

RESHAPING

Banda Aceh

Planning a better city in coping with future hazards of tsunami



Thesis Report

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Urban Climate Studio | Department of Urbanism

Faculty of Architecture | TU Delft 2010

Colofon

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Planning a better city in coping with future hazard of tsunami

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Cover:
Ulee Lheue area a month after tsunami 2004
(by the author)

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Preface

This thesis report serves as detail report of my thesis project named "Reshaping Banda Aceh; Planning a better city in coping with future hazard of tsunami" which is conducted under Urban Climate Studio of my graduation track at department of Urbanism of TU Delft.

The case study took place in the city of Banda Aceh where after tsunami 2004, the city is experiencing rapid change of urban development. While the city located in the tsunami hazard area, proper steps toward the prevention of future threat of tsunami should be strongly considered in the city planning while at the same time, city has to grow and provide better living quality for its inhabitants.

In this report you will be able to find most of my result of the city analysis as well as hypotheses and scenarios that lead to the strategies, guidelines and also the design in various scales of my spatial intervention.

1

Background

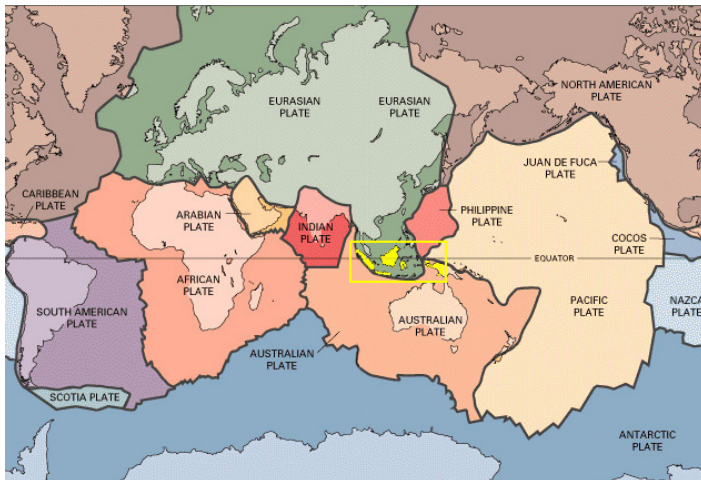
In 26 December 2006, a magnitude 8.9R earthquake occurred in the Hindian Ocean at South of Sumatra island of Indonesia. The intense earthquake lasted for several minutes, triggering a tsunami that swept most of the coastline of the Aceh province in Indonesia, as well as other countries such as India, Sri Lanka and Thailand. It's believed to be one of the most devastating natural disasters in mankind history ever recorded within this century. According to Ghobarah (2006), more than a quarter million people died and nearly 1.5 million people were pushed away from home and livelihood. No other natural disaster has been more devastating than tsunami 2004. It stunned world communities and an immediate response was launched to assist the affected region.



Banda Aceh after tsunami 2004

At the aftermath of the tsunami 2004, Aceh province suffered the worst hit of the disaster and civil war that afflicted the province aggravated the impact. Banda Aceh as the capital city lost nearly two thirds of it built area due to heavy inundation. JICA (2005) reported that more than 70.000 people died in this city alone while thousands of others were displaced from their homes.

The Local government with the help of international aid organization reacted quickly to response the disaster. The city soon recovered from the disaster and many of the inhabitants returned to their homes to start their livelihood activity. The city has grown once again and this time it gained a lot of support from international donors. A large amount of capital has been granted to rebuild the city with the expectation that the city will be much better than before. Such opportunity creates a rapid growth of the city and more people are coming to the city for a better life. Central Statistic Bureau (BPS, 2008) reported that from the population of 177.881 in 2005, the number of inhabitants has grown to 219.659 in 2007.



tectonic plates and fault lines

However, for such a huge disaster like the tsunami 2004, the city might well again hit by future tsunami as it lies on high seabed's earthquake prone area, while the current state of the city showed that a proper step towards tsunami prevention effort has not been fully implemented in sectors of city development. This fact leads to the increase of city's vulnerability rate against tsunami. With the rapid growth of the city, the impact of future tsunami can be highly devastated.

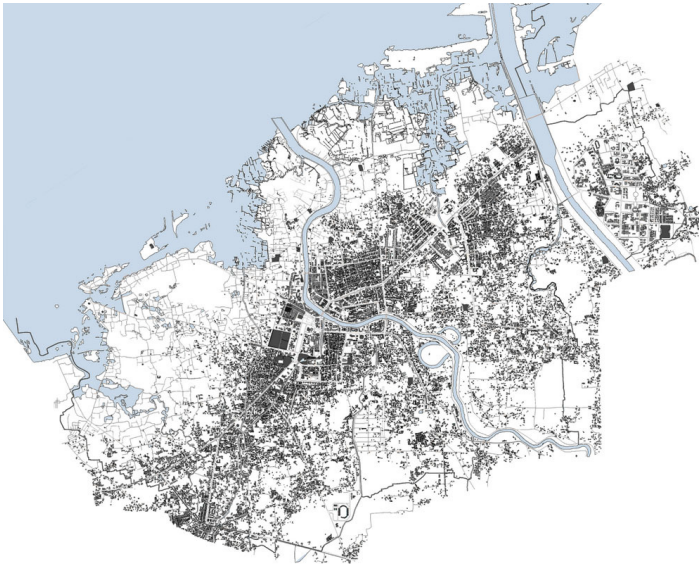
Such threat to the city required serious attention from the local government. Although tsunami countermeasures effort can be very expensive, especially for small city of Banda Aceh, the city still has to take tsunami precaution as one of the baseline of the future development. Smart combination between tsunami countermeasures efforts and urban regeneration projects might lead to more affordable approach while at the same time also improve the living quality of the city inhabitants. Therefore it's very challenging for the urbanist to plan a better city that has strong resiliencies toward tsunami and at the same time upgrade the living quality of the city in the affordable manner.

2 City Analysis

2.1. Geographical Location



Indonesian archipelago

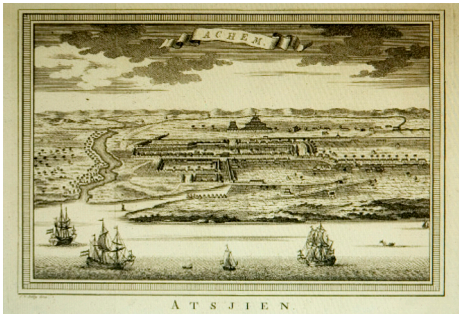


Banda Aceh city

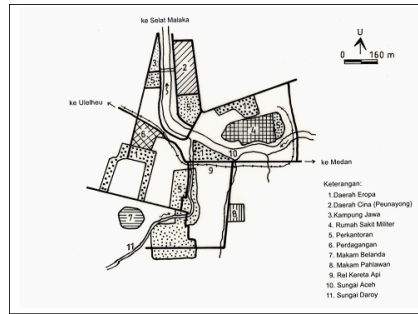
Banda Aceh is the capital city of Aceh province of Indonesia. It is located in the most western part of the Sumatra Island, one of the five biggest islands in the country. The city is relatively small with the area of 61.36 Km² and quarter of it is covered by water (river, lagoon, swamp and fishpond). The city divided into 9 sub-districts with the total of 89 villages.

Like many other cities in Indonesia, Banda Aceh lies close to the fault line of active tectonic plate that is constantly moving. Banda Aceh also located close to the volcanic island of Pulau Weh. This means that the city is located in high earthquake and tsunami prone area. A silence treats that wait to be awoken.

It is a coastal city with coastal line span to more than 15 Km long and two main rivers are dividing the city into parts. The city lies on the relatively flat area with the average altitude of 0.8m above sea level, this make the city highly exposed to the tsunami hazard. Rise of the sea level can also bring threat to the city as some coastal villages are regularly experiencing tidal flooding.



Banda Aceh during colonial time



Banda Aceh in 1940's



Banda Aceh in 1970's

2.2. History

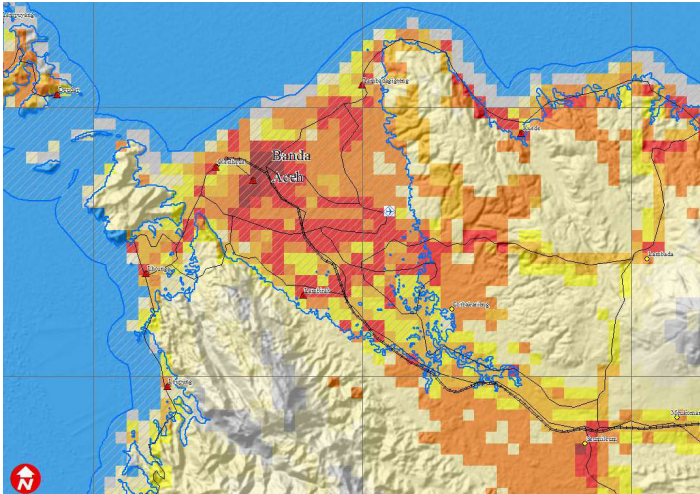
Banda Aceh is one of the oldest cities in Indonesia. Founded in 1205 as the capital of Kingdom of Aceh Darussalam, it gained prosperous advantage from the falling of Malacca to Portuguese in 1511 as most of the trading activities in Southeast Asia moved to Aceh. Pepper is one of the main trading commodities produced in Aceh. Under the rules of King Sultan Iskandar Muda (1607-1636) Kingdom of Aceh reach it glorious era, and important relationship was made with the Chinese, India, Turkish and European East India Company.

During the colonial time in Indonesia, the Dutch East India Company launched two major expeditions to Aceh. First expedition was held in 1873 under Major General Johan Harmen Rudolf Kohler. It was not a successful expedition because the expedition team faced strong battle from the Acehnese people and general died during the battle. Second expedition held a year later in 1874 led by General Jan van Sweiten. General Jan van Sweiten managed to capture the inner city of Banda Aceh and later on changed the name of the city to Kutaraja (City of King).

After the independent of Indonesia, the name of city restored to Banda Aceh in 1963 during the presidency of Ir. Sukarno. However, despite the independency of Indonesia, Aceh was still struggling with long time conflict. The civil war reign the province for nearly three decades as a result from disappointment of Aceh people to the central government of Indonesia.



Aceh after tsunami 2004



Density map of Banda Aceh (2004)

Aceh believes to be one of the richest provinces in the country yet the development in Aceh shows the other way around. It appears to be the third poorest province of the country. It makes Acehnese people react strongly to the policy of the central government and further led to the foundation of Free Aceh Movement (GAM) in 1976 and started the rebellion in Aceh.

The tsunami of 2004 created a massive chaos in the province. While the region was still in a long gone conflict, many aid organizations failed to reach the survivors and made the emergency response team found serious difficulties in the field. This situation pushed both conflict parties, GAM and Government of Indonesia to new history of peace agreement that settled the three decades of civil war in Aceh. It becomes a major stepping-stone for the future development of Aceh.

2.3. Users

Social Structure

Banda Aceh is the densest city in Aceh province. It has 2,440 inhabitants per km². Some of the densest population is found in the city center. This is because of the shop houses where people use the building for working as well as living is largely occupying the city center. After the tsunami 2004, the city lost more than 70.000 of the inhabitants. This is more than a quarter of total population of the city. The tsunami reconstruction work brought many new comers to the city. People with various skill and knowledge

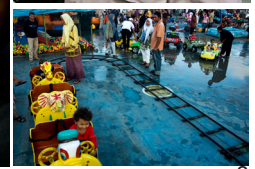
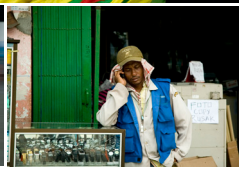


Street view in the inner city

come to Banda Aceh in search for job. This has increase the population rate of the city and at some point contributes to the social behaviour changes of the urban life.

Since early 2008, many aid organizations left the city as the work for the reconstruction is decreasing. This led to the increase of un-employment rate because many people lost their job. While in the other hand fresh graduate students with very low working experience also find it difficult to get a job. This increases the social problem in the city.

BPS (2007) recorded that there 5% of the city inhabitants live in poor condition. Furthermore, overall in Aceh province, number of poor people nearly reaches number of 50%. Some of the poor people live as unemployed person or farmer with no monthly fix income. Low education level could be one of the causes for this high unemployment rate. BPS (2007) recorded that nearly 2% of school age inhabitants do not go to school while 10% of the inhabitants do not graduated from the elementary school.



Tabel Jumlah Penduduk Miskin Per Kabupaten Tahun 2005

No	KABUPATEN/KOTA	JUMLAH KECAMATAN	JUMLAH DESA/KEL	PENDUDUK	PENDUDUK MISKIN	%
1	SIMEULUE	8	135	78.389	56.780	72,43
2	ACEH SINGKIL	13	189	148.277	102.720	69,28
3	ACEH SELATAN	16	247	191.539	108.312	56,55
4	ACEH TENGGARA	11	250	169.053	128.296	75,89
5	ACEH TIMUR	21	484	304.643	163.876	53,79
6	ACEH TENGAH	10	209	160.549	66.396	41,36
7	ACEH BARAT	11	321	150.450	61.984	41,2
8	ACEH BESAR	22	601	296.541	83.688	28,22
9	PIDIE	30	948	474.359	268.504	56,6
10	BIREUN	17	552	351.835	168.824	47,98
11	ACEH UTARA	22	852	493.670	222.424	45,06
12	ACEH BARAT DAYA	6	129	115.676	62.324	53,88
13	GAYO LUES	11	97	72.045	53.332	74,03
14	ACEH TAMIANG	8	209	235.314	93.652	39,8
15	NAGAN RAYA	5	222	123.743	73.980	59,79
16	ACEH JAYA	6	172	60.660	27.992	46,15
17	BENER MERIAH	7	115	106.148	45.740	43,09
18	BANDA ACEH	9	89	177.881	9.208	5,18
19	SABANG	2	18	28.597	3.896	13,62
20	LANGSA	3	51	137.586	45.236	32,88
21	LHOKSEUMAWE	3	68	154.634	50.908	32,92
JUMLAH		241	5.958	4.031.589	1.898.072	47,08

Sumber : BPS 2005

Number of poor village by district in Aceh Province

As poor people work in different daily routine with the rich, social segregation appears in the city. And with low intervention from local government, the city developments do not lead to improve the living quality of the inhabitants, especially the poor. Instead the rich people gain most benefit of urban development. This make rich become richer and poor become poorer.

Social Behaviors

Poverty issue and lack of education could be causes of the poor social behaviours of the city inhabitants. People have lack of discipline in almost all aspect. Traffic use is one of good examples to show how people behave poorly. People with fast vehicle have no respect to the slower ones. This makes street life become very inconvenient and it is no surprise to find that Banda Aceh has high number of street accidents.

People also do not show good behaviour in term of clean environment. In fact they have very poor awareness in it. Is it almost impossible to find comfortable place with clean surrounding. People throw trash as they like. Some of the trashes sweep by rain water to the drainage which in the end can cause flooding or source of disease.

Finding the cause of these poor social behaviours can be very tricky. Poverty issue and low education level can be some of the causes from the people side, but lack of law enforcement can be one of the reasons from the government side.



Heavy downpour during rainy season



Paddy field area out of Banda Aceh city

Productivity

Banda Aceh is a relatively small city with the area of only 61.36 Km² and nearly quarter of it covered by water. Therefore, in term of agriculture product, the city relies very much to it surrounding regions and also from the province of North Sumatra. However, the city also produces items from the small to household industries. The items vary from handicraft to textiles product.

