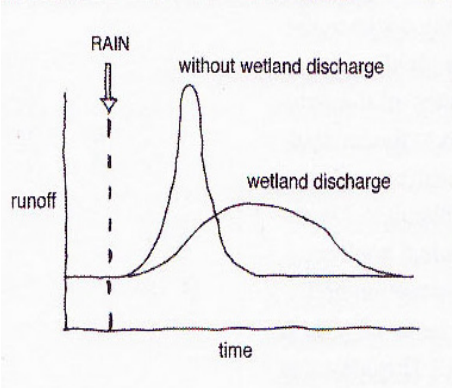


Figure 6.5 Graphic of water absorption in wetlands (France, 2003).

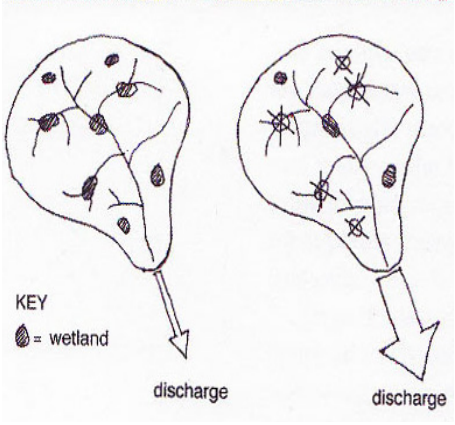


Figure 6.6 landscape influence in wetland design (France, 2003).

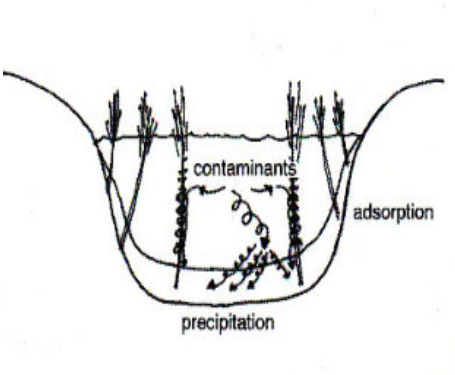


Figure 6.7 Contaminant removal in wetlands (France, 2003).

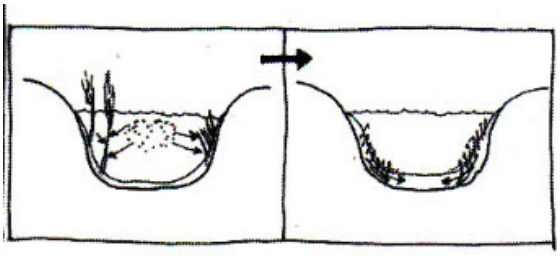


Figure 6.8 Biological method of contaminant removal (France, 2003)

From other literature about wetlands, Robert L France (2003) explained in his book *Design Wetlands* that wetlands creation is important tool that can offer region-wide landscape benefits in addition to site specific advantages. Furthermore, France elaborated on primary principle of hydrology modifiers such as for flood reduction as shown below:

a. for Site-specific. Wetlands operate like giant sponges in that they slow down absorb excess storm water runoff, then gradually release the stored water over a prolonged period. This is to reduces peak flows downstream and lessen the chance of flooding (Figure 6.5).

b. Landscape Influences. A strong positive relationship exists between the percentage of upstream wetlands that have been lost and the percentage increase in watershed peak flow discharge. (Figure 6.6).

c. Chemical. Contaminant removal is stimultaneously augmented through chemical precipitation and adsorption in addition to suite of chemical breakdown reactions (Figure 6.7).

d. Biological. Further removal contaminants occurs via microbial and plant (including algal) metabolism, plant absorption and eventual die-off, and sediment accumulation of organic matter (Figure 6.8).

Figure 6.5 Mangrove Ecosystem in Belawan (Source: Author)

6.2 Mangroves

Mangrove or in other name Rhizophora is a very special family plants. As coastal ecosystem, mangroves forest is unique and delicate but has multi benefits. The ecosystem has ecological and economic functions. For ecological function, it provides important ecological services and livelihoods for the mangrove associated communities themselves such as: as shoreline protection, prevent intrusion from sea water, as a habitat, feeding ground for various marine biodiversity, nursery ground, spawning ground, and also as micro climate control, mangroves can be used for household needs, industrial and for growing seeds (Rochana, 2011).

Mangroves refers to various kinds of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics – mainly between latitudes 25° N and 25° S (Wikipedia, 2012). Mangrove ecosystem distribution area spread on tropical and subtropical countries of the world. The Eastern hemisphere is Indo-West Pacific region that includes East Africa, Indo-Malesia and Australasia (Figure 6.7). The Western hemisphere is Atlantic East Pacific region that includes West America, East America and West Africa (Kathiresan, 2011).

In Sout East Asia, Indonesia has the largest mangrove ecosystem. Mostly found in Irian Jaya, Sumatra, Maluku, Kalimantan, Sulawesi, Java, and Nusa Tenggara.

Figure 6.6 Red Mangrove (Source: Wikipedia, 2011)

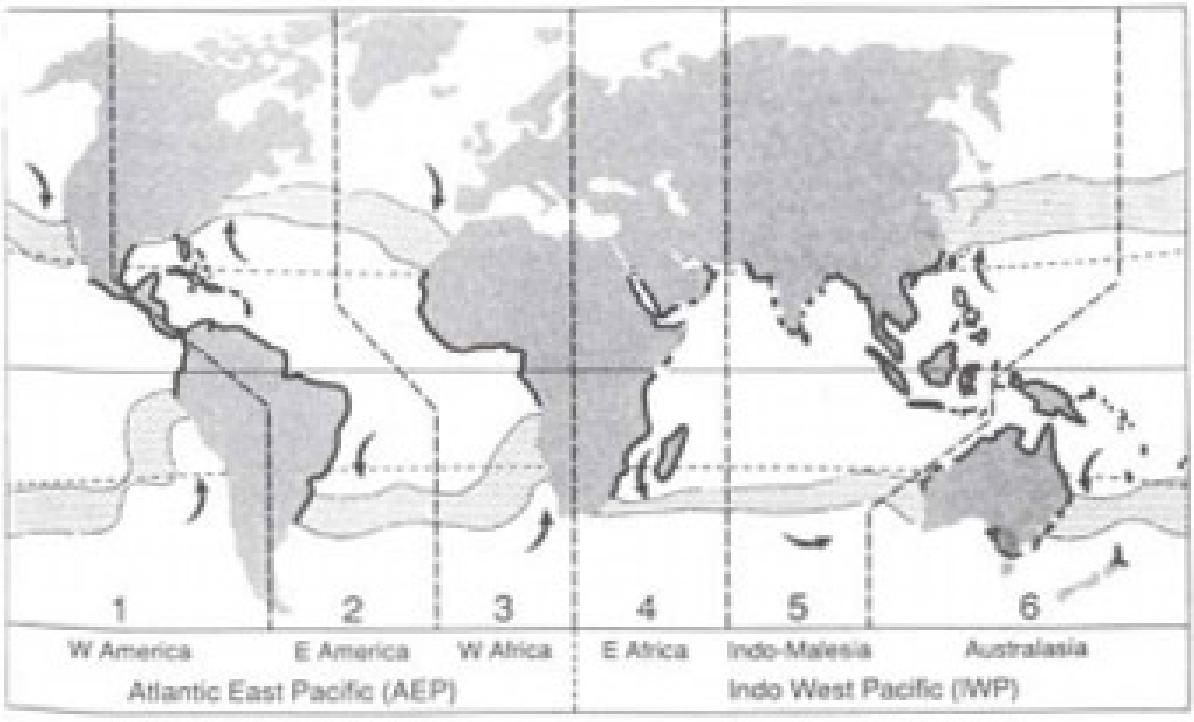
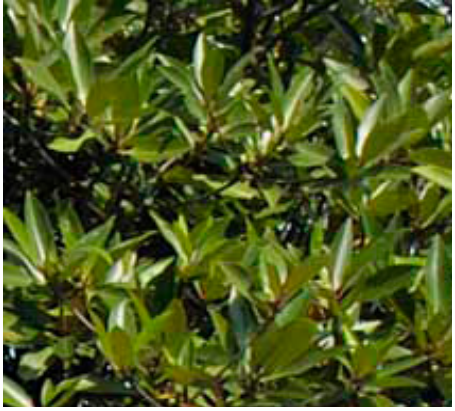


Figure 6.7 Mangrove World Distribution (Source: Kathieresan, 2011)





Principle Species of Mangrove Trees in Sumatra
Rhizophoraceae
Rhizophora apiculata (conjugata)
R. muncronata
Bruguiera cylindrica (caryophylloides)
B. gymnorrhiza
B. parviflora
B. sexangula (eriopetala)
Ceriops tagal (candolleana)
Kandelia candel
Sonneratiaceace
Sonneratia acida
S. alba
S. caseolaris
S.griffithii
Avicenniaceae
Avicennia alba
A. marina (intermedia)
A. officinalis
Meliaceae
Xylocarpus (Carapa) granatum (obovata)
X. moluccencies

Table 6.1 Principle species of mangrove trees in Sumatra (Source: The Ecology of Sumatra, Whitten, Damanik et al. 1987)

In Sumatra, mangrove forest is one of the many type of forest. It lies in some of the shores and functioned as a protective and productive margin to its coastline (The Ecology of Sumatra, 1987). There are only seventeen species which cover Sumatran mangroves (Table 6.1). Mangrove trees has characteristic of 'halophytes' that is how they are able to survive in saline soil.

