ÉCOLE POLYTECHNIQUE DE L'UNIVERSITE FRANÇOIS RABELAIS DE TOURS
Spécialité Aménagement et environnement
35 allée Ferdinand de Lesseps
37200 TOURS, FRANCE
Tél +33 (0)247.361.450
www polytech univ-tours fr

Master Thesis 2018

Research Master Planning and Sustainability: Urban and Regional Planning

The potential of selected Non-structural measures for improving Flood management in Bangkok Inner Zone

PAWEESUDA CHAIYASARN

VINCENT ROTGE

The potential of selected Non-structural measures for improving Flood management in Bangkok Inner Zone

Abstract :

Bangkok is a complex system in term of physical, institutional, and scale dimensions. consist of many factors which vulnerability to flooding is attributable to the ineffectiveness of the flood drainage systems and prevention measures. The implementation plan of Bangkok Metropolitan Administration clearly indicates its emphasis on structural measures and not seriously taken for non-structural measures, Flood still chronic problem in the city in case of heavy rainfall, structural measures cannot cope with flood totally, pointed out that It is important to acknowledge that protecting urban areas from floods is impossible even with massive structural measures and that implementation of non-structural measures also have a great potential to reduce damage and losses with the same level of floods.

This Research finds empirical data include clarification of the causal factors or causes of continued floods in the capital and the implementation of flood-related policies and imbalances between Structural and non-structural measures and showing that non-structural aspect is very important but have been overlooked for some reasons by a focus on resolving floods due to heavy rainfall. In the inner city, Which an important economic, transportation, business, industrial centers and tourist centers, Then proposes some non-structural measure which had potential properly with flood condition problem in Bangkok. This research had shown some examples of technical modifications include in the scale of Bulk control and Land Use Control / Activities Control. However, the most important non-structural measures which are The key to approach all solution of technical problems is public awareness.

In summary, found that measures are applied is of primary importance. First, The best order to develop public awareness, which will lead to the creation of the political will, followed by drafting and passing laws and regulations, and secondly, proposing measures to reduce risk and to offer education and Training. Approach to prepare plans for effectively managing requires a combination of technical, participation planning, Community, and stakeholder consultation should be an integral aspect of the flood management framework for Bangkok.

Keywords :

Floodplain inner zone in Bangkok / Analysis problem and symptom flood of Bangkok / The Weakness of the Master Plan and flood management measures / Efficiency of Non-structural measures / Non-structural measure solution / Improvement priority of Non-structural measures

PAWEESUDA CHAIYASARN
Paweesuda.chaiyasarn@etu.univ-tours.fr
Supervisor: Prof. : VINCENT ROTGE
Date of Submission: 17/06/2018

POLYTECH TOURS
Département
Aménagement et Environnement

35 allée Ferdinand de Lesseps
37200 Tours, FRANCE
Tél. +33 (0)247 361 452
http://polytech.univ-tours.fr/m2ri-planning-sustainability

citeres UMR 7324

TABLE OF CONTENTS

The potential of selected non-structural measures for improving Flood management in Bangkok Inner Zone

I. INTRODUCTION

An interesting question is why floodway movement in Thailand is not successful compared with the costly structural measure such as concrete walls that are becoming higher and longer everywhere on the floodplains. As a consequence of great floods in 2011, the government has introduced floodway as a part of flood prevention program that requires cooperation between and among local communities. However, most local governments deny openly that floodways will not be considered in their jurisdictions particularly the nearby provinces around Bangkok. It is understood clearly that any development on floodways cannot be allowed having strong negative impacts on land prices. This becomes politics of planning when decision makers at both local and national level get involved with property speculation. It is worth noting that every legal procedure in Thailand takes time, maybe years for passing flood regulations. That is another reason why the government gives more importance to structural measure such concrete walls that can be built immediately and fulfill political commitment within the shorter time. Certainly, numerous costly concrete structures have been approved shortly focusing on industrial estates on floodplains. Construction of thick and high concrete walls has started and would be completed before the coming monsoon season. This proves that industrial sector is the primary concern in the view of the government. Their vision is lack of urban resilience to floods just for against flood rather than working with the river. And They are still lack of awareness about an optimal engineering solution may not be the best because of social and institutional constraints, which means that traditional engineering code reflects criteria.

This research had referenced the results of other relevant research studies. And there is consistent content in discussing the importance of using Non-structural measure flood management. The researcher has used some of the information to analyze each topic by the researcher has applied for permission and had allowed referring to their studies. The use of other research data to analyze this research In addition to supporting information in the research. It also shows that There are many pieces of research that had similar conclusion that Bangkok Lack of integration flood management system and too much focus and rely on the structural measure. Refer to other research Mostly mention to the sustainable and effective management of floods are seen to require a broad approach which should incorporate an integrated view of strategies, policies, plans, specific project and other measures of social and institutional character. The selection and implementation of effective and optimized strategies by integration of structural and non-structural measure achieve a successful solution of the flood-related problem. This research is an extension of the results of other research. To point out that. How important Non-structural measure flood management and Which Non-structural measure appropriate to solve and reduce flooding problems in Bangkok inner city.