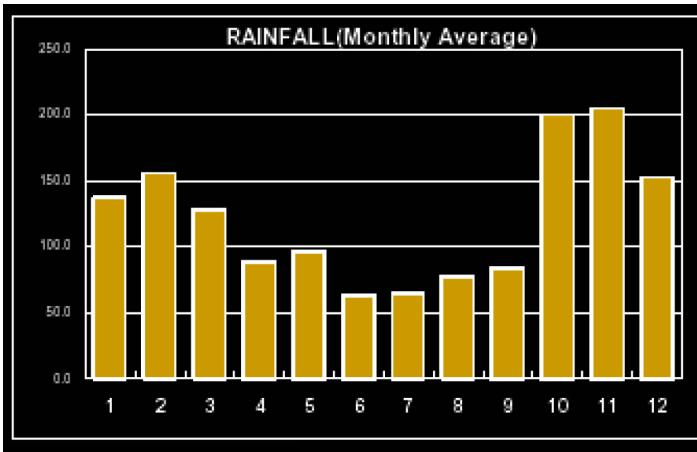
2.4. City Metabolism

Energy

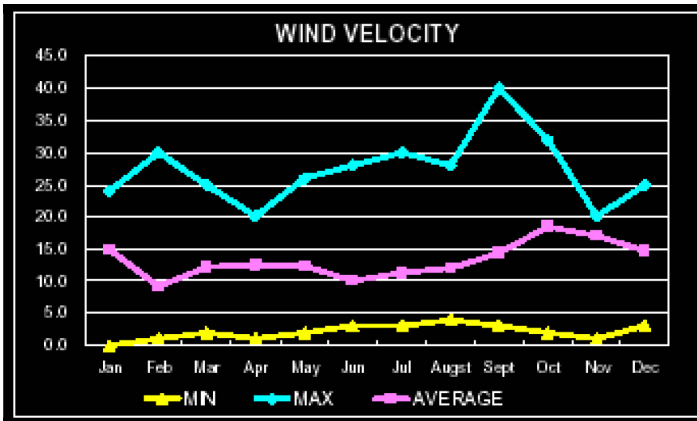
Aceh is one of the main producers of natural gas and oil in Indonesia. Therefore, Banda Aceh receives good supply of fuel from North Aceh as the source. However, lack of management in fuel distribution often lead to fuel shortage in the city. For electricity supply, Banda Aceh like other parts of Aceh relies very much on the power plant from North Sumatra.

Food

Foods and other agricultural product are being supplied from the surrounding regions. With the transports are mostly done by cargo truck, it may cause inefficiency of transport cost as well as fuel consumption.



Source: JICA Study Team



Source: JICA Study Team

Water

Most of people in Banda Aceh use ground water for the daily consumption. This is mostly because the inhabitants receive poor water supply, both in term of quality and quantity from the government's water network. Intense consumption of the ground water can cause land subsidence that in the future can increase the city vulnerability toward tsunami and climate change.

As it's located in a tropical country, Aceh region has two seasons of wet and dry. High rainfall intensity of 200mm is likely to occur during the wet season in October-December while highest temperature of 38 C is mostly felt during the dry season in July-August. The highest humidity can reach to nearly 100% in every month and during the changing period of dry to wet season in September, wind velocity can blow at its highest rate of 40km/hr.

However, although in August and September the rainfall rate is quite low, heavy downpour might still occur. And with the high wind velocity during September, heavy rain combined with strong wind can hit the city and produce serious flooding problem in the city.

Waste

Lack of awareness in clean environment and hygiene life often make people care less about the quality of their surroundings. People use to throw waste everywhere such as empty land, river, swamp etc which in the end can pollute the water and become source of disease. The local govern-



High class residential area around the inner city

ment service in waste management also still insufficient due to lack of equipments and manpower.

People also have poor awareness in waste segregation, this habit give extra work for workers to segregate the organic and recyclables at the landfill.

Air

As small city, Banda Aceh still has fairly good air quality compare to Jakarta or other big cities in Indonesia. However, the increase number of private vehicle brings more pollution to the city. Uncontrolled number of private vehicles can significantly increase air pollution in the future. No regulation on minimum rate of carbon emission.

2.5. Occupation

Working

For the typology, city is mostly occupied by residential area of 2-3 storage buildings. Along the main street, building of 2-3 storages called "ruko" or shop house filled most of the area. Residential area can be found in the back of the ruko and in most of the city periphery.

Most of the office buildings are low and mid rise structure up to 4-5 floor high. Office buildings usually have a sealed window and use air conditioners as a cooler. This type of design can increase the energy consumption as well as generate more carbon to the air.

Living

Residential buildings mostly are 1-2 storages building. Housing area are scattering around the city center, this type of neighbourhoods were originally a small village that merges with the development of Banda Aceh. New residential neighbourhoods can be found at the city periphery.

For security issues, people use to have dark glass window with small opening for their house. This can reduce amount of sunlight entering the building which in the end forced the owner to turn on the light. For the same reason, people also hardly ever open the window. As a result, people use air conditioner or fan for room cooling. Again, this habit increases both energy usage and carbon emission.

Facilities

City has most of the facilities required for its inhabitants, however, most of these facilities are lacking in both quality and quantity. Facilities such as fire station, hospital, land-fill, etc have minimum number that makes them unable to serve the community instantly. Public facilities, such as library, museum, etc are also very lacking in service as most of its hardly accessible by public. Some of these buildings only open during special occasions.

Culture

Aceh is very famous for its delicious coffee, enjoying nice cup of coffee has become daily culture for the people. Therefore it is almost impossible to see one street without any coffee shop at it. This habit brought both good and



People spending time in the coffee shop

bad influence to the people. Sitting at the coffee shop might be good for social interaction, but spending too much time in the shop may lead to the fact that people become very unproductive. The design of the shop doesn't allow the visitor to do other thing else except having a coffee. With many of old and teenagers spent hours in the coffee shop, this creates an unproductive habit that can cause to low productivity and creativity.

As most of the culture-related public facilities are hardly accessible, people especially creative classes unable to express their creativity to public. They sometimes have work hard to find space for their creativeness.

2.6. Infrastructure

Mobility

Public transport service is still far from good. Government-owned buses has lack in number and only serve very small part of the city, while private owned minibuses called "labi-labi" are ways from comfort and also lack in service coverage. This



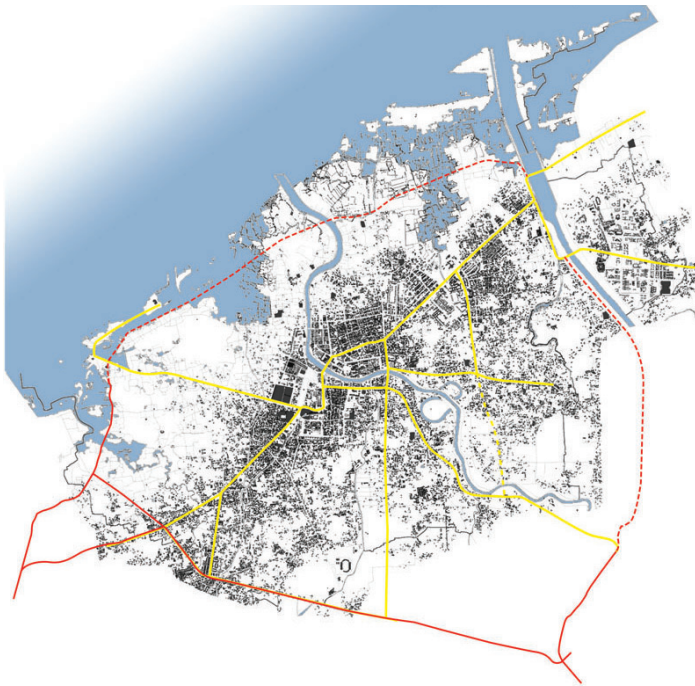
poor service of public transport has led to the increase of private vehicles. Motorbike seems to suit most for the low-medium income people of Banda Aceh. Therefore it is almost everywhere we can see that the motorbike has taken most of the space in the street. And with very poor discipline of the bikers and lack of law-enforcement from the government make motorbike become nightmare for the street users especially for pedestrian and cyclists.

Network

Five main streets connect important part of the city to the city center. Some of these streets also lead to Medan, the capital city of the North Sumatra province as well as to the other cities in the western part of Aceh. These main streets become the backbone for the cross province economic activities.

In the city, the main street network is still developing as some new routes are still under constructions and the local government also planning to construct the ring road at the city periphery. However, the construction of the ring road does not followed by the regulation on traffic in the city center. The ring road only means to complete the circle of the street network while to go to the other end of the city, cars can still take old route through the city center. This intervention will not solve the traffic problem in the city, in fact it will force people to buy more car which in the end lead to more traffic congestion.

As a coastal city, we can find many fishermen settlements



Street network and proposed streets

along the coastal area in the city. This settlement depend their live on the fisheries activities of both marine and cultivated fishing. In case of tsunami, the coastal settlements are the front lines to be hit by the wave. Therefore, with the city is lacking in proper infrastructure to prevent the wave, these settlements become highly exposed to the hazard.

2.7. Public Space

Living Environment

For the public space, the city has fair amount of public space. After tsunami the number of this public space increased as the local government tried to convert the some of the tsunami affected area into the memorial park or museum.

Certain number of public spaces can be found around the city center. However, most of them are hardly accessible as it's located in the 'island' inside the busy traffic. In the end, the spaces become 'dead' space with very low accessibility to users. The quality of space and public realm is decreasing as traffic take over most of the area and pedestrian has to fight with motorbike and car for the space.



The ground floor of Tsunami Museum is designed for the public space



Blang Padang public space during the mid day

As a tropical country, being outside means you have to fight with the heat of the sun. Some of the public spaces are not properly design to give tropical comfort for the users. This makes people reluctant to be outside or they only spent very little time to stay outside.

Culture

As the public spaces are hardly occupied by people, it is almost impossible to see any cultural interaction in the public space. Sometimes, local government or other parties held cultural event in the public space, but in the daily bases, the pubic space are usually empty.

Nature

Some of the public spaces serve as the city park. Nowadays these types of spaces are decreasing due to force of urban growth. The government plan to increase number of city's park in the tsunami inundation area.



Fishponds along the coastal area of the city

2.8. Underground

Network

Most of the drainage system has been damaged by tsunami 2004. Some of its have been repaired but still poor in quality (cracked concrete, etc). The city also don't have good drainage network. Some of the networks do not lead to main extraction point but ended in the empty land that in the end can cause flooding in some locations.

The habit of people in throwing waste not in the proper place can also lead to the drainage being block by garbage. This can cause serious flooding problem in the city, especially during the heavy downpour in wet season.

For the coastal area, strong tidal wave can also block the drainage flow. It even sometime can push the drainage flow back to the city. Therefore it is often to see that the city experiences occasional flooding from both heavy downpour and tidal wave.

Soil Conditions

Most of the areas in the city are covered by swamp. This means every construction in this location will need good soil improvement such as earth fill-in. Aceh Besar, the neighbour district of Banda Aceh loses hectares of it hillside due to land mining to fulfil the need of earth fill-in for Banda Aceh reconstruction. If continues, the hill side area in the Aceh Besar might have problem in losing it natural green spaces.



2.9. Tsunami

Indonesia is a meeting point of three large earth plates. The fault line located at the seabed and stretch from west of Sumatra to Maluku islands. Along the fault lines lies series of volcanic activities both inland and underwater. It has 155 active volcanoes spread within the country (BBC, 2006). This makes Indonesia as one of the most hostile regions on earth in term of earthquake and volcanic eruption.

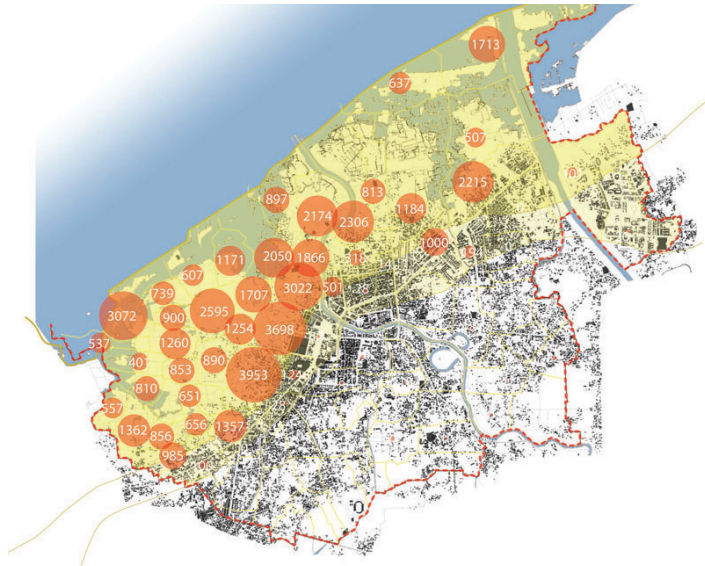
Earthquake and volcanic eruption on the seabed are the main cause of tsunami. With 290 cities located at the coastal line, Indonesia face serious fear of tsunami. History recorded that most of the earthquake occurred in the pacific region, some of it triggered tsunami.

However, latest state shows that big earthquake is likely to occur in Indian Ocean. Three major seabed earthquakes stroke the island of Sumatra in Indonesia within the period of less than five years, an 8.9R earthquake in Aceh (2004), 8.1R earthquake in Nias Island (2005) and the latest 7.6R earthquake in Western Sumatra (2009).

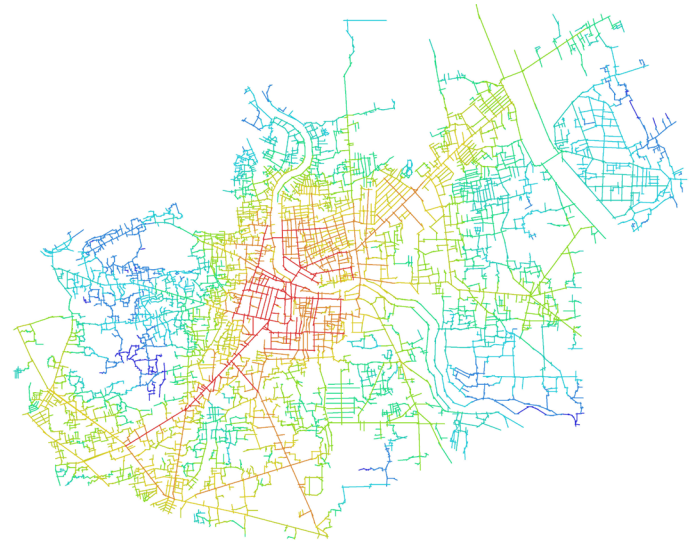
All of these earthquakes have high probability of tsunami, however, only earthquake of 2004 that produced massive wave that hit the coastal settlement not just in Aceh but also in some part of the city far away from it source. It believes to be one of the most devastated disasters ever recorded in mankind history within this century.

Banda Aceh suffered great loss of the aftermath impact. Nearly two third of the city were heavily destroyed with more than 70.000 people died and damaged more than 12.000 houses (JICA report, 2005). The tsunami inundation stroke the city to nearly 4 Km inland and at the same time reshape the coastal line of the city as it sank some of the low land in the coastal area. The tsunami run-up itself reaches up to more than 9m high.