Adaption capability of Mangrove

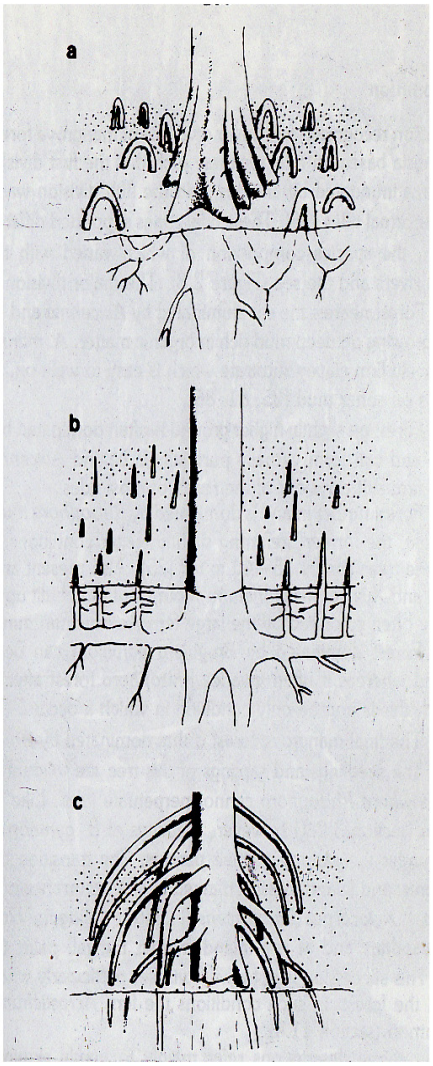


Figure 6.8 Different types of roots in mangrove trees: a. knee roots as found in Burguiera spp; b. spike roots as found in Sonneratia spp, Avicennia spp. (sometimes Xylocarpus moluccensis); and c. stilt roots as found in Rhizophora spp. (Source: The Ecology of Sumatra, Whitten, Damanik et al. 1987)

Mangrove is special because physically it has the adaptive capability against certain circumstances. Their adaptation is include their leaves, their roots and their reproductive methods in order to survive in a harsh, dynamic environment of soft, low oxygen soils and varying salinity (www.indiscapes.com, 2011).

1. Leaf adaptations to saline conditions, many mangrove species have leaves that storage a lot of salt and excrete it if its too load, by large opening of the stomata it alows mangrove to conserve fresh water and it allows to survival in saline environment. The leaves are also able to reduce its size to reduce evaporation during hot sun.

2. Root adaptations to soft, saline, low oxygen soils. Other special of its roots is its distinctive far reaching roots with differen shapes and sizes, they all perform an important function – structural support in the soft soils (Figure 6.8). Some species with above ground roots allow oxygen to be transferred to the roots trapped below ground in the anaerobic (low oxygen) soils. Other values are many mangrove species are also adapted to stop the intake of a lot of the salt from the water before it reaches the plant.

3. Reproductive adaptations to tidal environment. Some mangrove species have evolved to produce seeds that float. The tide acts as the method of dispersal to avoid crowding of young plants. Other mangrove species are viviparous. They retain their seeds until after it has germinated and a long, cylindrical propagule has formed. When it has matured to this stage, the parent tree drops it into the water, where it remains dormant until it finds the soil and is able to put out roots.
(Source: Adapted from www.indiscapes.com, 2011)

Roles of Mangrove Ecosystems (From Saenger et al. [70])
Physical functions
Stabilizer of coastlines
Accelerator of land extension
Buffer againts waves and storms
Protector of beaches and river banks
Assimilator of waste material
Biological functions
Nursery ground for fish, prawns and shellfish of the open sea
Sanctuary for large nesting birds
Natural habitat for many forms of wildlife
Potential commercial functions
Aqualture
Salt ponds
Recreation
Timber

Table 6.2 Roles of Mangrove Ecosystems (Source: The Ecology of Sumatra, Whitten, Damanik et al. 1987)

Benefit of Mangrove

According to International Union for Conservation of Nature (IUCN), the benefit of mangroves can be direct and indirect values (Table 6.1).

Direct use value of the mangrove based on local use was assessed from the gross income generated by community, from the mangrove in terms of shellfish, fish, timber & poles, herbs and vegetables, fuel wood and other products. Market prices were used to calculate the gross income generated.

Indirect Values:

(a) Near shore fisheries: Indirect use value is determined by the contribution of resources in terms of their environmental and ecological services to support current production and consumption. One important ecological service of mangroves is the support to off-shore fisheries by serving as a breeding ground.

(b) Shoreline protection: Another important ecological function of mangroves is to serve as a windbreak and shore line stabilizer. It has been experienced that the damage due to tidal surges and storms is much less with the presence of mangroves. This was evident during the Indian Ocean Tsunami where mangroves acted as barriers to reduce the force of the waves in some locations.

Product of the mangrove ecosystem. (From Saenger et al. [70])

A. MANGROVE FOREST PRODUCT

FUEL	TEXTILES, LEATHER
Firewood (cooking, heating)	Synthetic fibres (e.g. rayon)
Charcoal	Dye for cloth
Alcohol	Tannins for leather preservation
CONSTUCTION	FOOD, DRUGS & BEVERAGES
Timber, scaffolds	Sugar
Heavy construction (e.g. bridges)	Alcohol
Railfoad ties	Cooking Oil, Vinegar
Mining pit props	Tea substitue
Boat building	Fermented drinks
Dock pilings	Dessert topping
Beams and poles for buildings	Condiments from bark
Flooring, panelling	Sweetmeats from propagules
Thatch or matting	Vegetables from propagules, fruit or leaves
Fence posts, water pipes, chipboards, glues	Cigar substitute
FISHING	HOUSEHOLD ITEMS
Poles for fish traps	Furniture
Fishing floats	Glue
Wood for smoking fish	Hairdressing oil
FIsh poison	Tool handles
Tannins for net and line preservation	Rice mortar
Fish attracting shelters	Toys
AGRICULTURE	Matchsticks, Incense
Fodder, green manure	PAPER PRODUCTS
OTHER PRODUCTS	Paper of various kinds
Packing boxes	
Wood for smoking sheet rubber	
Wood for burning bricks	
Medicines from bark, leaves and fruits	

B. OTHER NATURAL PRODUCTS

Fish	
Crustaceans	Birds
Shellfish	Mammal
Honey	Reptiles and reptile skins
Wax	Other fauna (amphibians, insects)

Table 6.3 Products of the mangrove ecosystem. (Source: The Ecology of Sumatra, Whitten, Damanik et al. 1987)