This research focuses on solving problems. Resolving floods suddenly due to heavy rainfall. In the inner city, Which an important economic hub, a hub for transportation, business and industry centers and tourist centers and proposes some non-structural measure flood management properly with flood condition problem in Bangkok by the focus on inner zone area And also Supported and consistent with existing structural measures. To promote the most effective flood management plan and reduce future damages associated with flooding

A: Background and Situation

Bangkok and its vicinities have developed into the main economic base of the country. Economic, political, cultural, administrative, educational, transportation. Finance, banking, commerce, communication, and prosperity. Throughout the international contact throughout. It is a center for economic and trade. Southeast Asia's services are ranked as the 15th largest metropolis in the world and the largest international financial center in Southeast Asia. The result is Bangkok. In terms of production, 51% of the country's total output Bangkok has a total area of 1,569 square kilometers, with a population of more than 5 million registered residents, Bangkok is the Primate City.

Bangkok and the surrounding area are also located in the deltaic floodplain of the Chao Phraya River. Historically, people in Bangkok lived in floating houses or elevated houses, but over the last decades, a densely populated city with a population of over 10 million people has developed. Some form of protection is achieved by the King's dike that forms a ring around Bangkok. An extensive system of irrigation canals, hydraulic structures, such as drainage sluices and floodgates, and pumps have been developed to drain the city. Over the last decades, several industrial estates have been developed around Bangkok and these are home to very large production and manufacturing facilities. As these are located in floodplains and/or flood prone areas, dikes were constructed around many of the estates. Thailand experienced its worst flooding disaster in half a century in 2011, inundating large areas of Bangkok. According to World Bank estimates, this disaster caused US$46.5 billion in damage and reduced Thailand's economic growth potential. It also raised important questions concerning the sustainability of the country's economic development path. The government has set up a master plan for flood management in the Chao Phraya River Basin in Bangkok and its vicinities to respond to public outcry over bad management of disaster and poor planning in watersheds. Although the Master Plan identifies ways of strengthening water supply and managing disasters, it focuses mainly on investment in physical infrastructure. Although many projects have been developing for years, While the design is arguably not wholly practical for a massive city like Bangkok, That always floods every time when heavy rain in the city. Until this October 2107, Bangkok has been exposed to crisis again. Due to flooding spread to 55 points due to the rainfall up to 214.5 mm, resulting in traffic paralysis. And most important is the homes of people and businesses. Heavily damaged overnight.

Bangkok faces major challenges with regard to climate change and the availability of purified water. Demand for water in the country's main economic sectors, such as tourism, industry, and agriculture, continues to increase, having a major impact on the country's fragile water infrastructure and resources. Current, wastewater and sanitation infrastructure in Thailand is underdeveloped. There is an excessive discharge of industrial waste in rivers, causing water pollution and health problems.

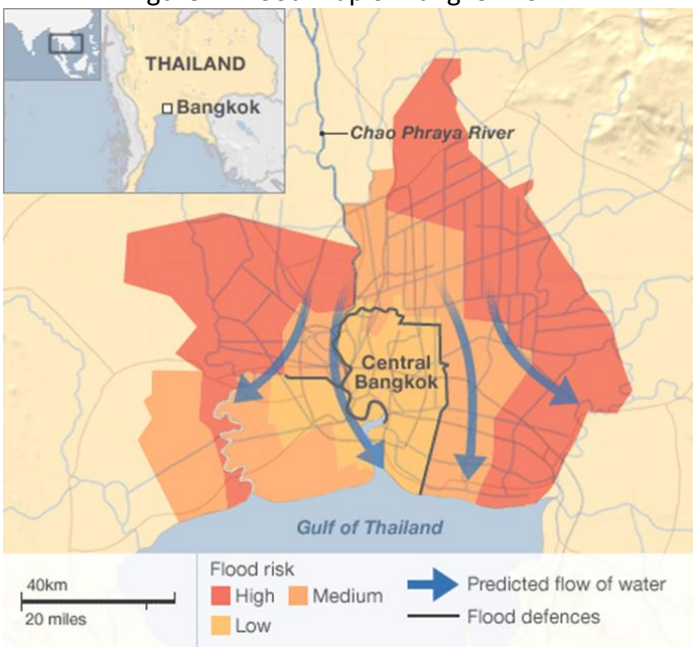
However, Thailand's legislative and institutional framework needs to be strengthened Although a Master Plan has been drafted, institutional competition and political issues prevent it from being implemented. The institutional framework is highly fragmented, lacking a single-commanded authority and an integrated approach, which leads to inconsistent strategies and budget allocation. The Thai government increased investment in its water sector and has announced new projects and funds to address the persisting risk of floods and drought, providing business opportunities. However, major challenges remain.