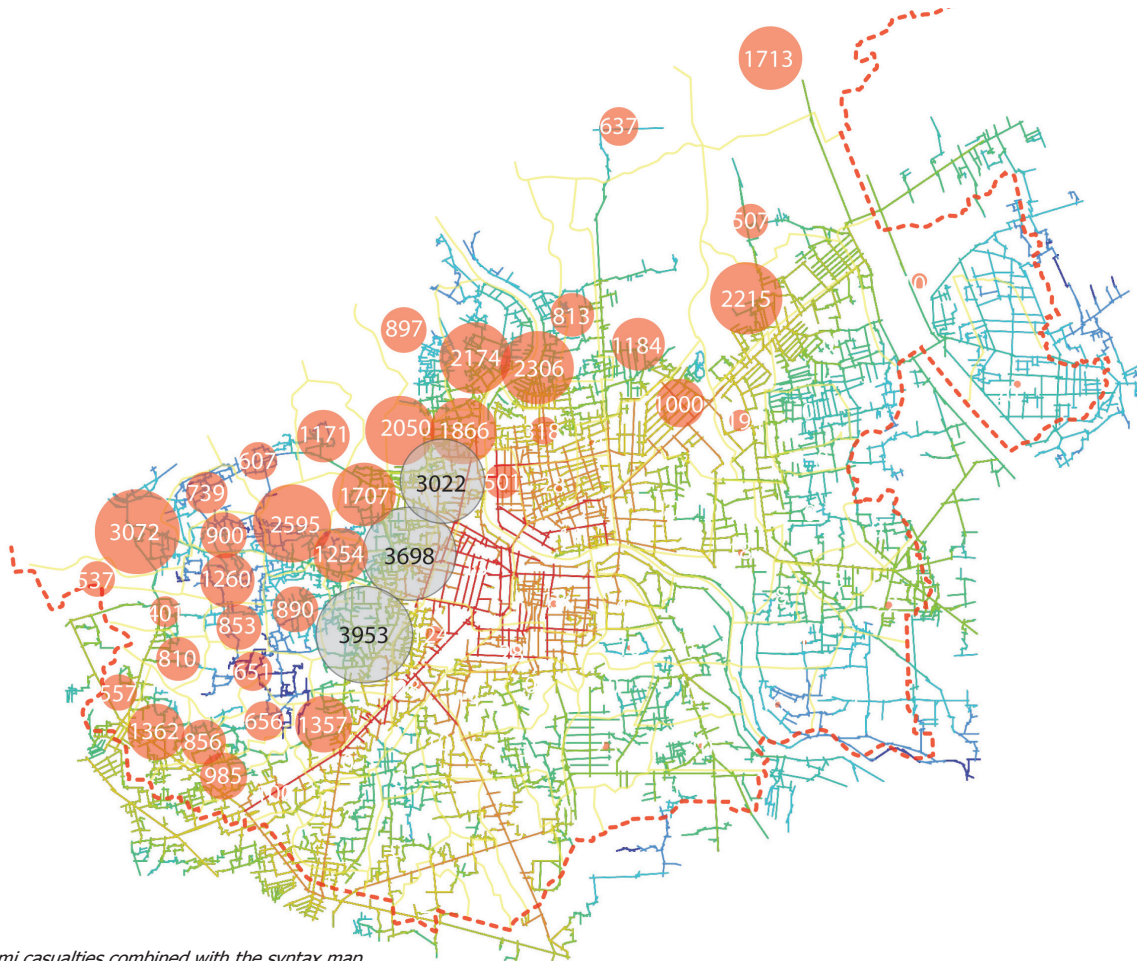
Tsunami 2004 brought massive impact to the city Banda Aceh. With no previous experience of tsunami, many of the inhabitants were un-aware about the signs of the upcoming wave. Earthquake that lasted for more than 15 minutes followed by the descending of sea water level did not put people in high alert about the upcoming danger of tsunami. Lack of local awareness is one of the aspects of why there are so many people died in tsunami 2004. Furthermore, the city was not fully equipped with the tsunami prevention countermeasures as there has been no tsunami ever recorded in the city before.



Number of casualties caused by tsunami 2004 per village (source: JICA Study Team)



Syntax analysis of the street network



Number of tsunami casualties combined with the syntax map

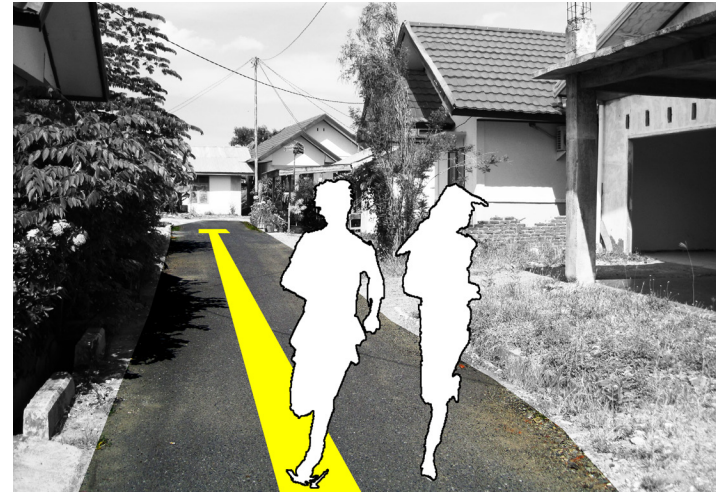
Tsunami has destroyed nearly two third of the city area and killed more than quarter of its inhabitants. However, current state of the city did not show that proper effort has been made to prevent future disaster, while lesson learnt from the previous disaster did not fully included into consideration of the city plan.

Street structure

From many of the cause of high mortality rate of tsunami, complicated street structure become one of my interesting subject to look at. Like most of other cities in Indonesia, Banda Aceh growth by merging with its surrounding vil-lages. The organic street pattern of the village, become a base structure of the area surrounding the city center. With



Narrow street with many turns in the neighbourhood area



Neighbourhood street which has dead end

the complicated street structure, people can hardly find good orientation on fleeing the tsunami. Especially during the panic in running from tsunami, people can easily get trapped in their own neighbourhood if no proper escape route is available.

The complicated street network in most of the part in the city has high contribution in increasing the mortality rate on escaping the tsunami. The reconstruction work done by the government doesn't take this issue as their consideration. Many villages in the tsunami's affected area still have previous street structure that can again cause high death rate in future tsunami.

Further analysis from previous experience of tsunami shows several important points that are strongly useful to develop good strategy for city in facing with future threat of tsunami:

1. The current space syntax map of Banda Aceh show that the neighborhood area around the city center has less integrated street.
2. In combination with map of tsunami mortality rate by JICA 2005, the area with low integrated street experienced more death than other.
3. Tsunami survivors in Banda Aceh city shared that while running on tsunami people tend to behave as follows:
 - People fled to the opposite direction of tsunami

- During the panic of tsunami, people escape by following the flock of the running people
 - People just follow the street without clear orientation toward safety area.
4. Therefore in the neighborhood with less integrated street, people have difficulties to escape from the tsunami, and as the result:
- People trap in their own neighborhood
 - Ineffective flee time

To conclude from the analysis:

- During panic of tsunami, people don't recognize their own city as their used to. They are almost like strangers in their own neighborhood. This is because panic can reduce people's capability to memorize the surrounding.
- **The author could not find any research of how people behave during the panic, especially when escaping the disaster such as tsunami. However, from the story of the survivors, it seems to show that eye orientation (high buildings, sign, hill, etc) is more acceptable than the mental map of the neighborhood. People seems to react faster to what they saw (run away from water, go to high building, follow the flock of people) than to what they can memorize about the neighborhood.**
- City with clear street structure and good escape orientation can help people to effectively flee from the disaster.

3 Project Framework

3.1. Problem Statement

The tsunami disaster has bring peace to the province of Aceh, and with the help of international organization, Banda Aceh has grown fast to recover from disaster.

However, the growth of the city did not equipped with good hazard prevention effort in coping with future threat of tsunami and lesson learnt from the previous disaster is not fully applied to the city development.

3.2. Research Question

How the good city structure can minimize the mortality rate in term of tsunami and earthquake disaster and contribute to improvement of the living quality?

Sub-Research Question

- Toward what scale that different disaster prevention strategy can be applied?
- What type of prevention effort is suitable in the developing city like Banda Aceh?
- How the local culture can contribute to the community resiliencies of tsunami?
- How the disaster prevention project can be used as a backbone of community's daily activities?

- How can the top-down and bottom-up approaches contribute each other and give value to the success of the disaster prevention efforts?

3.3. Project Aim

With the help of International Organizations, Banda Aceh city is experiencing a rapid growth post to the tsunami disaster. This thesis project is aimed to study about what strategic program can be implemented in the city in order to create resiliencies toward future hazard caused by tsunami. At the same time the program should accommodate the daily needs of the inhabitants, create better living condition and improve living quality.

Hopefully in the future, this graduation project can be introduced to the Planning Department and the Mayor of the city, expecting that some of the suggestions from this thesis will be considered into long-term vision of the city development.

4 Guiding Principles

4.1. Theoretical Framework

Human activities always contribute to the change of the environment. Some of the changes bring benefits while more also produce negative impacts to the environment. When the Earth is at its over capacity damaging natural disasters may occur in the future. Natural disaster can have both good and bad impact for the environment itself and humans will always react to the disaster by carrying out response effort. This response effort aims to recover the human environment in dealing with the disaster. The diagram shows how this relationship is looks like (Etkin et al, 2005).

United States National Tsunami Hazards Mitigation Program introduced seven principles for coastal city in Planning and Designing for Tsunami Hazards. The principles are as follows:

1. Know your community's tsunami risk, hazard, vulnerability, and exposure
2. Avoid new development in tsunami run-up areas to minimize future tsunami losses
3. Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses
4. Design and construct new building to minimize tsunami damage
5. Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans

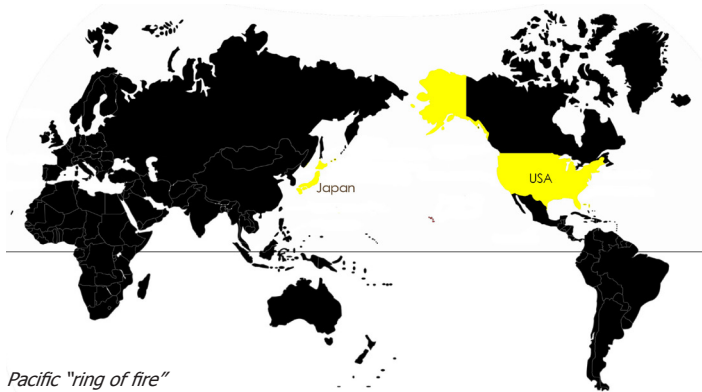
- and projects
6. Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage
 7. Plan for evacuation

However, the above principles are mostly only related to the tsunami mitigation issue only. Cities which came from poor and less developed countries, planning the tsunami mitigation program can be very expensive. Therefore, in order to have more affordable program, the programs should be correlated with other natural disaster mitigation which has more frequent recurrence (i.e. flood, storm surge, etc) and at the same time it should also be combined with the urban regeneration programs. Previous tsunami that destroyed most of the coastal area also should be taken as a chance to restructure and rebuild better city.

4.2. Case Study

Tsunamis are a rare event for a natural disaster. However, the impact of a tsunami can be very catastrophic. Countries in the Pacific Rim are subject to tsunami threats and therefore certain efforts toward tsunami resiliencies must be taken in order to protect the city or reduce the impact of tsunami.

Pacific ring of fire believed to be one of the highest earthquake and tsunami prone on Earth. Therefore countries like Japan and United States are experiencing serious threat of



Pacific "ring of fire"



Tsunami countermeasure efforts in Okushiri Island, Japan

tsunami, especially for its growing coastal city. Blackford (1999) believes that “Japan and the United States are perhaps the leaders among nations in the area of tsunami mitigation”. Both countries have developed advanced countermeasure strategies to protect the coastal cities from future threat of a tsunami. Japan suffers frequent threats of a tsunami. Therefore, large infrastructure such as sea walls, wave breakers, water gates and other hardware countermeasures have been implemented in most of the coastal cities while at the same time, the country has developed advanced software countermeasures through land use planning, promotion of escape building, tsunami education for coastal communities, and early warning systems to increase the community resiliencies.

The United States on the other hand experienced lesser tsunamis compared to Japan, and according to Blackford (1999) “the tsunami threat the United States has been mainly from the distant tsunami”. As a response, United States established advanced technology in early warning systems that allow coastal communities to take early necessary steps in evacuating the disaster. To increase the community’s resiliencies, coastal cities promote tsunami escape routes together with safety zones and escape building, while at the same time public awareness also become a priority.

“Although nearly 60% of tsunami occurs in the Pacific, they can also threaten coastlines of countries in other regions” (IOC, 2008). The 2004 tsunami hit 19 countries in the Indian Ocean region stretching from Southeast Asia to Western Africa. According to Ghobarah et al (2006), “damage from the event is staggering and loss of life exceeded 300,000 with an estimated 1.5 million made homeless” (figure.4). This region is home to the most third world countries on the planet: Bangladesh, India, Sri Lanka, Indonesia, Pakistan, Somalia and Kenya are some of the examples.

Karim (2007) argues that “most the technologies and knowledge’s in coping with tsunami disaster are originally come from wealthy countries.” Cities in the third world countries have to adapt this strategy to its socio and economic condition in order to have successful achievement. Many of the tsunami counter measurements are financially expensive to be implemented, especially for installation of hardware countermeasures. Additionally, the frequency of a tsunami is rare and unpredictable for both time and place which also contributes to the lack of hazard awareness in third world countries. Cities tend to focus on mitigation of more periodical disaster events, such as flooding or storm surges, and only have little effort for tsunami mitigation.

Social and culture conditions also contribute to how people react to the disaster. The perception of disaster as “acts of God” in which human has no power to stop it has reduced the community resiliencies toward disaster.

5 Design Guidelines

5.1. Tsunami

By studying the tsunami behaviours, it is possible to see how the urban intervention can be planned to adapt with the destructive behaviours of tsunami. Some of the findings are:

Tsunami force in long and straight street that perpendicular to the beach

Tsunami also has similar behaviour with wind. From Storm Surge and Tsunami Simulator in Oceans and Coastal Areas (STOC) shows that tsunami has relatively high speed in the open and straight line channel, especially in the line which has same direction with the water force. This argument is strengthened by the amateur video recorded in Banda Aceh when tsunami 2004 strikes. The video shows that the street that has same direction with the water flow suffered bigger damage and the water flow faster than the streets that are perpendicular to it. This means that the area with street directly perpendicular to the beach line (tsunami source) and has building in parallel at both sides can create a channel-like area that make tsunami wave move faster and reach more area inland.

This finding is in contrast with the purpose of effective escape on tsunami. Street that located perpendicular to the beach line actually very good for the people to escape the tsunami. They can directly run away from the beach to the

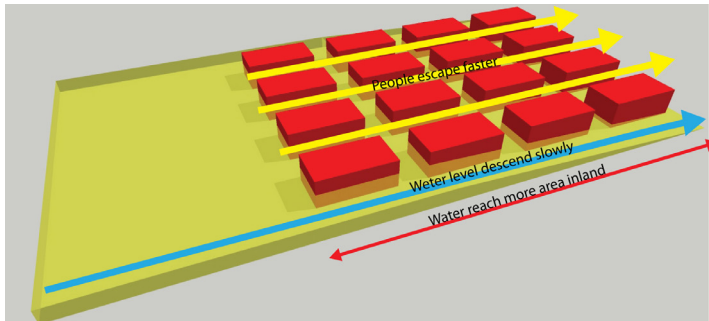
safer ground. However, when tsunami arrives, this type of street can be deadly to people, the wave will be very fast and with no obstacles along its path, the wave can damage more area inland.