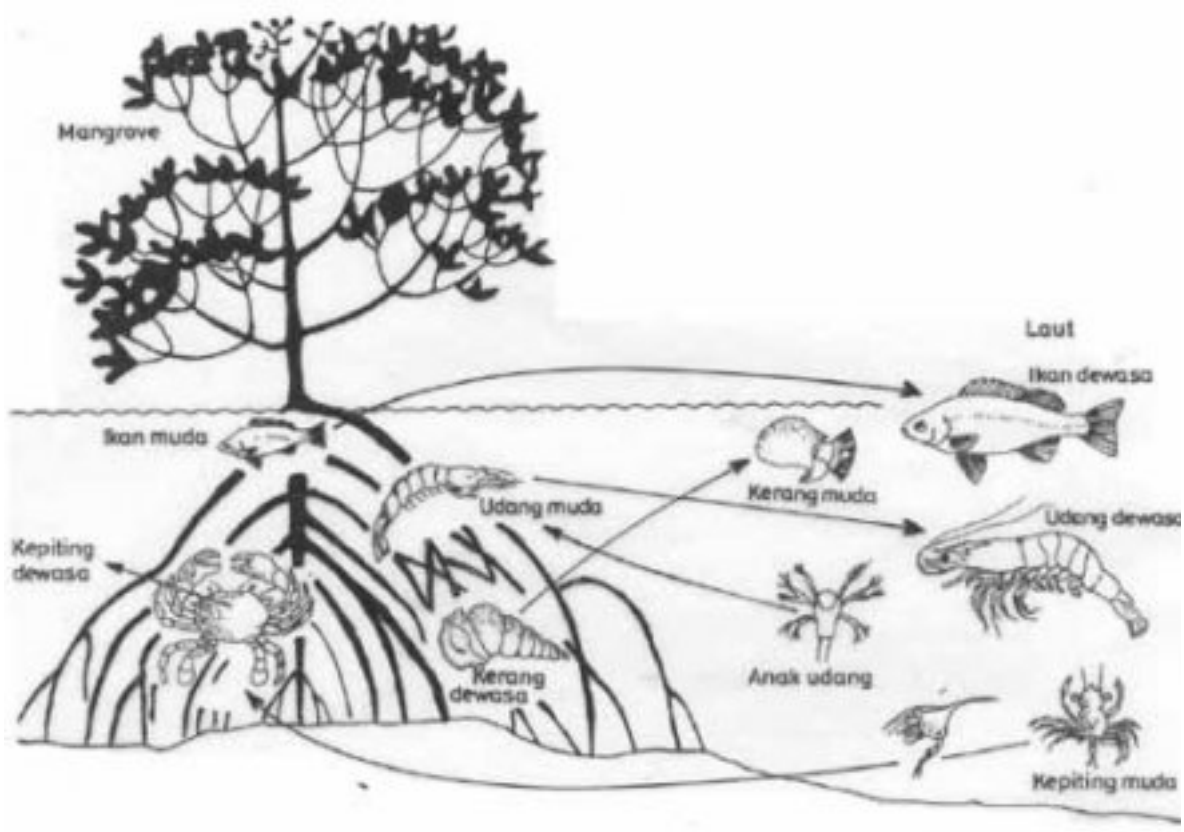


Figure 6.9 Ilustration of fauna distribution in mangroves ecosystem (Source: Kuswadji, 2001 in http:// amri050890.wordpress.com, 2011)

Furthermore, as indirect values, mangroves ecosystem are fucntioned as food chain for marine biodiversity (Figure 6.9). Not only family of fish, mangroves also as nursery ground, feeding ground and shelter. Although, these types of fish are not permanently, but types of migration fish which come on certain season. These types of fish are very commersial and can be benefit for local fishermen. There are 4 types of fish that can be harvested in this ecosystem (*Anonym, 2009 in http://amri050890.wordpress.com, 2011*):

1. Permanent habitat; Gelodok fish (Periopthalmus sp).
2. Temporary habitat; Belanak fish (Mugilidae), Kuweh fish (Carangidae), and Kapasan fish, Lontong fish (Gerreidae).
3. Migration fish during high tide; Kekemek, Gelama, Krot (Scianidae), Barakuda / Alu-alu, Tancak (Sphyraenidae), and familiy of Exocietidae and Carangidae.
4. Seasonal migration; type of fish which escaping from predator.

In the food chain, basic source of food is Detritus which come from the fallen leaves and having decomposition process. Detritus is main nutrient for Crustacea and Mollusc. These species are important for the economy of the fishermen and the local people as they have higher value in the market.

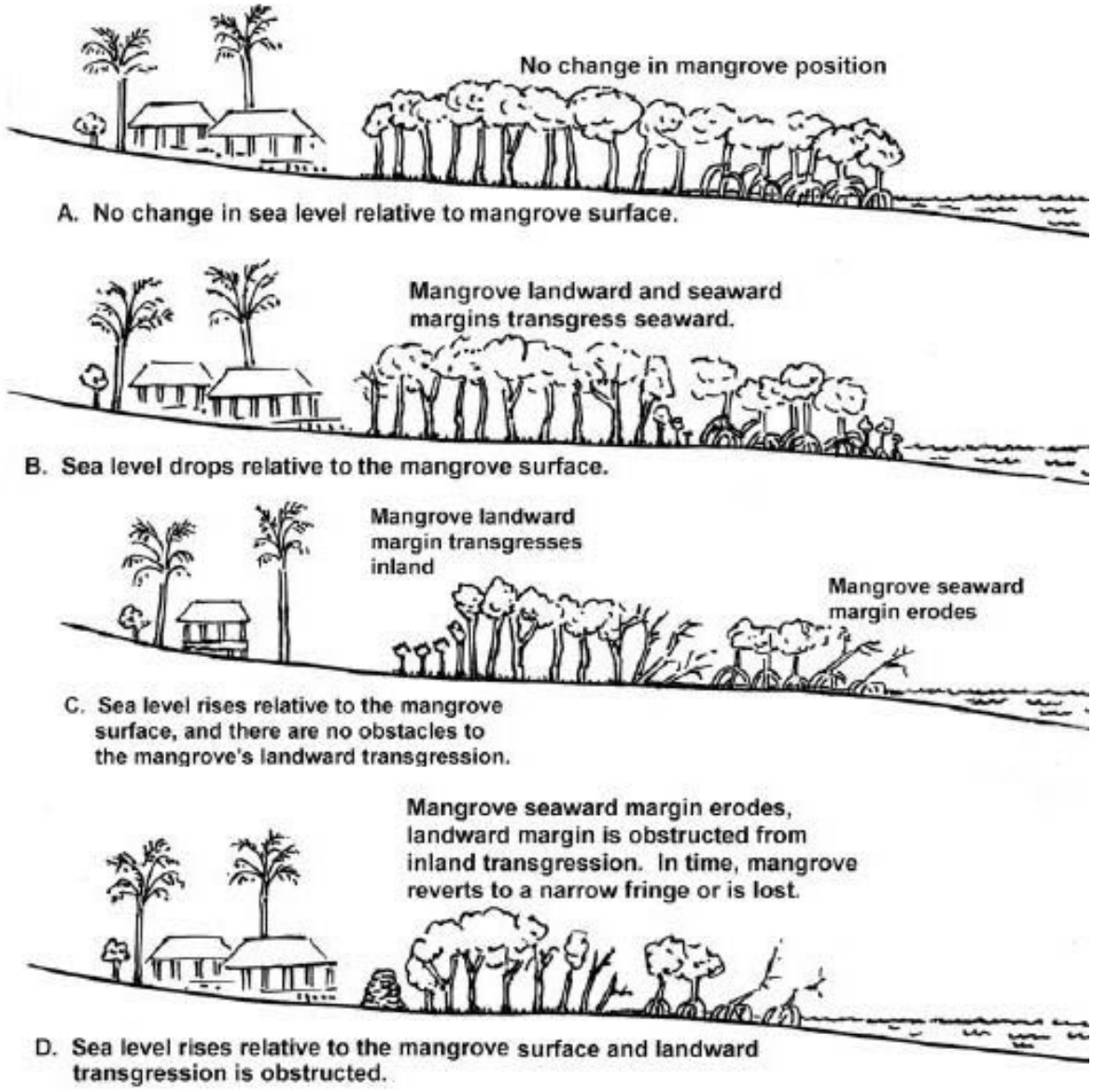


Figure 6.10 Possible mangrove responses to sea-level rise. (UNEP Report 2006 in Horigue, 2007)

Mangroves have high economic values, although the ecological values gave direct benefit if the ecosystem maintain well. Not only benefit and also opportunity to develop, it also has the challenge for survival in the coastal ecosystem. It can function as natural barrier against the sea-level rise. However, sea level rise can also affect to the reduce of the forest layer by erosion or less sedimentation. Studies in the Caribbean, Florida and the Pacific Islands showed that mangrove responses to sea-level rise depend on the rates of submergence vs. sedimentation (Doyle 2003, McKee et al 2007, UNEP Report 2006, Society of Wetland Scientists 2006 in Horigue, 2007). Moreover, Horigue (2007) explained on Figure 6.9 that shows the migration patterns are relative to sea-level rise and the presence of land obstruction. This means that mangroves layer has to be able to maintain the sedimentation.

Figure 6.11 'Tambak' brackish water fish pond on Nipha forest (Source: Bambang Gunawan)

6.3 Aquaculture Fish Pond

Brackish water fishpond is one of the fish farming culture. It is located in coastal swamp and mangrove area because of its nutrient richness and peaty acid soils. The soil is also important for the construction of the dike. In relation with this thesis, brackish water fish ponds are used as coastal protection against high tide. The construction of fish ponds surrounded by high embankment and it can be used as dike to protect the land from high tide.