In contrary, buildings that are scattered and placed in a way that not create a channel can somehow reduce the power of tsunami. But, this type of structure means that the street will be shorter and people have to make more turns to escape from the wave. It can slow down the speed of water, yet at the same time it can also slow down the escaping people.

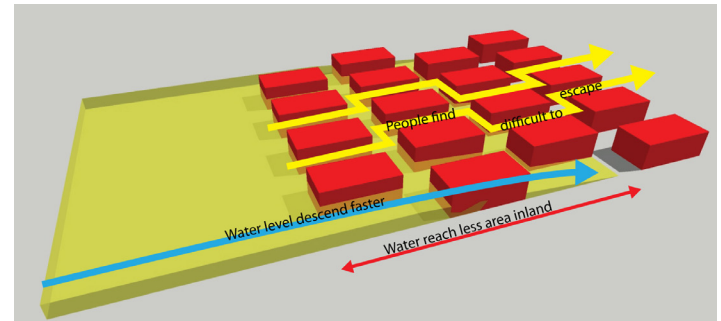
Therefore, in planning for better city structure in tsunami prone area, it is important to look carefully on the topography of the area and see from which direction the tsunami can strike the city. This information can be valuable in planning the structure of the city. The suggestion is that the street structure (direction), especially in the beach area should be not directly perpendicular to the beach line (tsunami source). The more of this kind of street means the city could suffer the heavier damage, because the tsunami will flow faster in this type of street and penetrates deeper into the city.

Buildings to reduce the tsunami force

Good building structure can reduce the force of tsunami or even block the wave. Although the building at the frontline will be hardly damage by the tsunami, the building behind it will receive smaller force of the wave and with the run-up being blocked by the structure. Tsunami wave will reach shorter to the inland and cause less damage.



Straight streets which are perpendicular to the wave direction are very good for escaping people but also deadly when tsunami strikes



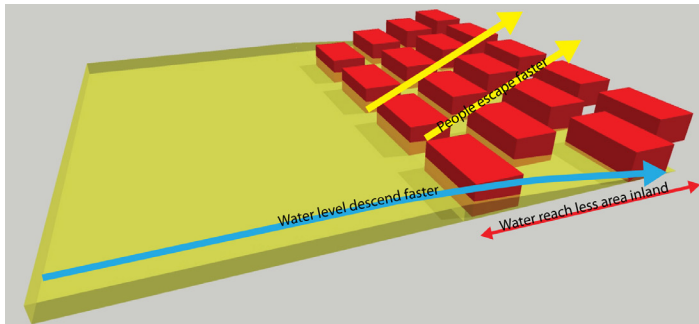
Less straight streets are good to reduce tsunami force but with too many turns, it can be deadly for escaping people

Usually, engineers design the building that can withstand the earthquake and tsunami. As a planner, it is also important to see how buildings should be located in the neighbourhood level to produce good urban structure that has better resiliencies toward tsunami.

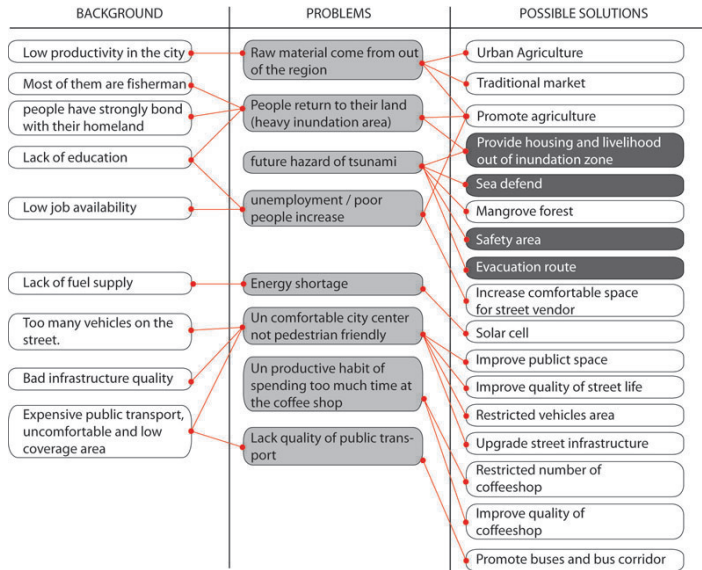
Street obstacles to reduce the tsunami force

It can't be avoided that escape route should be planned as straight as possible to the escape zone. According to the previous finding, this means that the escape route itself could be in serious danger because the straight line means the water can slowly generate its force and produce faster tsunami. Therefore, a smarter solution is required in designing the efficient escape route yet safer from tsunami force.

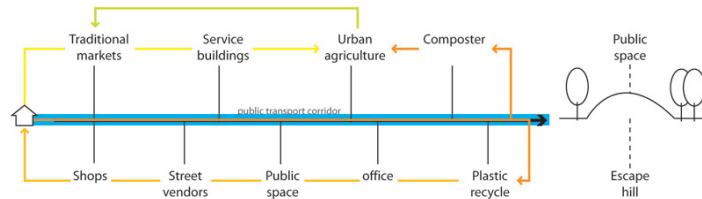
Street obstacles can be very important elements in reducing tsunami force in the escape route. But we have to be very careful on locating the obstacle to avoid difficulties for people in running the wave. It is also important to look on type of materials for the street obstacles itself. Previous tsunami showed the wave pulled down most of the trees in the street which at the end increase the destructive power of the wave. This means that trees can't be used as wave breaker in the escape route. Strong reinforced concrete pillars work better than trees. Previous experience on tsunami showed that most of the two storages building survive the wave. This means, structure for two storages building is strong enough to withstand tsunami force. Therefore in my escape route design, concrete pillars will be placed along the street. In the street scale, these pillars can also work



Straight streets that are not perpendicular to wave direction can make people flee easily and building can also reduce tsunami force



Spatial Intervention in Tsunami Related Problems



Combination of escape route with other urban socio and economic activities

as structure for street facilities such as bus stop, light post or other outdoor facilities. To increase its' resistance, pillars will also be tied up together and work as solid structure along the street.

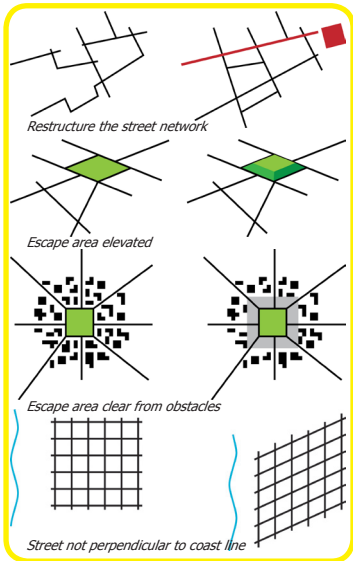
5.2. Project Combination

From the city analysis, it is possible to derive problems occurring in the city. By identified it background and source of problem, certain solutions can be introduced. Both socio and economic conditions can be improved with good strategic urban interventions. However, since the city also facing other threat of tsunami, those urban interventions should be combined with the adaptation effort of tsunami disaster.

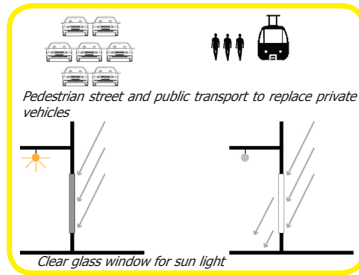
Combinations of the urban interventions and tsunami adaptation measures can be strategically planned in some of urban spatial interventions for example in planning the escape route and escape zone. Escape route and escape zone are a critical aspect in escaping the tsunami. People should have good orientation toward the escape zone while running in the escape route. It should have good paving quality with minimum obstacles. People should also easily recognize the area. This means that the escape route and escape zone should be part of their daily activities.

From these criteria, it is clearly shows that the area should be part that most of people use it every day. It should accommodate both social and economic activity of the inhabitants. Therefore in the urban regeneration point of view, these areas could be also introduced as one of the strategic shopping street and public spaces with active street life.

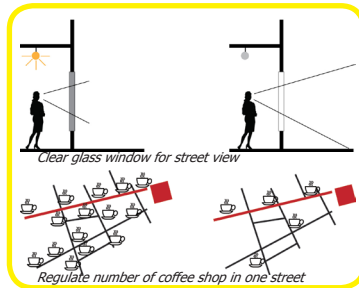
Tsunami wise



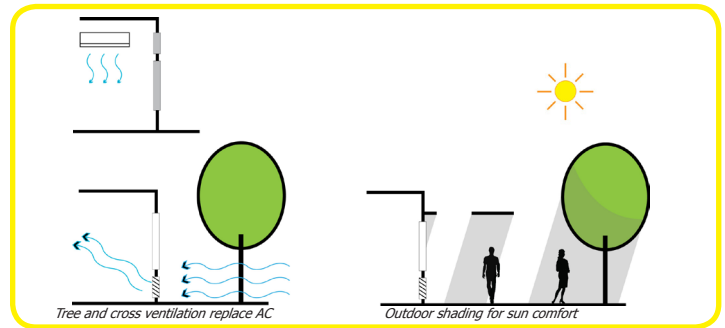
Energy efficient wise



Social comfort



Tropical comfort



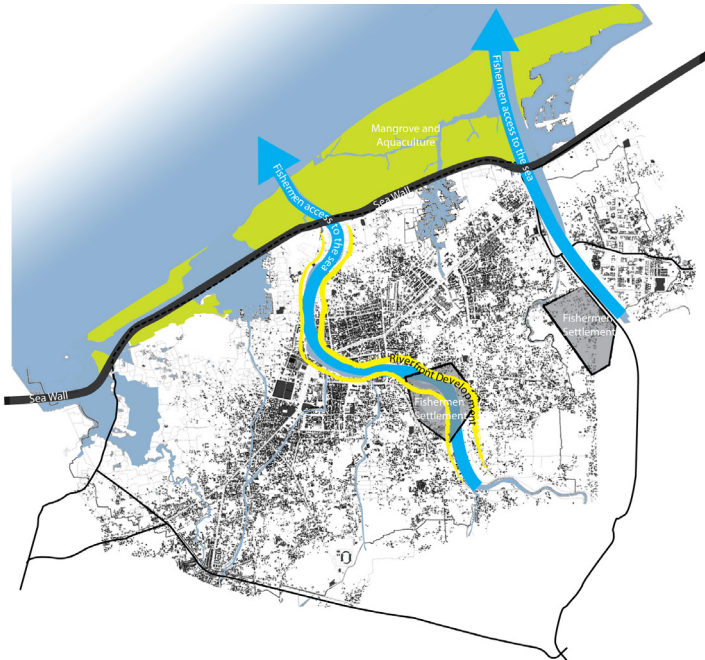
6 Plan and Project

The thesis project starts by identifying the soft and hard countermeasures possible to be implemented in the city of Banda Aceh. It is also good to look at the current plan of local government and see how this plan can be improved and insert some of the tsunami countermeasures aspect to it.

6.1. City Scale

The project will be divided into several scales that allow me to tackle different portion of problems. The largest one will be the city scale, at this scale I will try to see how the city work toward the tsunami resiliencies and implementation of several hard and soft countermeasures projects at the larger scale. This includes the elaboration of land use plan in the inundation zone, planning the infrastructure for tsunami and identifies the escape zone area and the critical escape route.

At the city scale, it is important to see some of the settlements that are located in the coastal line. Most of these settlements are occupied by fishermen whom their work directly related to the sea. If the tsunamis strike again in the future, these settlements will be the first area to be hit by the wave. Therefore it is important to relocate them to more inland to avoid heavy tsunami destruction. As the city has two main rivers, it is possible to make these rivers as

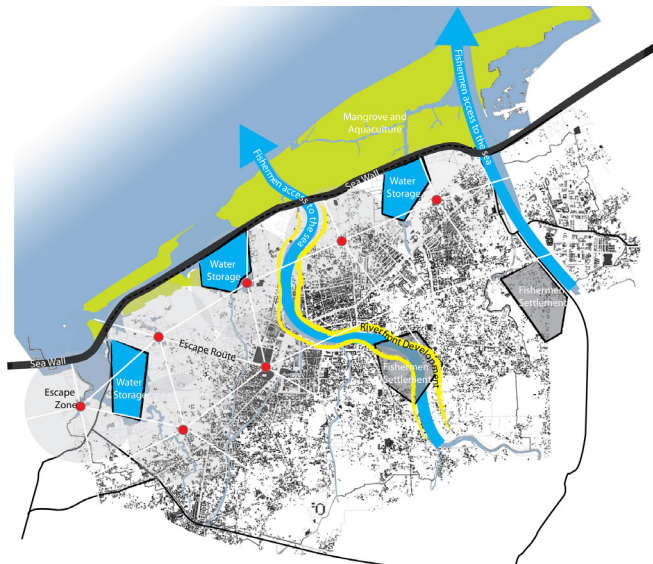


Fishermen settlement relocate to more inland and use rivers as main access to the sea

main access to the sea when the settlements are relocated. At the same time, city can also introduce navigable river for both transport and recreation and improve the river-front area.



▶ 3 Km/h ▶ 0.5 hours run ▶ distance travel: 1.5Km ▶ turning ▶ r: 1km

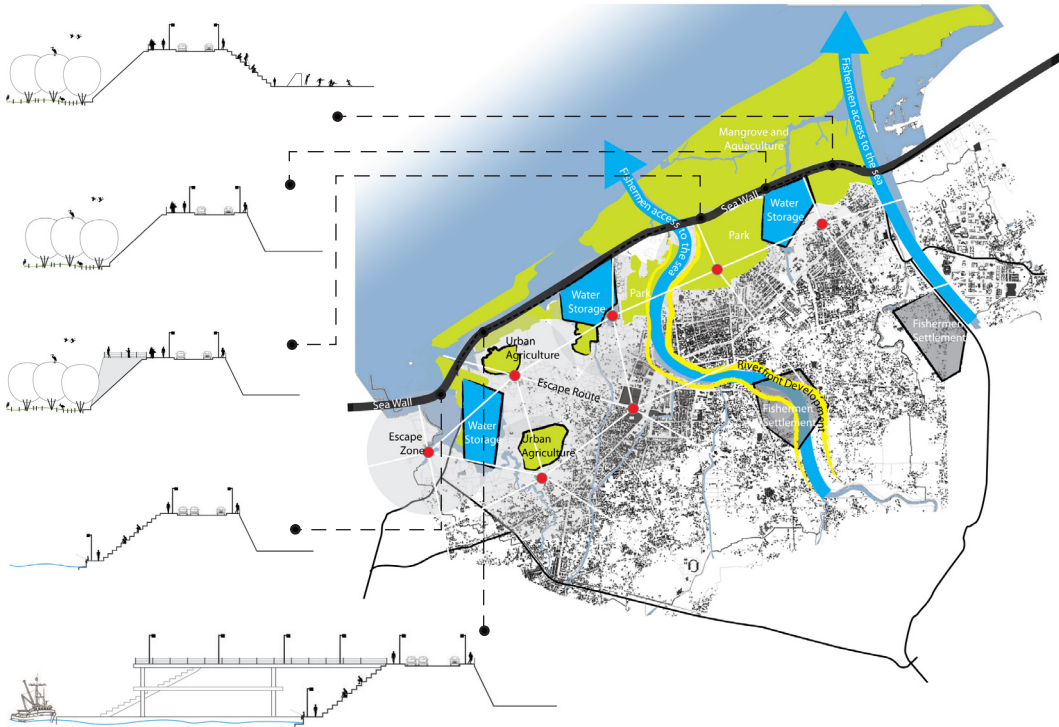


Scheme of location of escape areas and escape routes

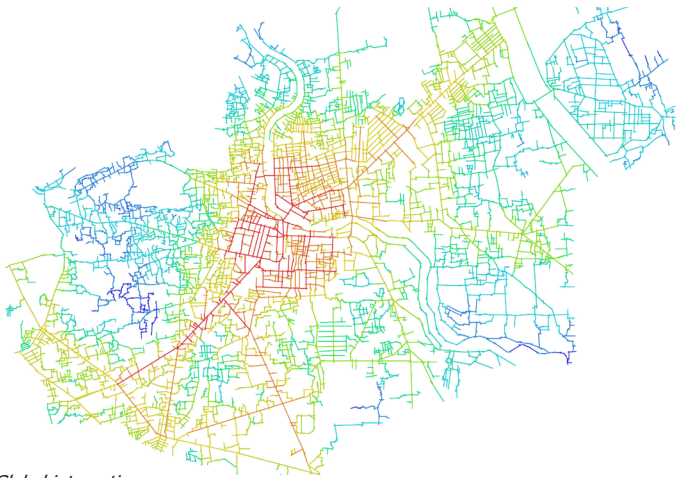
The plan for ring road at the Northern part of the city also can be combined with the construction of sea wall to prevent tsunami damage. As soon as the fishermen settlements are relocated, the abandoned area can be preserved for the green conservation such as mangrove forest or for cultivated fisheries such as fish pond, etc.