In choosing the location for fishponds there are several requirements need to be fulfilled. FAO made the step by step manual for the brackish water fishponds construction. A brackish water fishpond is said to be properly designed when the arrangement of the pond compartments, water control structures and all other facilities mutually harmonize each other giving the most efficient water management and manipulation of stock (FAO manual, 1981).

Figure 6.12 'Tambak' brackish water fish pond in Nipha Forest (Source: Bambang Gunawan)

FAO manual (1981) on brackish water construction requirements are as follow (refer to figure 6.13):

1. A buffer zone of at least 100 meters from the sea to the main peripheral dike or 20 meters along river banks should be left undisturbed for ecological reasons and physical protection from flooding and wave action.

2. The main gate should be placed at one side of the pond where fresh unpolluted sea or brackish water is available during spring tides. The main gate should be located preferably at a straight stretch of the stream and should not be located at the corner of the dike, nor facing the open sea.

3. Whenever possible the longer dikes should be parallel to the direction of the prevailing winds so that there is less damage on dike due to wave action.

4. If necessary, diversion canals placed more or less perpendicular to direction of run-off or flood flow should be provided and they should be large enough to carry surface run-off during times of flood. This canal should be as short as possible and discharge to the nearest stream or channel.

5. Water supply. In choosing the site to make fishponds, water supply needs to be the main consideration. Usually, the water comes from river, a creek or from the sea and it must meet the quality and quantity requirement throughout the year.

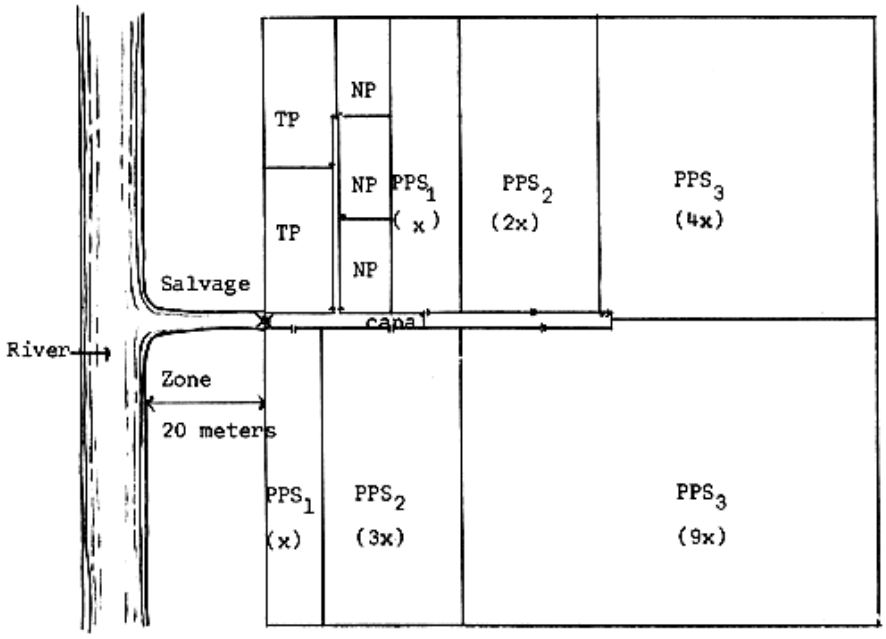


Figure 6.13 Modular Pond System (FAO manual, 1981)

Mangroves Fish Ponds

There have been studied shown that mangrove habitat is benefit to reduce the environment's ability to process wastes from the ponds. Mangrove trees produces nutrients for small species and it can mantain the water.

Most of mangrove forest fish ponds in Indonesia are brackish or saline water for saline fish ponds. Thus, integrated system of maintaining mangrove forest and using the nutrients to feed the fish is a sustainable way of mainataining the ecological balance as well as economy.

In general mangrove in Indonesia are suitable for brackish (saline) fish pond. Therefore the "tambak-forest system" can be applied to reforest mangroves. The tambak (brackish fish pond)-forest system is only recommended for the saline zone. The size and the arrangement of the tambak-forest is 1:5,5. The tree species to be planted in the tambak-forest are the suitable for the saline zone of the mangroves, such as Rhizophoramucronata and bruguieragymnorrhiza, etc. with planting distance of 3mx2m. the fish raised in the saline fish pond are usually: ChanosChanos, Tilapia Mosambica and MugilCephalus. Tree planting should start at the beginning of the rainy season in relation to the optimal germinatability of seeds (Alrasjid 1971).

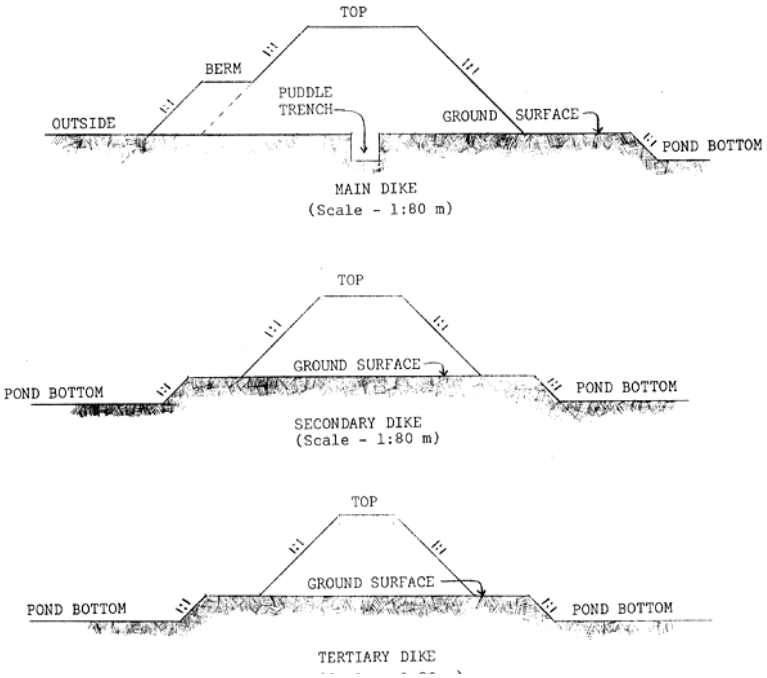


Figure 6.14 Construction of Main Dike, Secondary and Tertiary

Fish pond Dike

FAO also set on the manual for the dike construction. Dikes in fishponds are the system of partitioning for water control and stock separation (Figure 6.14). They are made of soil with trapezoidal shape. They must be able to hold water as well as prevent the seepage under or through the dike. The FAO manual on fish ponds dike construction are as follow:

a. Height above the waterline. The top of the dike should extend sufficiently above the waterline to give a safe margin against overtopping at high tide and flood, and such allowance should include wave action caused by exposure to winds. The designed height of a perimeter dike normally has a free board, after shrinkage and settlement of 0.6 to 1.0 m. above the maximum flood water level observed in the locality for at least 10–15 years. Freeboard for secondary and tertiary dikes is usually 0.30 m.

b. Top Width. There are several recommendations for determining the top width of an earth dike. The minimum recommended width for dikes less than 3.0 m high is 2.4 m. For dikes used as roadway, a width of at least 4.0 m. is specified. This width provides space for roadway and shoulder on each side. The width of dikes used as roadway for access to ponds should be at least 3.5 m., but preferably 4.0 m.

c. Side Slope. The side slope (ratio of horizontal to vertical) is a function of the type of soil used. The side of the dike inside the pond which is saturated all the time is generally flatter than the outer side which is dry. If both sides are saturated, both side slopes are the same.
Fishpond dikes constructed lower than 4.26 m. should have a slope of 1:1. Dikes constructed above 4.26 m. should adopt 2:1 slope.

Chapter VII. Alternatives for Design Intervention

7.1 Possible Intervention
7.2 Chosen Intervention

VII. Alternatives for Design Intervention

From the problem analysis, it has been defined that Belawan is facing and will deal with flood and inundation problems. There are two types of problems based on the occurance; the current and the projected future problems. To be concluded the goals are

1. Flood and inundation on the relative flat ground dense housing area. To cover problems of storm water during the rainfall and the inundation afterward and also from after the high tide.

2. Coastal prtection agaits high tide, tidal power and sea level rise.

7.1 Possible Interventions

7.1.1 Flood and inundation on the relative flat ground dense housing area.

In this area, the current drainage system is not able to hold the surface runoff due to the over loaded sewage with siltation and also garbage. However, the causes are not only those but there are also other contributing factors as shown below:

- less infiltration area: most of the housing area are covered with aspalt and no appropriate space for open grass or yard.
- the distance between the tertiary sewage to the second collector are to far.

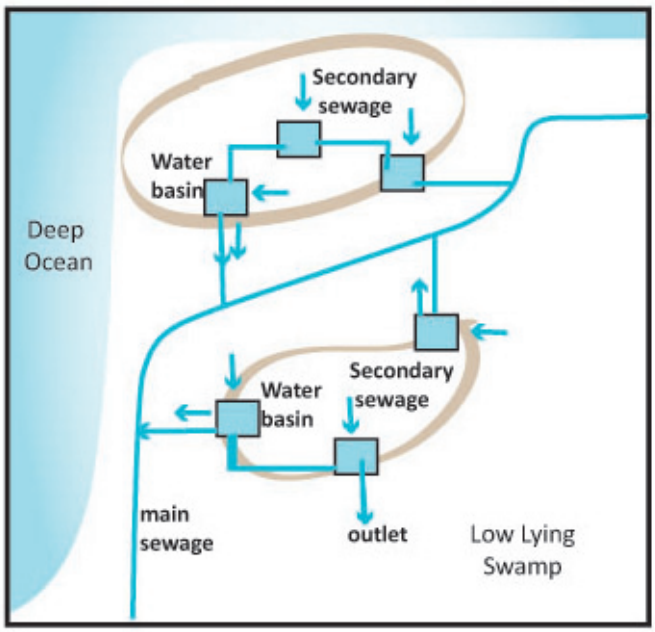
Alternatives for solving this problems are:
1. Connecting the tertiary sewage to water retention and convey to the closest secondary sewage.
2. Collecting all the sewage systems into a canal in the middle of the dense housing area.
3. Conveying the tertiary sewage to a constructed wetlands sytem to be purified and then to be transffered to the sea or natural wetlands.

Figure 7.1 Sewage system in Belawan

The drainage system in Belawan is three sewage lines that convey comestic waste water together with the storm water to the sea. The tertiary sewage collecting the waster water from each house and convey to the secondary sewage and to the primary sewage in the main street. However, not all housing areas have appropriate sewage and the distance from the secondary sewage is too far.

Alternative A

1. Expand the width of the primary sewage
2. Construct waste water retention ponds for the closest tertiary sewage and convey them to the secondary sewage. From the secondary sewage and then release to the primary sewage.



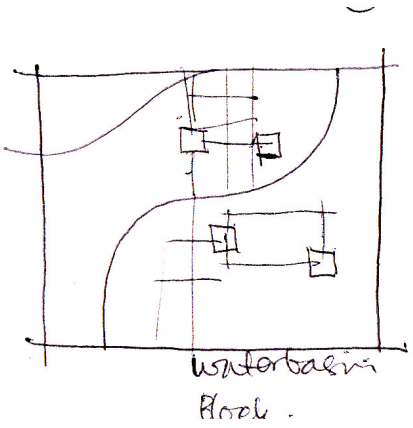
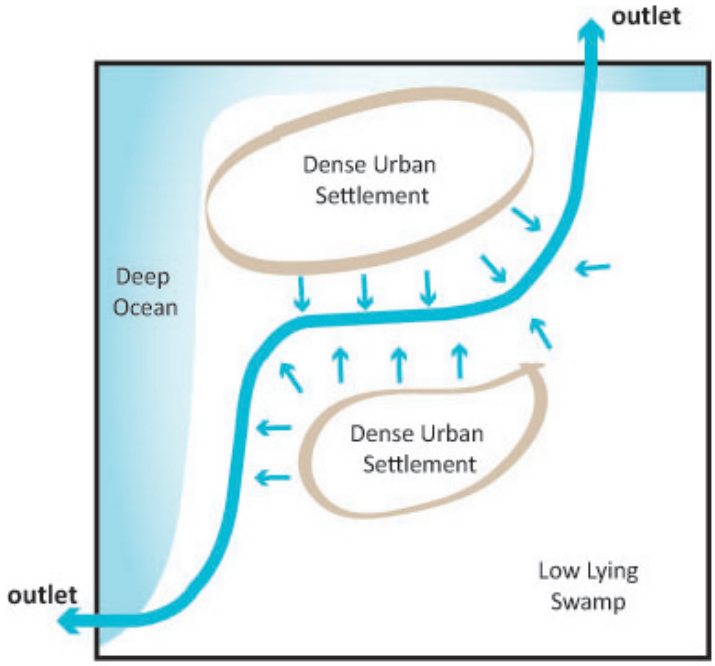


Figure 7.2 Primary Sewage

Figure 7.3 Secondary Sewage

Alternative B

1. Construct a main canal that divide the city in two parts and able to hold and convey a large amount of waste water and storm water toward the sea outlet.
2. An outlet for secondary sewage and the closest tertiary.



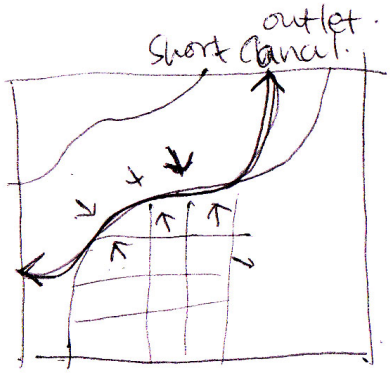


Figure 7.4 Flood canal in Jakarta (Source: Internet Download).

Figure 7.5 Tertiary Sewage

Alternative C

1. Expand the primary sewage.
2. Construct wetlands in strategic locations as water retention and also treatment received from the secondary sewage and the closest tertiary sewage.
3. Convey the purified water to the primary sewage that connected to the sea outlet.
4. Other alternative is to transfer the purified water to the natural wetlands that can be used as water stock for the fish ponds.

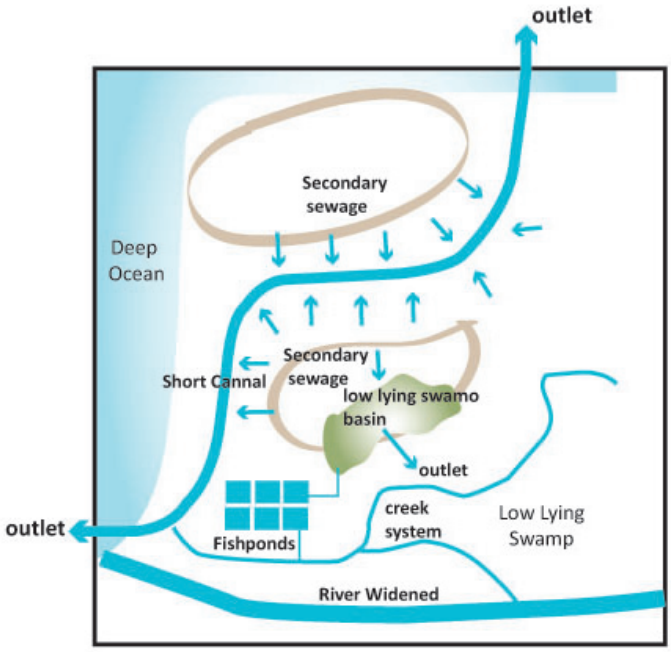


Figure 7.6 Natural Wetlands

Fogure 7.7 Fish ponds

Figure 7.8 a Earth Dike in Percut

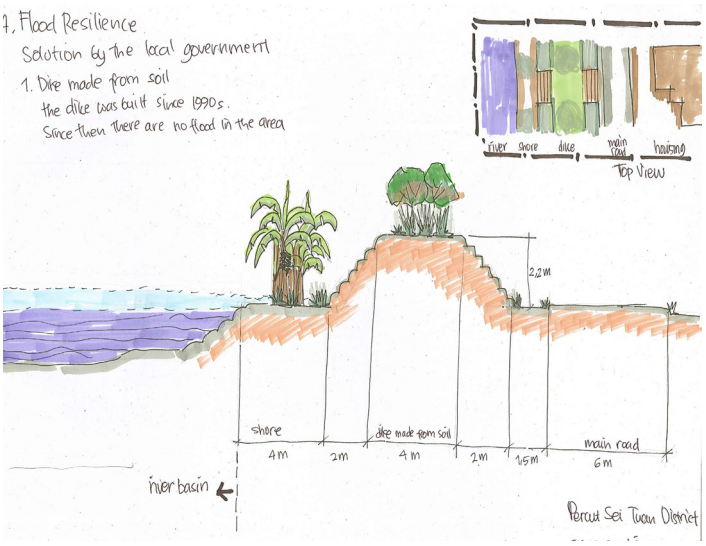


Figure 7.8b Sketch of the earth dike

Figure 7.8 c Retaining wall in Percut

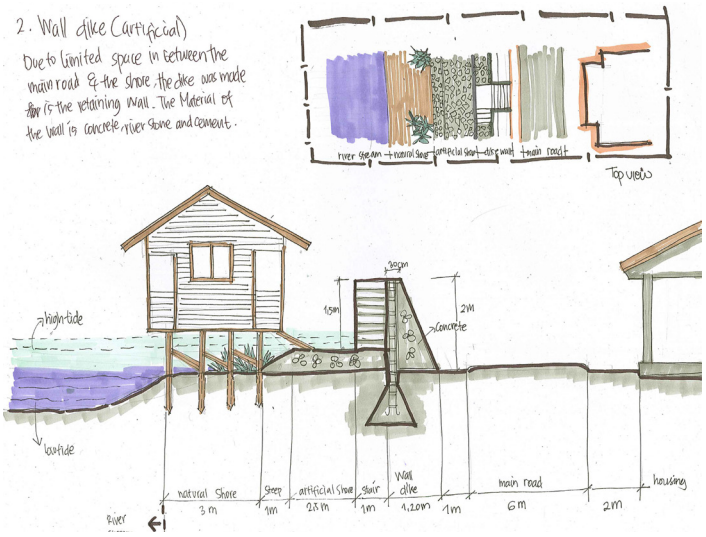


Figure 7.8d Sketch of the retaining wall

7.1.2 Coastal Protection againts the high tide

There are several ways to protect the land from the high tide and the sea level rise. The current protection that has been done is a shallow retaining wall that keeps on hightened everytime the tidal power get stronger.