Project at the city scale also will identify the location of tsunami escape areas and well as the escape routes. The guideline from FEMA (2009) explained that for portion of people with limited mobility due to age, health, or disability the escaping speed are approximately 3km/h. If we assume the tsunami alert will be announced half an hour before the wave arrive, people will be able to flee at the distance of 1.5 km. Therefore, considering the flee distance and the amount of turn made while running as well as time taken for people to react from the alert, it is best to put escape area at the radius of every 1km.

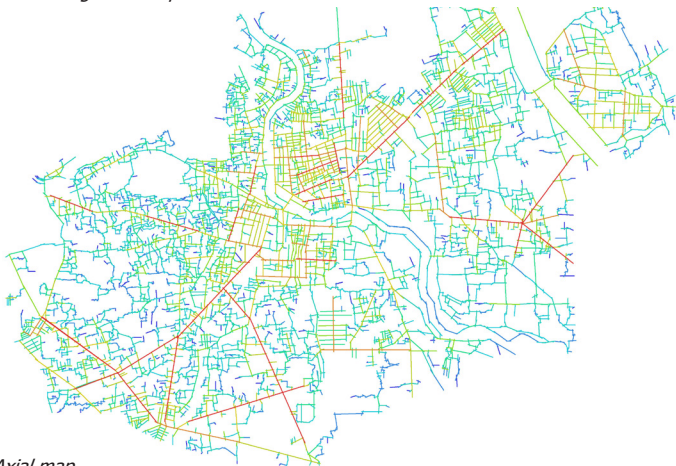
Scheme of how the wall can integrated to the surrounding



Original Street Network

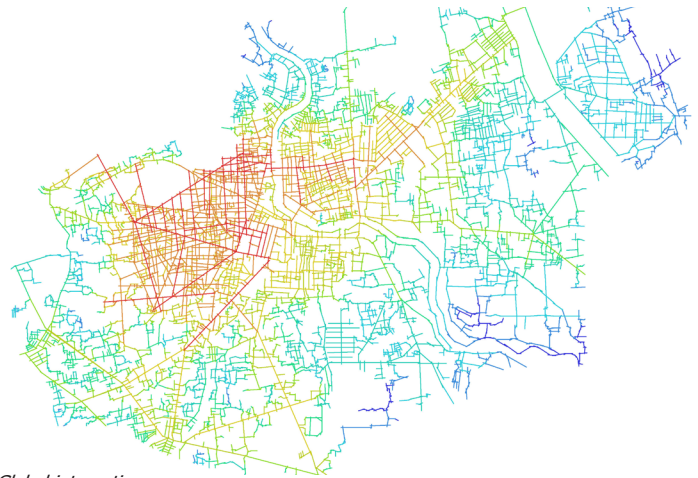


Global integration map

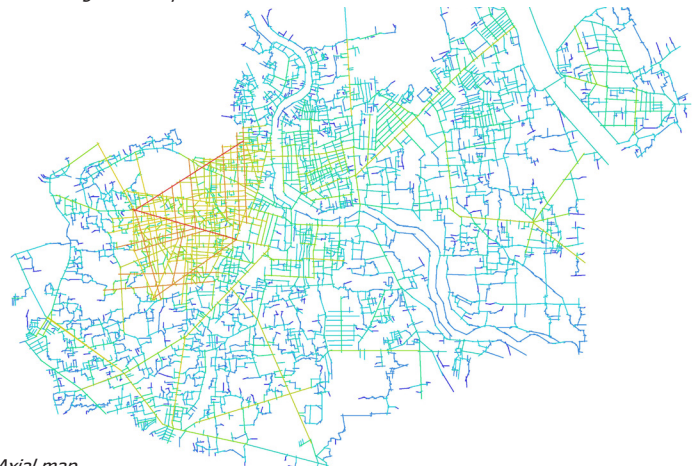


Axial map

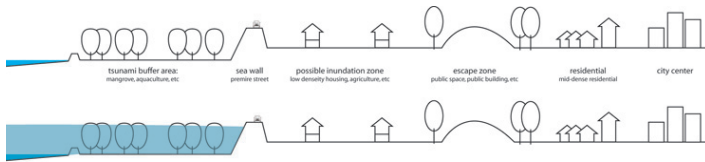
Proposed Street Network



Global integration map

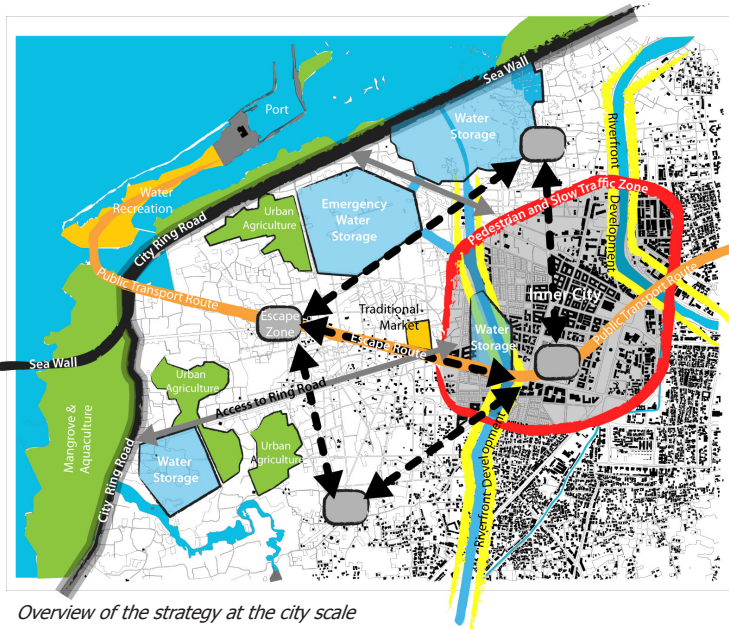


Axial map



Section of the proposed design for the coastal area of the city

In the combination with the urban regeneration project, escape routes will be one of the critical streets that also become strategic street for socio and economic activity. Therefore it's also possible to design escape route as public transport corridor. Furthermore, in planning the transport corridors, the line should connect most of the strategic areas in the city to give significant impact to the city. The location of University area, the city centre and the Ulee Lheue Port should be some of the strategic areas to be connected.

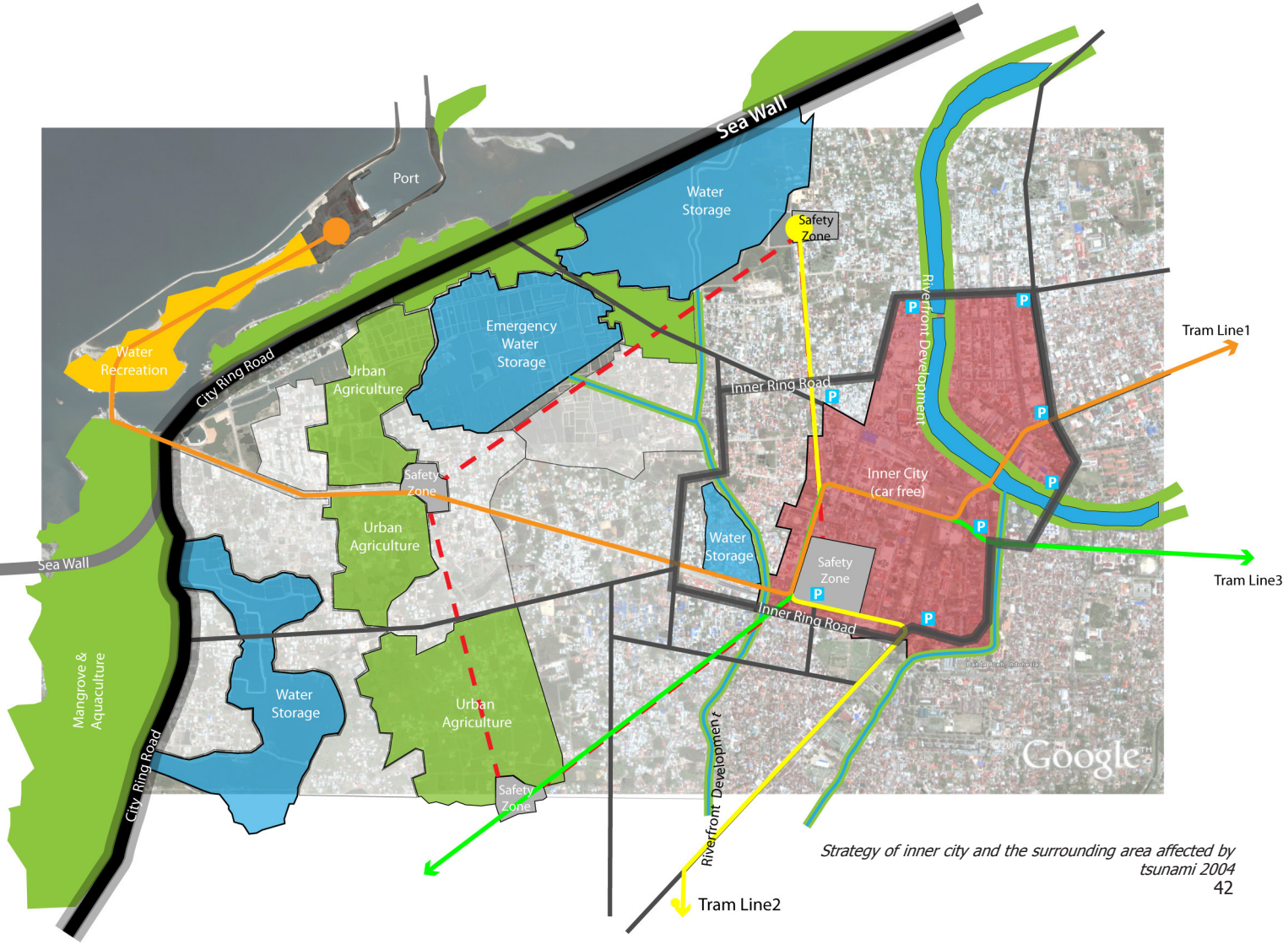


Overview of the strategy at the city scale

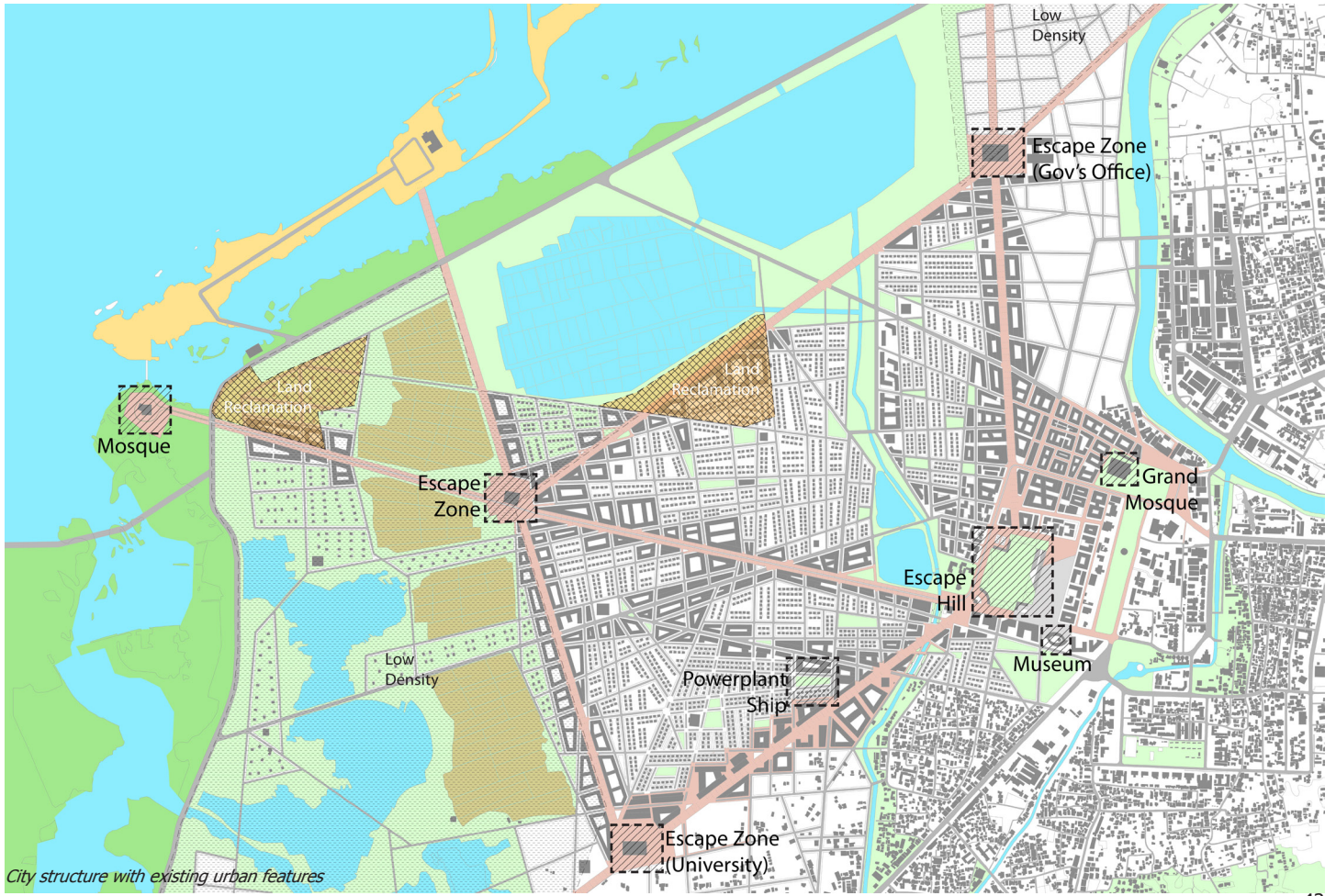
Water storage

As the city also suffer flooding during the wet season, it is also important to plan the structure that also has strong resiliency toward flooding, since flooding has more frequent recurrence compared to tsunami. Therefore, the design will also look closely to the development of the riverbanks and improve the quality of it. The smaller rivers that are usually over loaded during wet season should have wider embankment as extra water storage. This embankment can be creatively design as park during the dry season and let it flooded during heavy intake in wet season.