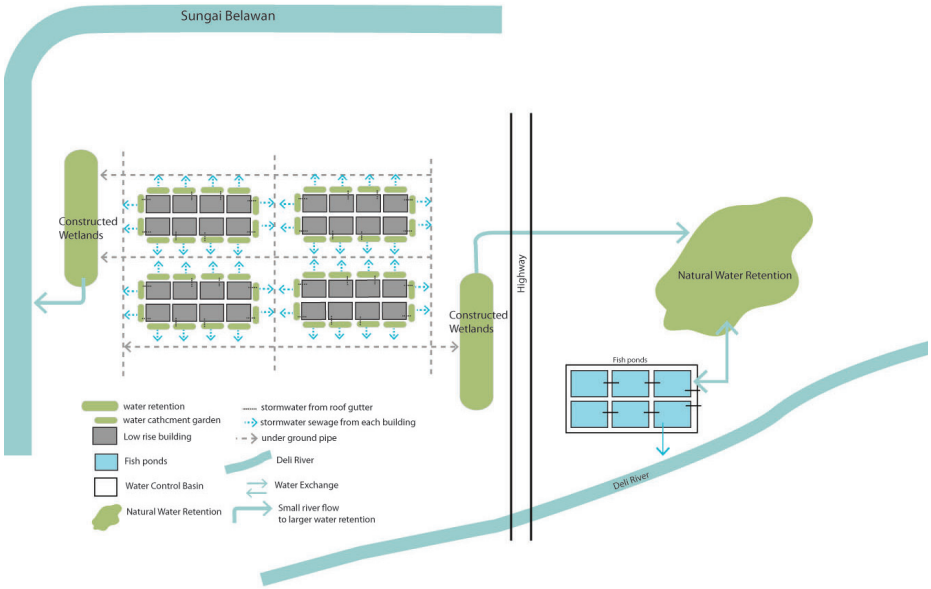
At other parts of the eastern coast Strait Malacca are defensed with retention wall and earth dike (Figure 7.8) However, to apply such constructions need to have bigger space and that is not possible to do so in dense area such Belawan.
Hence, other methods that might usefull are:

1. by reducing the tidal power and hold the soil from erotion by conserving and planting marngrove trees.
2. constructing earth dike in the nearby river at the low lying swamp, and to make use of the earth dike as fish ponds.

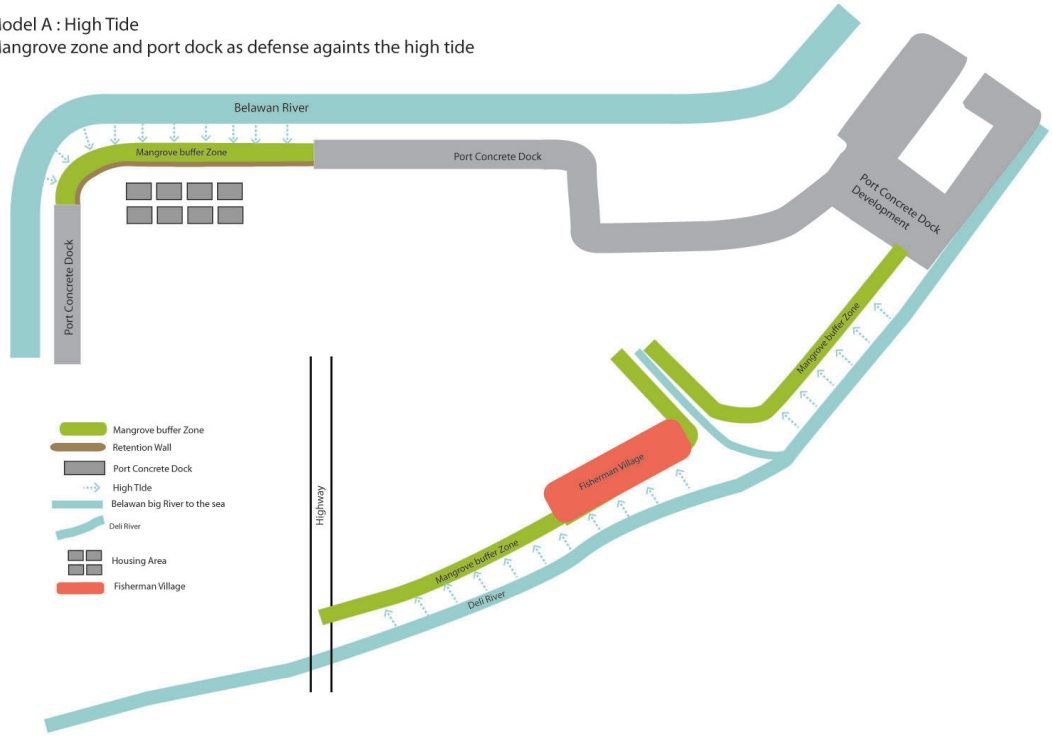
VIII. Detail Design

8.1 Design for Storm water Runoff

Several studies on solving the inundation because of storm water runoff from high precipitation recommend that by making an infiltration zone



Model A : High Tide
Mangrove zone and port dock as defense againts the high tide



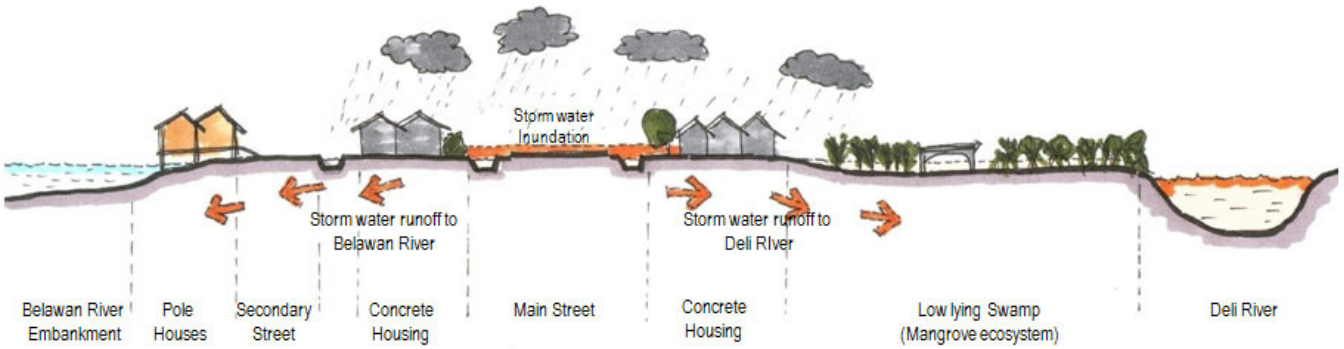
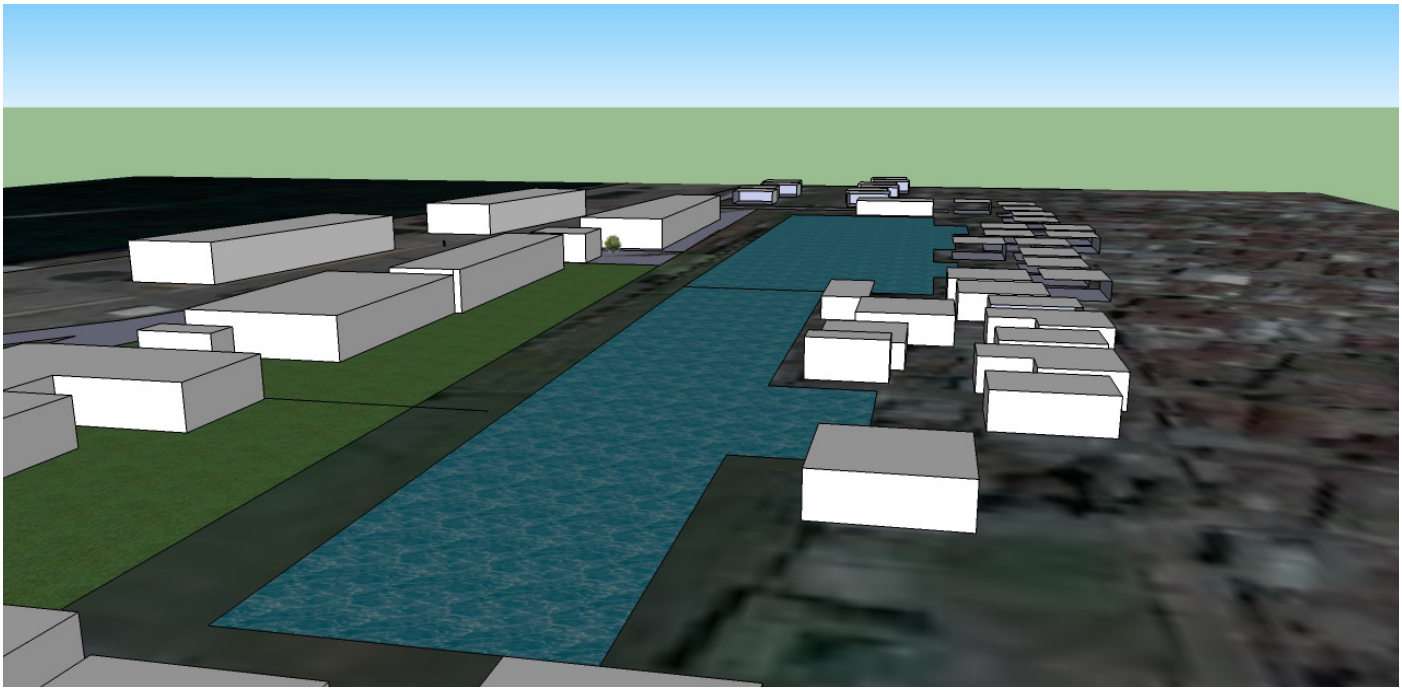

Storm water
Inundation
Storm water runoff to
Belawan River
Storm water runoff to
Deli RIver
Belawan River
Embankment
Pole
Houses
Secondary
Street
Concrete
Housing
Main Street
Concrete
Housing
Low lying Swamp
(Mangrove ecosystem)
Deli River

Figure 8.1 Water Flow Direction

Figure 8.2 Available Open Space

Figure 8.3 Possible Water Retention with the closest Outlet

Drawing 8.2 Water Retention Plan



8.2 Design for Coastal Defense

Model A : High Tide
Mangrove zone and port dock as defense againts the high tide

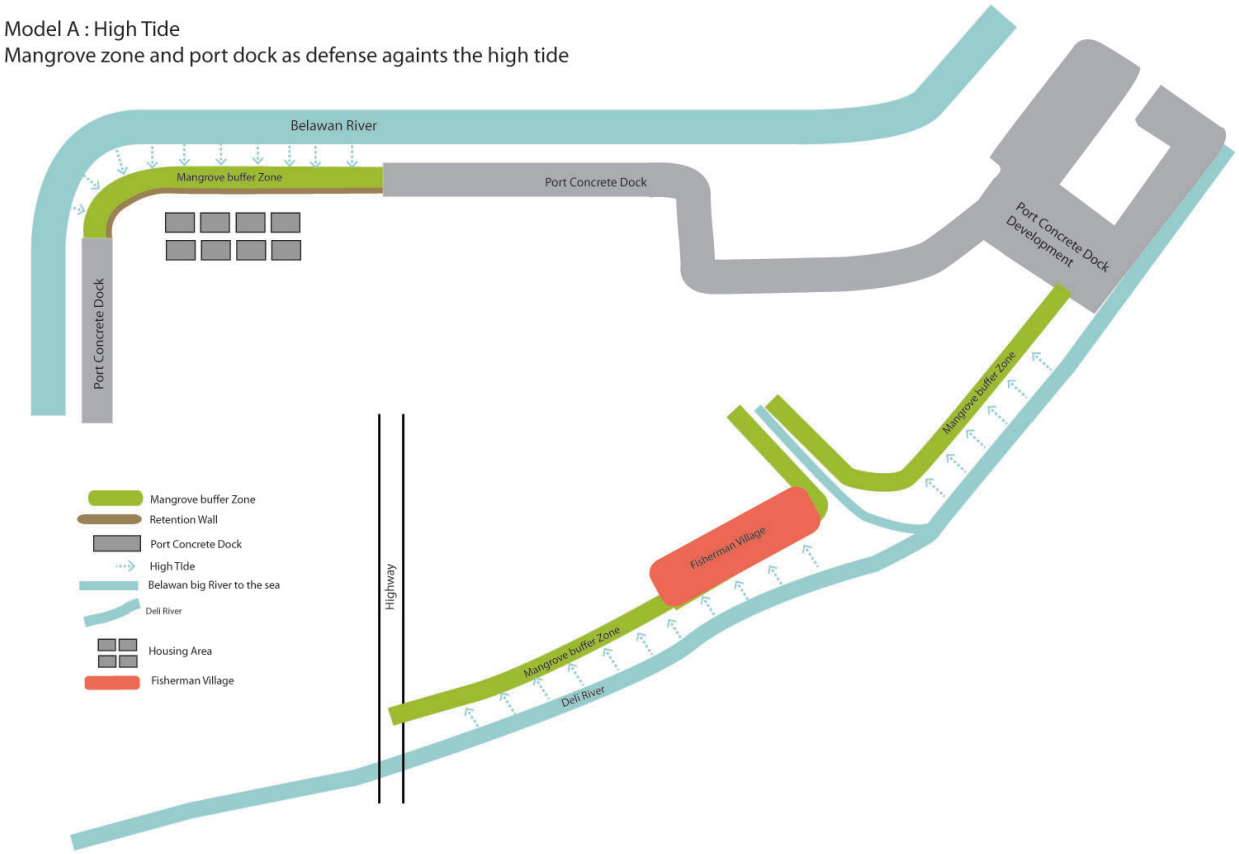
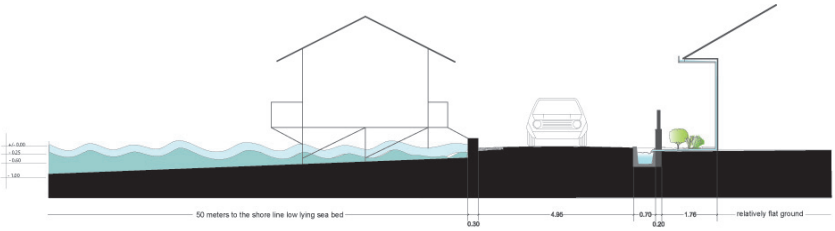
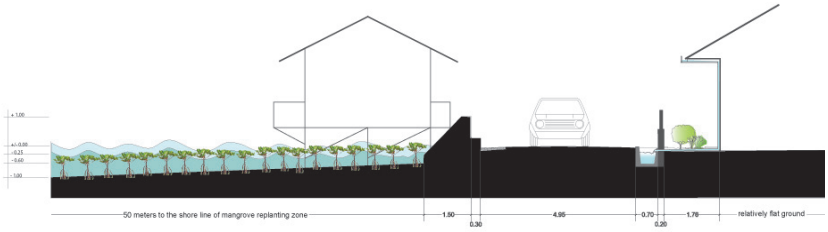
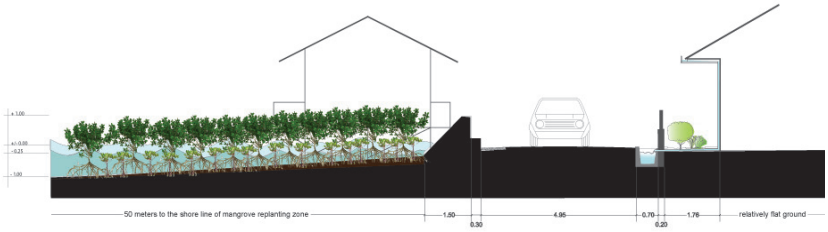
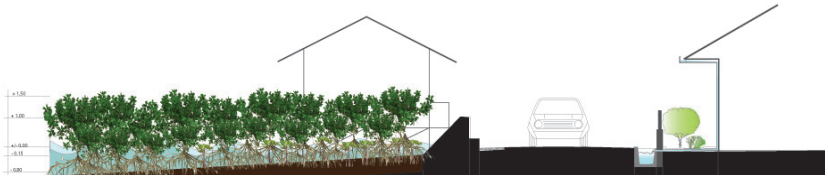