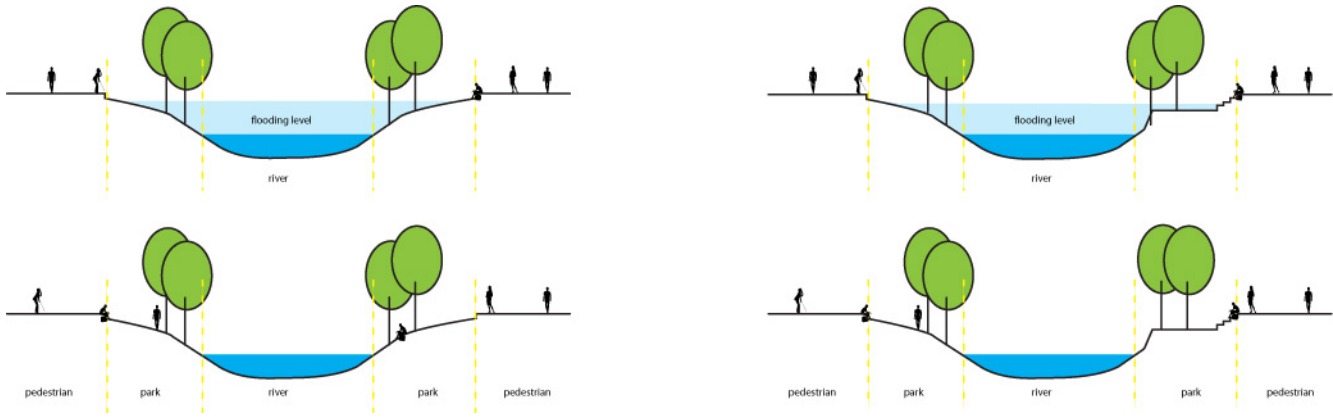
Larger water storage can also be placed in some part of the city to store rain water and work as an integrated system with the flooding issue. At some point, fishponds area in the city can also be converted as emergency water storage if the city suffers heavy flooding and need more space to store water.



Strategy of inner city and the surrounding area affected by tsunami 2004
42



City structure with existing urban features



Section of proposed riverbank development



Krueng Daroy, one of the river that cross the project area



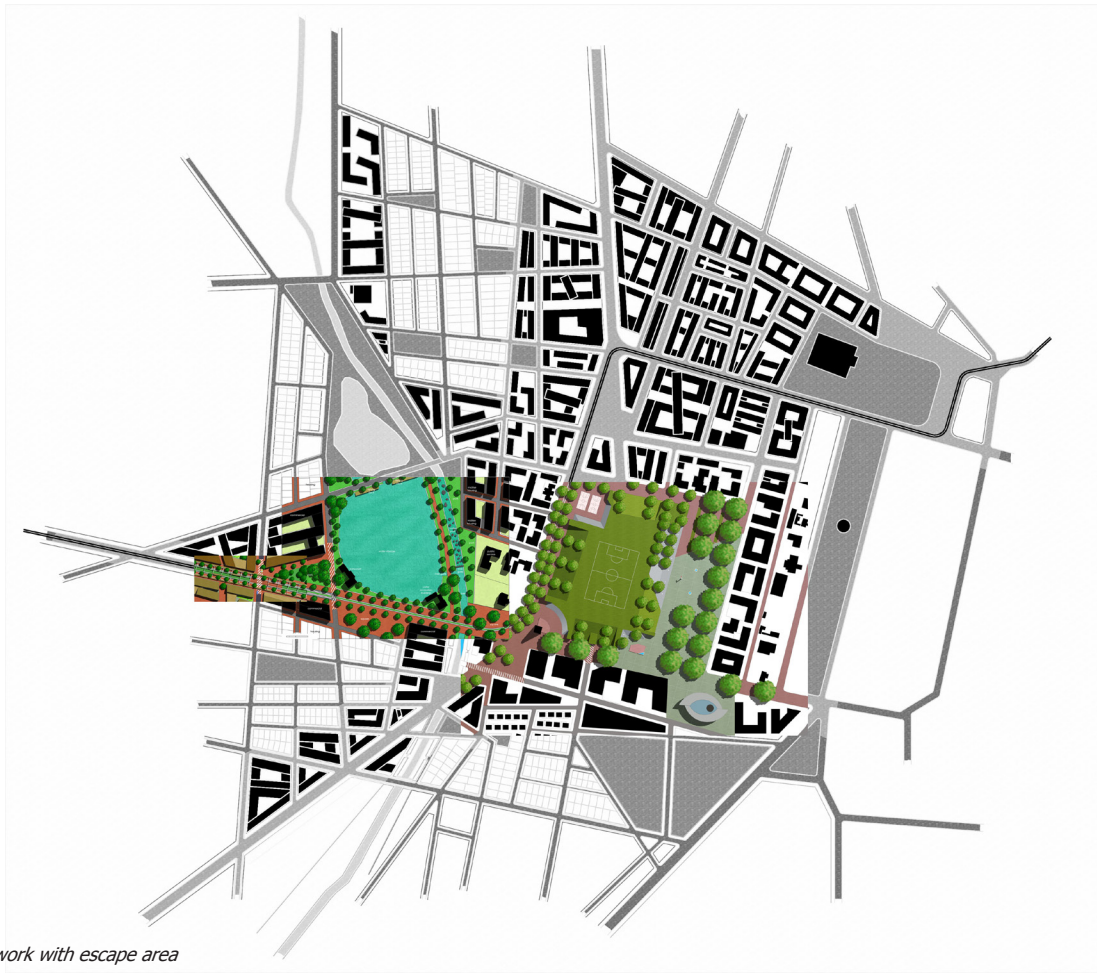
Original street network

6.2. Local Scale

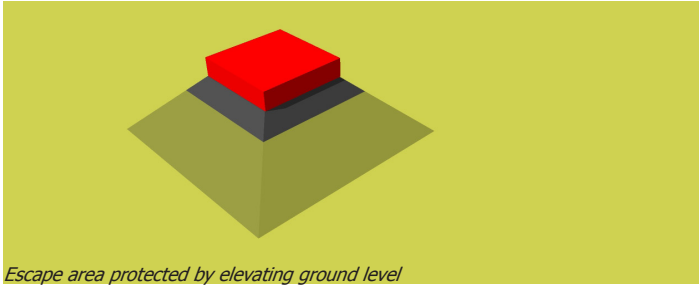
This scale is identified by the analysis of the mortality rate in comparison to the street integration from the syntax map. The combination of these two maps shows an interesting result. The area around the city center where the street network is less integrated, the mortality rate from previous tsunami is much higher than the area with more clear street structure. Therefore, this area will be selected for the design in local scale level.

The output from this local scale strategy will be the proposal of land use plan in more detail, the street restructuring plan, identification of the exact location of the escape route and escape zone and strategy to combine the tsunami adaptation effort with the urban regeneration projects.

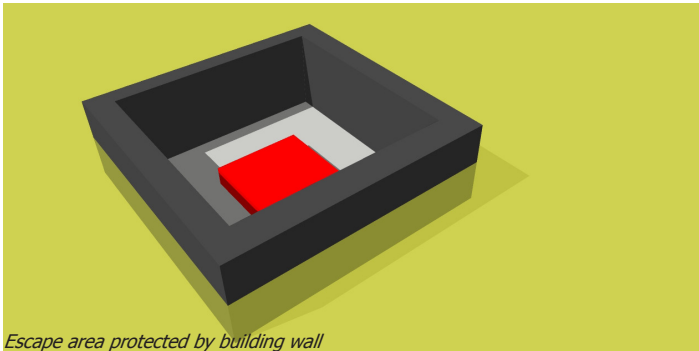
The new proposed street structure will be tested again by the syntax analysis to see how the streets change in term of integration.



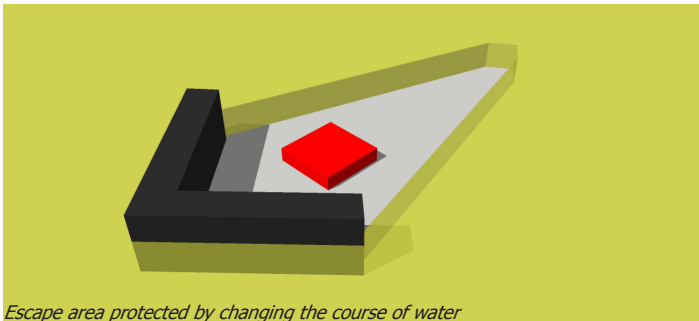
Proposed street network with escape area



Escape area protected by elevating ground level



Escape area protected by building wall



Escape area protected by changing the course of water

Water storage

There are many different ways to protect escape zone from the tsunami strike. One of the solutions is to change the course of the wave. Previous tsunami 2004 in Banda Aceh showed that some part of the city suffered less damage from tsunami because the neighbourhood was surrounded by the river. Deep channel of the river has reduced the force of tsunami and also slightly change the direction of it.

From this experience, we can also plan safer evacuation zone by protecting it with the channel or strategically locating the water storage close to it to reduce the tsunami force or slightly change course of the wave.

On the other hand, water storage can still work as flooding system and also as park in the city. Large water pond can also reduce the temperature in the city and produce cooler space for people to be around.

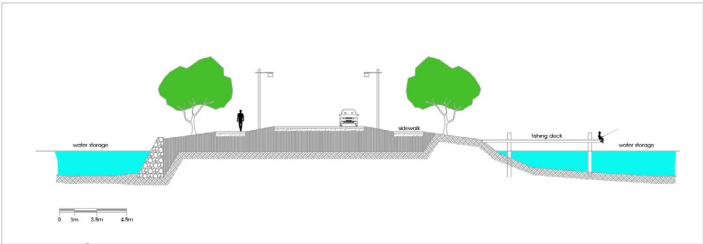
6.3. Neighborhood Scale

The locations of the neighbourhood scale are identified from the area in the local scale that need more detail attention. At this scale, more detail design will be introduced and see how the tsunami countermeasures effort and urban regeneration project can implemented in the scale of urban development project.

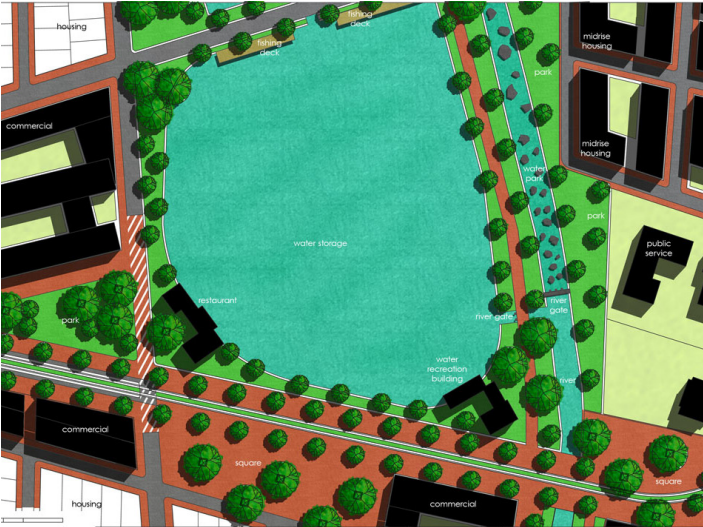
The neighbourhood scale will also introduce some of the design approach to tackle various aspects of problem. How the building should be design (building code) in order to have better resiliencies toward tsunami as well as operate in more energy efficient manner while at the same time give comfort for the users.

One of the locations selected for the neighbourhood scale is the open space of Blang Padang. This area is located at the edge of the city centre. According to the scheme of locations of the escape areas, public space of Blang Padang is suitable to be design as one of the escape zone area.

At the moment, Blang Padang is a quite active public space surrounded by open drainage. Some of the design proposal for this area will be to close the drainage to minimize the surrounding obstacles and elevate the ground level and use the area below it as parking space. When the city centre is being pedestrianized this location is suitable for parking as it located on the edge of the city centre.



Section of water storage area



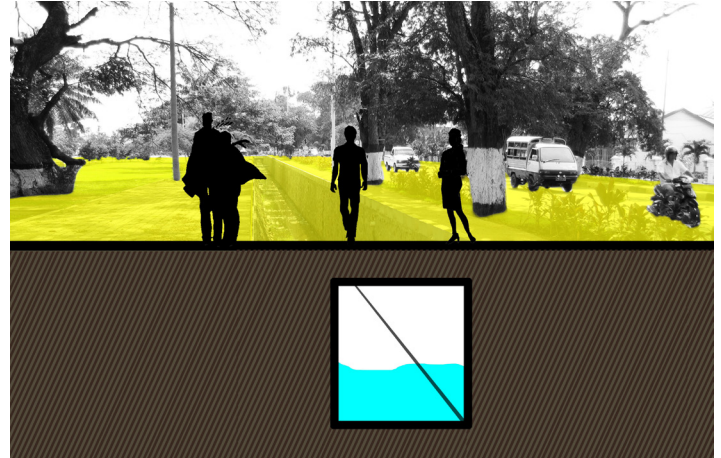
Water storage for flood protection as well as city park



Original site plan of Blang Padang



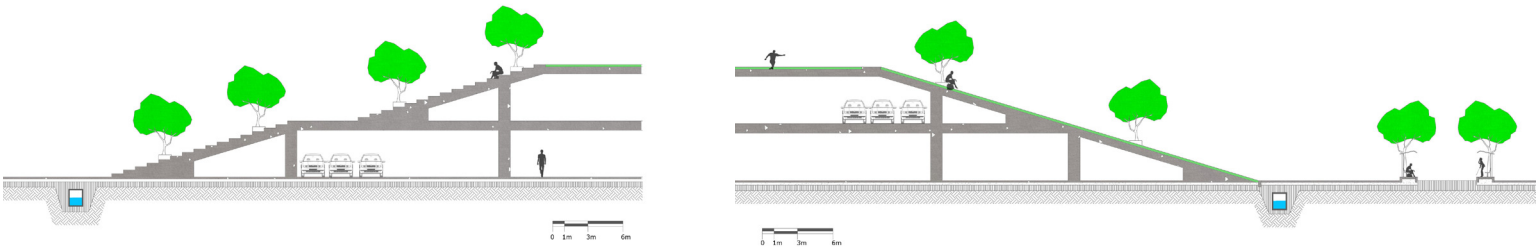
Open drainage surrounding the open public space



*Flat pedestrian route with closed drainage
to give bigger access for pedestrian*



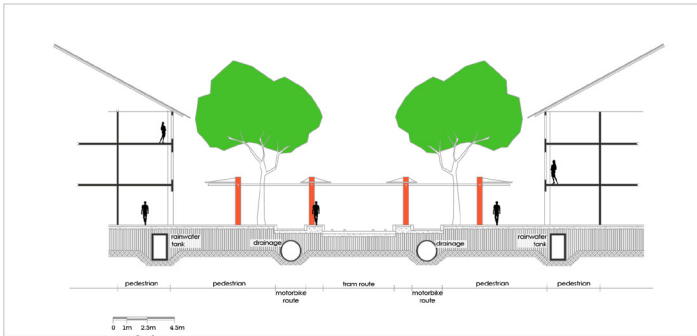
Propose site plan of Blang Padang as escape zone