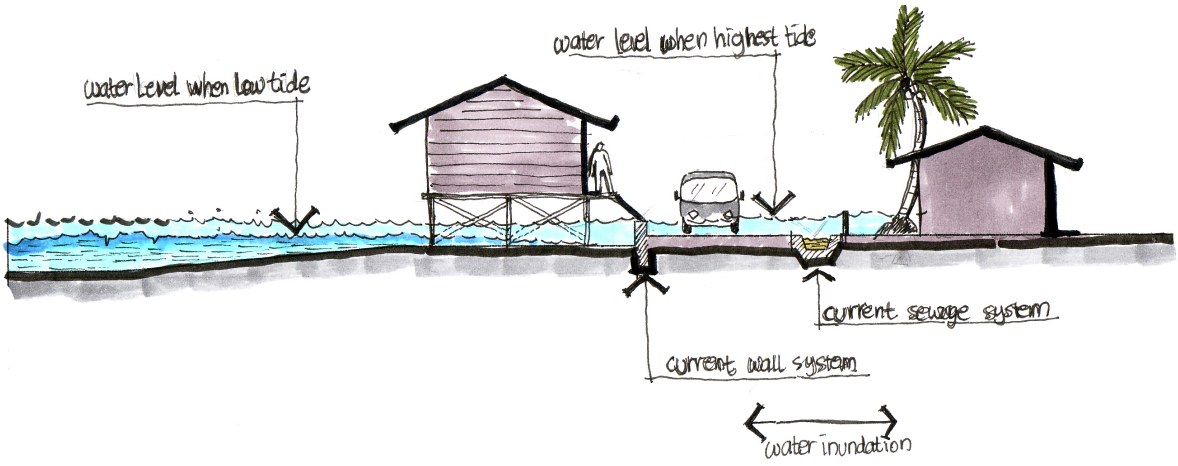

Image © 2011 DigitalGlobe

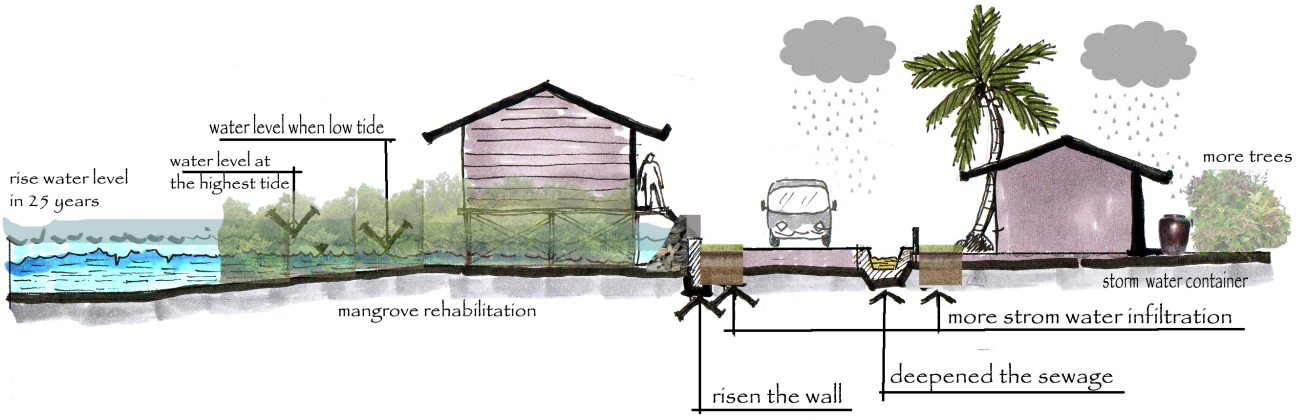

50 meters to the shore line low lying sea bed
0.30
4.95
0.70
0.20
1.76
relatively flat ground


50 meters to the shore line of mangrove replanting zone
1.50
0.30
4.95
0.70
0.20
1.76
relatively flat ground

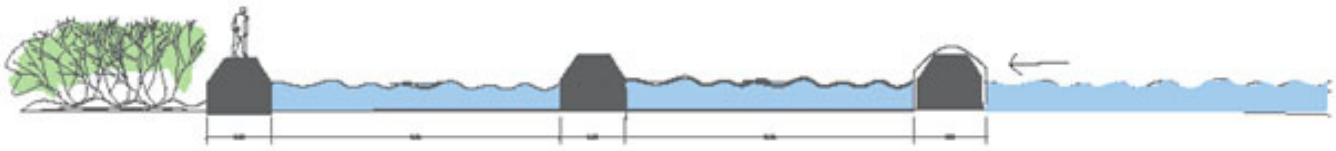

50 meters to the shore line of mangrove replanting zone
1.50
0.30
4.95
0.70
0.20
1.76
relatively flat ground




water Level when low tide
water level when highest tide
current sewage system
current wall system
water inundation


water level when low tide
water level at
the highest tide
rise water level
in 25 years
mangrove rehabilitation
more trees
storm water container
more strom water infiltration
deepened the sewage
risen the wall


1/13/2003




1/13/2003
2000
2009

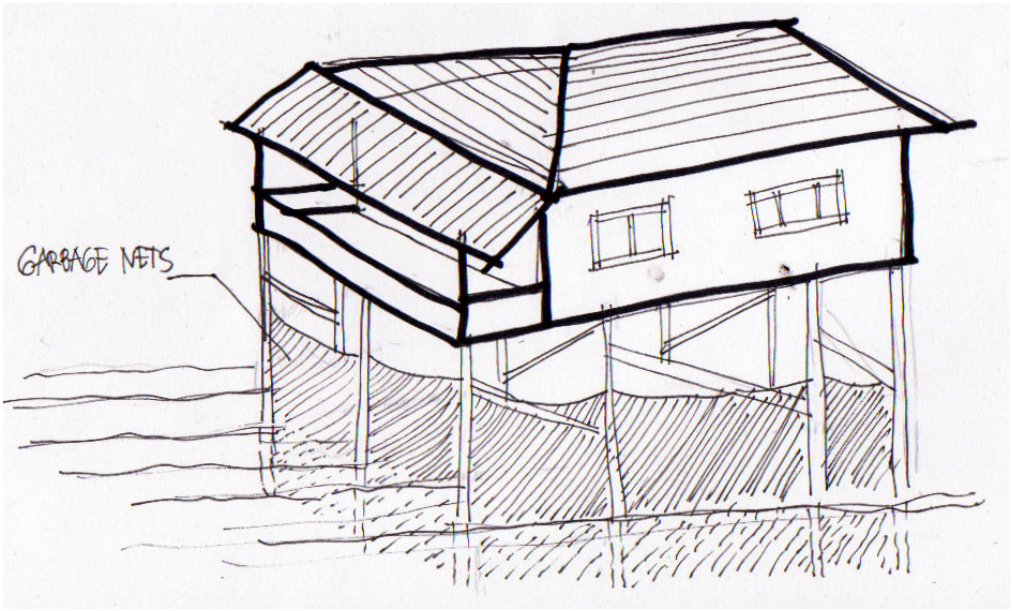
Architectonic Design Solution

Cleanness
Problem in the pole house of the fishermen village is that there are always plastic garbage and other domestic waste that is flow with the high tide into the sea bed underneath the house. After the water down, then the garbage will remain and give unpleasant view of dirty. Thus to solve this problem, I have designed recommendation for the pole houses to create layers of net system under the house in between the poles.

How it works:
There are two netting system. First layer of net will be put in the second pole's row from the bottom until the normal high of the low tide. This net is functioned as the filter for the garbage. When the high tide flows underneath the house the garbage will stay with there with the inundation. After the tide is low it is normally going down slowly and the garbage will stuck in the net.
The second layer of the net is set at the bottom in between the poles, and when the water down the net can be pulled up like fishermen harvesting their fish from the net.

This method can be done regularly, and most of the garbage are plastic can be sold to be recycle, in this way each houses owner may have their extra income by collecting plastic garbage.

Colours
Malay people appreciate colours. Colours can be translated into flowers with beautiful colours in their yards and garden. Thus, designing the water retention with gardens of flowers will give much of aesthetic appreciation by the people.



The qualitative method analysed data based on… the descriptive method analysed data on the implementation of acts, regulations?? By comparing results of qualitative and descriptive analysis, problems and constraints

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Salju pertamaku, Wageningen 2009

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Shindi