Cross section of Blang Padang as escape zone



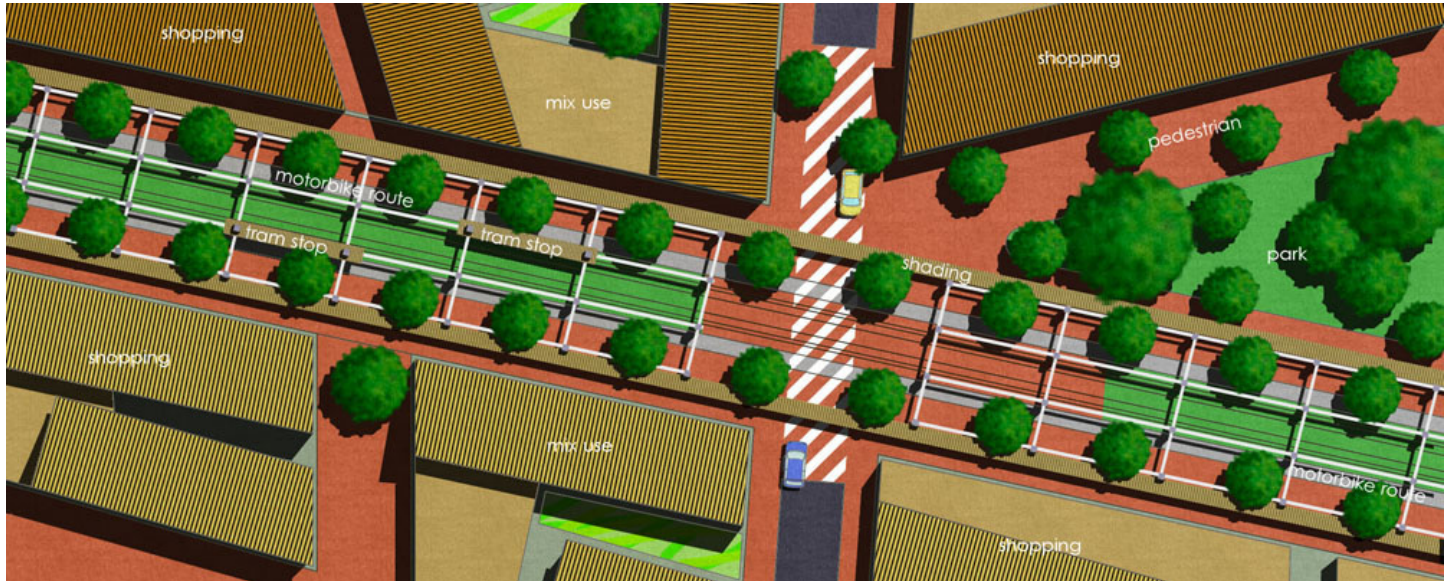
Blang Padang public space area as well as tsunami safety ground



Cross section of the escape route

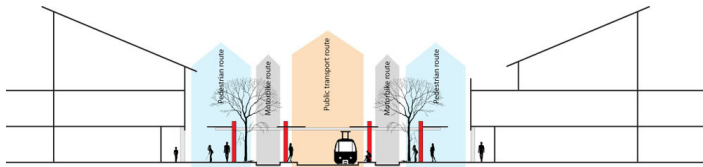
Other location selected for the neighbourhood scale will be one of the main escape routes in the local scale area. This street is currently use as one of the shopping area in the city. The design suggest some of the street features as well as building typology in related to the tsunami adaptation measures as well as energy efficient manner.

Reinforced concreted pillar will be used as outdoor street furniture such as tram stop, light post, etc which at the same time also work as a tsunami's breaker. Shopping buildings also design to have maximum height by using

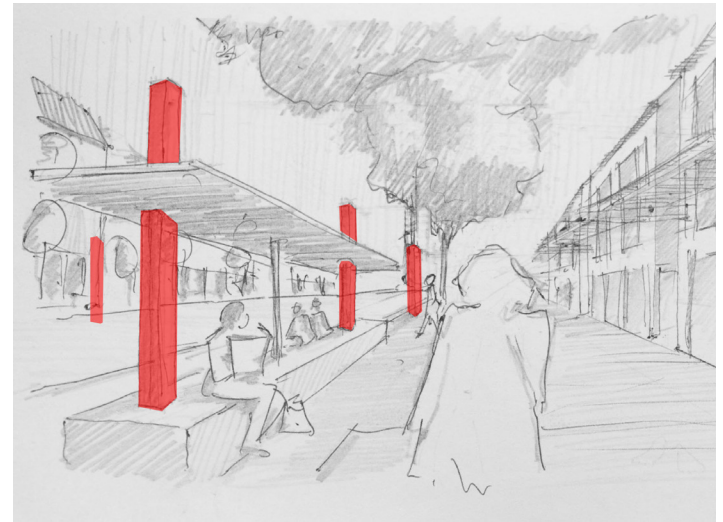


Site plan of one of the escape route that also serve as shopping street

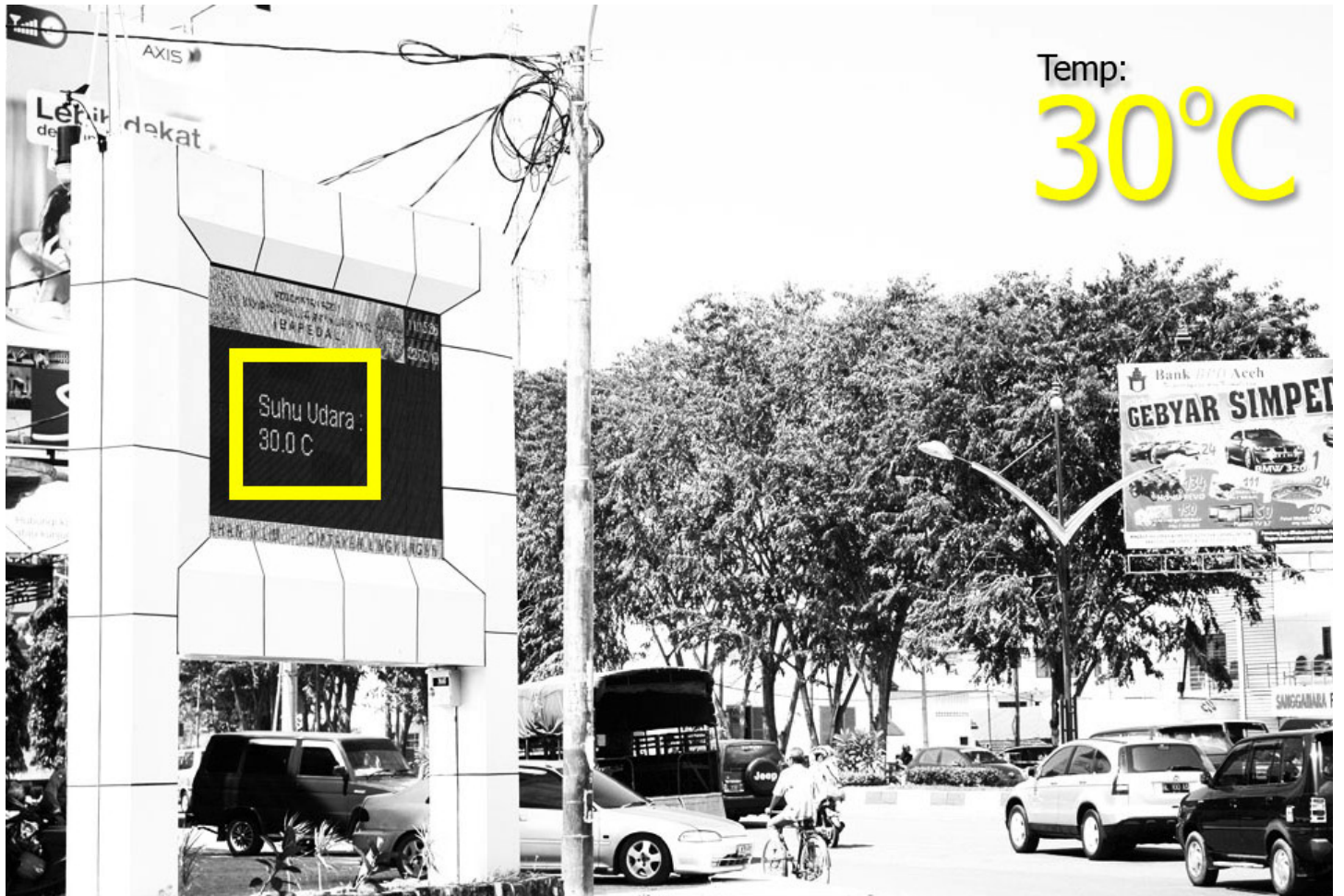
one-slope roofing. This to allow people in the neighbourhood area to easily identified the escape route and give good orientation toward the escape area. The buildings also will be equipped with the rain water storage, and one-slope roofing is a good design to minimize the need of piping for this purpose.



Cross section of escape routes as shopping street



View of the concrete pillars at the escape route which also work as structure for outdoor furniture



Hot and humid day experienced almost everyday in the tropical city of Banda Aceh

Tropical comfort

Banda Aceh is located in the tropical area where the temperature can be very hot during the day and sunlight can be very harsh. Hot and humid weather reduce the outdoor comfort for many pedestrians. Therefore it is very hard to find attractive street life in the city. People prefer to be inside the building with nice air conditioner or travel by car even to a very short distant.

During the visit to the city, writer observed one of the pedestrian paths in the city. From the observation, the writer found that people prefer to walk in the shading area instead of in the sunlight. Behaviour in the outdoor public space also showed the similarity where people prefer to sit in the shadow rather than in the open sunlight. This means that in the tropical city like Banda Aceh, shading area become a very comfort space for outdoor activity.



People prefer to walk in the shadow rather than in the harsh sunlight



People will try to find shadow when sitting outside



From all of outdoor elements, trees can be one of the effective features for the outdoor comfort. Not only because trees can produce shading, but trees can also reduce temperature to 2-3 degrees in its' shading area.



6.4. Integration with Existing Urban Feature

At the current stage, city has many urban features that give good influence to both economic and social condition of the inhabitants. Some of these urban features are part of important heritage of the city such as Grand Mosque Baiturrahman, Gunongan (Princess' bath) from Kingdom of Aceh, Kherkoff (Dutch graveyard from war of Aceh) etc, also some other new urban feature that is available to commemorate the impact of tsunami in Aceh such as tsunami museum, Power Plant Ship Park, Tsunami Mass Graveyard Park etc. All of this feature are now become important element of the city and give new identity of the city it self.

The new plan project will try to integrate and strengthen the position of each of this feature and improve the quality of it surrounding area, i.e. new plan to make inner city as a pedestrian area will make Grand Mosque become more expose to the visitor as slow mobility in the city center will give chance for pedestrian to enjoy the beautiful architecture of the mosque in more detail. The pedestrian area of the escape hill will also integrate with the new Aceh Tsunami Museum located next to it. By re-routing the vehicle area to the backside area of the museum, people can now easily access the museum by foot and museum front yard can become part of the escape zone area.



Baiturrahman Mosque one of the important existing urban feature in the city

Public space activities in the Blang Padang escape zone integrated with the existing Tsunami Museum



6.5. Materials

Choosing the right material for the project is very important to give comfort for the user as well as to improve disaster resistant of the planned area. Therefore, two aspects should be considered in choosing material for this project:

1. Disaster aspect

By considering the disaster aspect, the selected material should have good resistant toward the force of disaster. This means that after being hit by disaster, the area should be easily cleared and quickly restored without significant effort required.

2. Outdoor comfort aspect

For the tropical city like Banda Aceh, being comfort in the outdoor is highly necessary to attract more people to be outside. At the moment, people prefer to be in the house and hardly force them self to be outside in the public.

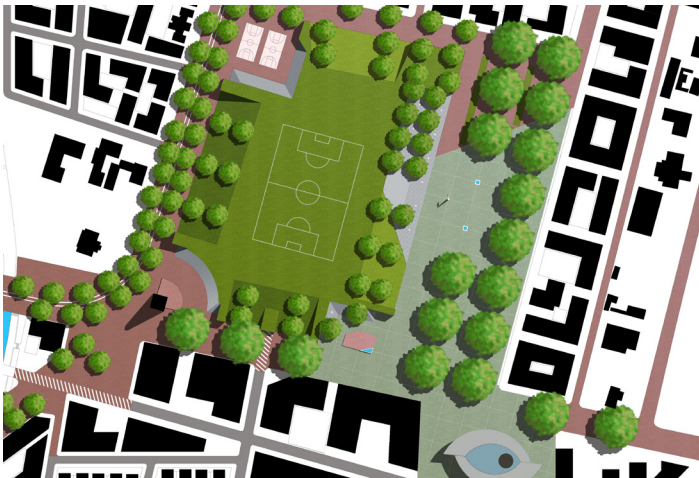
Being outside is important to improve the social condition in the city and can be economically benefit for the inhabitant. By being outside, people can also have good cognitive map about their neighborhood, which in the end can improve their ability in escaping the disaster.

Outdoor comfort in the tropical city related to the heat comfort from the harsh sunlight. The material should not reflex heat from sunlight and should be still cool enough to walk/sit on even in the hottest day.



With two different characteristics of the both aspects, conflict occurs in choosing the right materials for the planned project, i.e. according to previous tsunami on 2004, materials like concrete and asphalt can withstand force of tsunami, however, in term of tropical comfort, asphalt and concrete can reflex heat that can be very inconvenient for the pedestrian. On the other hand, natural material like grass can be very comfortable to walk/sit on in the hot day, but this material is not strong enough to withstand the tsunami force.

Brick paving and concrete grass block can be good choice for the both solutions. Furthermore, creative combination in selecting the material in for different function of the area is required to provide comfort for the user.





Blang Padang escape zone with the escape route and existing urban feature.

7 Evaluation

Question arisen about how this change of structure will effect on the daily life of the inhabitants. How the new street structure influence on the social life and what type of new social interaction will be provided

To answer this question, it is good to see how is the current situation in the city at the neighborhood level.

Weather constrain

As the temperature is very hot and the humidity is high, being out door is not a favorite choice of people. Most of people prefer to be at home and only go outside if there is necessary. Therefore, even in the neighborhood level, it is almost impossible to see a very busy street with vibrant street life, especially during the midday.

The new proposed design of the city will change the pattern of the street and at the same time improve the quality of the street condition in order to give more comfort for the inhabitants. Street with more trees and shading area with pocket of shaded gathering area (intimate square) will be very inviting for the people to sit outside and play with others.

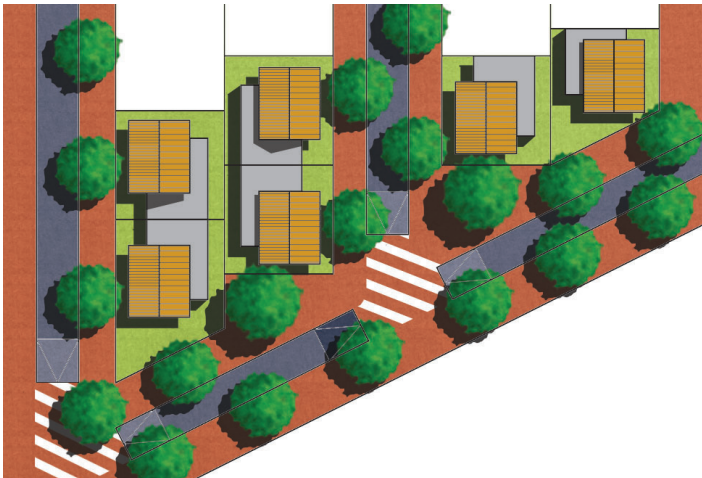


scene of empty street life can be found in most of street in the neighborhood level

Street quality

It is often to see that the street is not comfortably designed for the pedestrian. In all junctions where the pedestrian path meet with the asphalt street, the pedestrian path will be cut off and give priority to the car. Discontinued path give less comfort for the pedestrians, and if we combine this with the unpleasant weather, more people will choose to mobilize by vehicles or just be at home.

Giving priority to the pedestrian while at the same time provide comfort for them to walk outside can be good triggering point to improve quality of both street life and social interaction.



Neighborhood with continous pedestrian and pocket of gathering place



Pedestrian path should be priority

Street at neighborhood level will be design at much lower level than the pedestrian area. This is aimed to give no chance for the vehicle to interfere the pedestrian (driving or parking on the side walk).

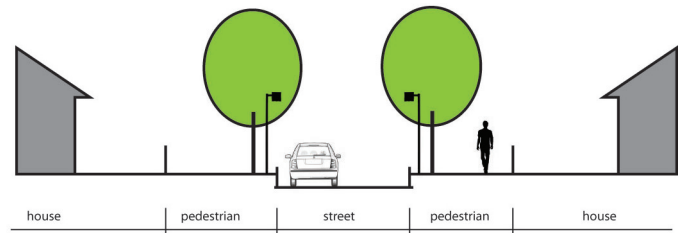
Open space

The city is very lacking in providing open space for the community at the neighborhood level. Almost all neighborhoods in the city don't have space for people to interact. As a result, people only interacting by visiting other house or chat in the coffee shop. While for children, most of children play at home, at school or at main streets, which can be quite dangerous for them.

Improving policy in the building density with strict regulating of Floor Area Ratio especially in the tsunami-affected area, required neighborhood to have some open space, which can be use for social interaction and play for children to play.



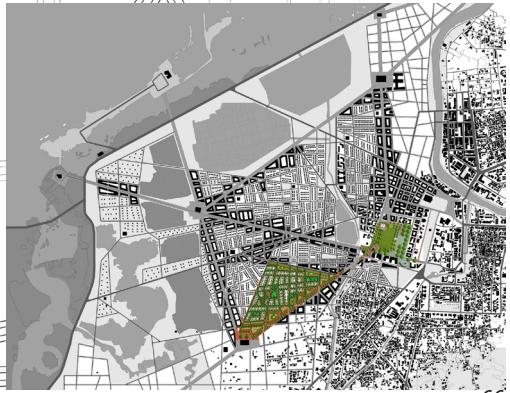
Lack of open space at neighborhood level forces children to play on the street



street will be much lower than the pedestrian.



Sample of new neighborhood which integrated to the new street structure





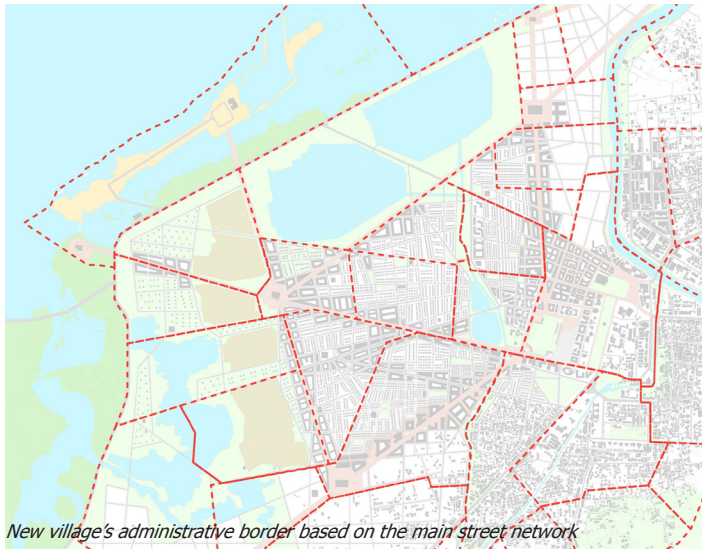
Bird eye view of new neighborhood with escape route lead to the escape zone

Other question is about how this plan can possibly be done. Many aspects related to this question such as how the implementation should start, issue related to land property issue also acceptability of the inhabitants, which their house will be relocated.

To answer this question, it is good to look at the structural level of the local government. In Indonesia, the lowest structure of local government is a village. Every village has their own head of village and coordinators. Above the village is Kecamatan (Sub-district), which consist several villages.

This plan is possible to be implemented by starting at both village and Kecamatan level. Current project related to village street restructure (tsunami escape route) is done by UN-Habitat in several villages in Kecamatan Meuraxa Banda Aceh. "The project started by one village then expanded to the neighboring village," said Bruno Dercon (Head of UN-Habitat Aceh).

Working at the village level is important because each village will have their own portion to focus on, however, this step require strong coordination between each village, especially the neighboring village to avoid disconnected street structure at the neighborhood level. Therefore to avoid this problem, government should also start with the bigger structure at the Kecamatan and inter-Kecamatan's level. Structure at the Kecamatan level will be the main network of tsunami escape routes together with primary and



New village's administrative border based on the main street network

secondary street. For this bigger structure, the government can then continue with re-organizing the administration border of each village according to the new structure. This is to make the work at the village level easier and avoid the disconnected street between each neighboring villages.

Property Right

The local inhabitants own most of land in the project area. During post-tsunami reconstruction process, government with the help of International agencies has restored the property right issue related land ownership at the tsunami-affected area. This means that each land has been identified and owner is legalized with the certificate of ownership.

With the new plan of village structure, it is un-avoidable that some of the houses will be demolished or some of the landowner will have the smaller plot, etc. Government can solve this issue by providing the compensation for owners who has their land affected to this plan. For families, which the house need to be relocated, Government can offer them to move to housing area in more inland or provide them with compensation money and let them find the house by them self. Some villages also have village land (communal land), which mean that the land belongs to the village. If this land is affected with the plan, government can work together with the village to find best solution to the village. Either that government will have to pay compensation to the village or new plan should provide other plot to replace this land. If there is no structure in that

land, communal land is usually being used as empty park or place for religion activities.

All of these steps should be well coordinated with all parties in all level especially with landowners. Government can work together with local NGO's or social organizations to socialize the plan and encourage public and private partnership to get involve, especially to provide valuable funding with share benefit of the project.

Bird eye view of the project area (picture taken in 2006)



8 Goals

The thesis project starts by identifying the soft and hard countermeasures possible to be implemented in the city of Banda Aceh. It is also good to look at the current plan of local government and see how this plan can be improved and insert some of the tsunami countermeasures aspect to it.

8.1. Long Term Goals

Long term goals related to tsunami will be as follows:

- Integrate city infrastructure with natural hazards mitigation
- Restructuring street network especially in the tsunami inundation area
- Banda Aceh as role model city in integrating tsunami mitigations with sound urban regeneration

Long term goals related to urban regeneration will be as follows:

- Develop escape routes as urban development corridors
- Improve the quality of the inner city to be attractive public realm
- Promote Banda Aceh as favorite touristic destinations

8.2. Short Term Goals

Short term goals related to tsunami will be as follows:

- Develop a northern street plan as tsunami.
- Develop mangrove conservation area which also works as tsunami wave breaker.
- Design for escape routes and escape areas.
- Develop effective land use plan to minimize impact of natural hazards.
- Relocate coastal communities to more inland.

Short term goals related to urban regeneration will be as follows:

- Inner city should be free from car traffic.
- Inner city as a place to express creativity, provide strong socio-economic value and gives opportunity for people to improve the economic condition.
- Introduce new model of public transport that give better service and comfort and also operate in more energy efficient manner.
- Extend the inner city to the escape route and escape zone area.
- Reduce/optimize energy consumption in the city.

9 Conclusion

In planning city with potential threat of disaster, planners have to look carefully in every aspect of planning. Every hazard has to be mapped to prevent greater loss in the future. In order to have good preparation toward disaster resiliencies, several principles related to this issue can be applied and creatively adopted with the local condition of the city.

Know the risk is one of the important principles when planning the city in disaster prone area. Risk has to be carefully mapped to give good overview about the threat that might strike the city. From the risk map, planner can start to evaluate potential threat of the area and plan for the countermeasure effort.

However, although man's advance technology is capable in minimizing the impact of the disaster, it is always wise enough if we can plan the city by avoiding the area which



Coastal community living in the Ulee Lheue area

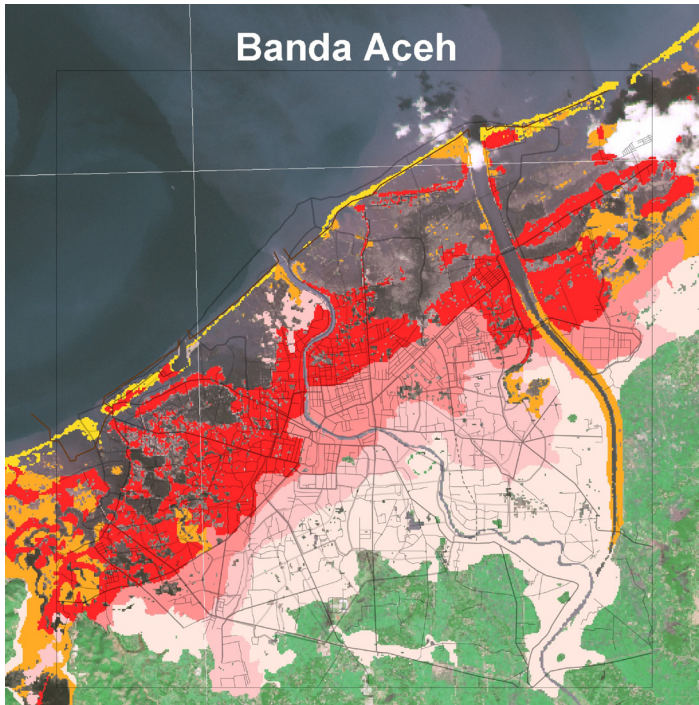
has threat of disaster, especially major disaster like tsunami, land slide, etc.

Banda Aceh is a small coastal city where most of its area are in the great threat of tsunami. Avoiding tsunami disaster in this city means that the city has to develop to further to the East or Southeast to cross border area with Great Aceh District. However, as the city is historically developed through naval trading, the city center is located close to the sea, which makes it expose to the tsunami threat. Last tsunami on 2004 destroyed more than half area of the city center.

While city center is the area with both socially and economically attracted in the city, it is very difficult to avoid the new development around it. Therefore, good planning in minimizing impact of tsunami threat is required in the city of Banda Aceh especially in the area where previously suffered greater loss by tsunami 2004.



Tsunami impact map in Banda Aceh city



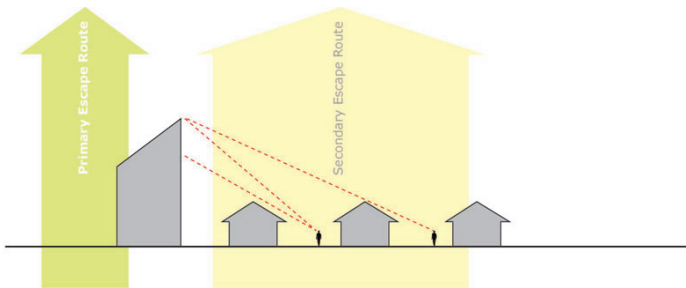
9.1. Street Structure

In escaping the disaster, special route need to be well planned to give greater chance for the inhabitant to flee from disaster. According to my research, several aspects need to be carefully addressed in planning the escape route:

1. Know the source of the disaster, direction of hit and nature of disaster.
Tsunami come from the sea with the direction of flow is usually perpendicular with the coastline except for the bay area.
2. Plan for safer destination.
Fleeing from disaster means people try to search for safer ground. Therefore, escape route always has to lead to the safety ground. Psychologically, people will always run to the opposite direction of disaster. Safety zone has to be strategically located in the city to give greater chance for people to reach the area.
3. Eye orientation along the escape route and at the safety zone
Eye orientation in an important element in escaping the disaster, although some of the inhabitants have live in their neighborhood for many years, but during the panic, their cognition ability toward the surrounding is slightly reducing. This means people can also get lost in their own neighborhood. In this case, people

will always try to rely on their eyes to lead them to the safer ground. Good eye orientation can lead people to the safer ground.

4. Try to avoid too many turn
Good escape route is the one that directly lead to the safety zone, therefore we should try to avoid designing escape route with too many turn. However, in the neighborhood scale, it is also important to look at how the escape route it self connect to the surrounding neighborhoods.
Similar to the above aspect, making a turn is also related to the cognition ability of the surrounding. Too many turns can slowly reduce the ability to remember the surrounding which in the end lead to the inefficient move.
5. Try to avoid street obstacles
Street obstacles such as open drainage, different floor level, etc can slow down the speed of running people, especially for people with limited mobility, this obstacle can even completely stop their run. Safer escape route should have clear and comfortable path.
6. Design escape route with good disaster's resistance material.
Planning for disaster-proof material is related to the recovering ability after the disaster strike. In postdisaster period, escape route should be easily cleared and become the main entrance point for the evacuation team



Shopping building as escape orientation

to reach the affected area and also as an artery for the humanitarian assistance activities. Therefore, material of the escape route should be well designed to withstand the force of disaster.

9.2. Combination with The Urban Regeneration

Planning the countermeasure project for the disaster can be very tricky, especially for tsunamis where the probability of the reoccurrence is unknown. And with the disaster countermeasure project require large budget, cities in the third world countries often ignore the need of this countermeasure project. Therefore, creative approach in combining the disaster countermeasure effort and urban regeneration is required to give optimal result of the city development.

Banda Aceh has serious threat of tsunami and also seasonal flooding during the heavy rain. Therefore the proposed plan will try to combine both tsunami flood countermeasure. And one of the approaches is through the street restructure.

Since inner city is also located in high tsunami's prone area, it is also possible to combine the tsunami countermeasure with the inner city regeneration. Design of the escape route and street restructuring together with the improvement of the safety zone can be combined with the improvement of street life quality in the city center and improve mobility in

the city center area.

Good quality escape route with high accessibility is also become economically attractive. This means, escape route located close to the city center can be used as corridor of new city center development (expansion).

9.3. Repetition of the Project

The proposed project for Banda Aceh is based on the aspect of planning city with threat of tsunami disaster, which then adopted with the current stage of the city. Social and economic aspects also included, increasing the feasibility of the project.

Repeating the project to other city is always possible, especially for cities, which also has threat of natural disaster. To implement the plan in the different city, planner can start by identifying the risk in the city and plan for the counter-measure effort.

Other cities can also adopt the escape structure of the proposed plan and depend on the current stage (social, economy, etc) of the city the escape structure can be creatively combined with the urban regeneration project to improve the street life quality as well as mobility issue in the city.

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With this thesis research, I would like to take a special moment to commemorate all people who died by the 2004 tsunami, especially to all families and colleagues from Banda Aceh, Indonesia. Thanks to all colleagues in the United Nations, and Local Government of Banda Aceh for all the hard work in post-tsunami response. It has been 5 years since the disaster hit the Indian Ocean. May all the efforts bring Aceh people into a better life.

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