B: Bangkok and The flood 0f 2011

In 2011, years of water mismanagement, political competition and administrative decisions culminated in a massive flood disaster, Thailand's worst flood in recent history (World Bank, 2012)

The main cause is the excessive flow of water, rivers, torrents, and tides. Excessive river flow can cause widespread flooding. According to the Royal Irrigation Department, approximately 400 million cubic meters of water from the Chao Phraya River can usually empty into the sea by a combination of natural water flow and a network of slut gates. During the 2011 flooding, an estimated 16 billion cubic meters needed to drain. Heavy local rainfall is usually the main cause of inland floods, as it often exceeds the drainage capacity of the local areas or streams. Tidal fluctuation at the river mouth of the river can affect the drainage of floodwaters into the Gulf of Thailand and likely played a role in October and November of 2011. This prolongs the duration of floods, especially in coastal regions. The most common human causes of flooding in the region are deforestation and the expansion of farmland and urban areas. Rapid urbanization and land development in downstream areas along the Chao Phraya River have led to an increased potential for flood damage. A substantial amount of industrial growth has also taken place on the floodplain north of Bangkok. The situation was further complicated by the government's decision to keep the center of Bangkok dry by shoring up floodwalls. (see in Figure.1)

Figure.1: Flood map of Bangkok 2011



Source: Thailand floods: Bangkok 'impossible to protect', https://www.bbc.com/news/world-asia-pacific-15381227

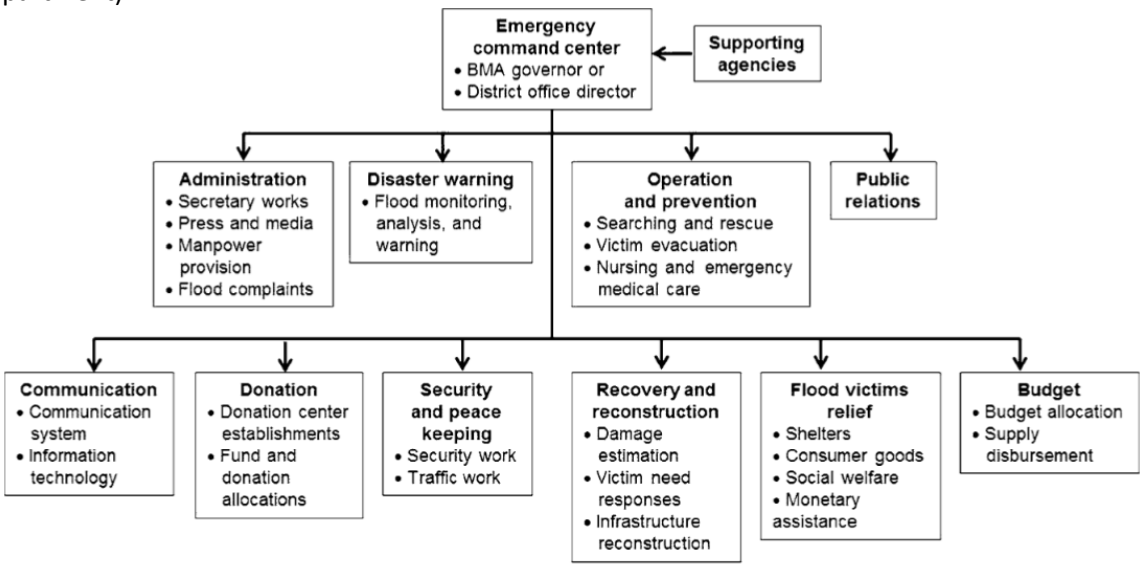
The rationale was to try to save the economic engine of the country, and flooding the inner parts of the city arguably would not have a great enough impact on draining surrounding suburbs to justify the cost. However, this resulted in some communities being flooded in order to spare the capital, leading to resentment among those who ended up on the wrong side of the sandbags. There were protests in some affected communities and reports of residents intentionally breaching the floodwalls. In some cases, this happened while the authorities and police looked on, not wanting to intervene in an explosive political and public safety situation. After it failed to protect the entire capital by diverting the floodwaters to either the western or eastern side of Bangkok, or both, the government gave its first priority to protecting important places and economic areas in inner Bangkok (e.g., palaces, hospitals, and business centers) in order for them to be flood-free. Flood dikes and sandbags were installed surrounding inner Bangkok, and floodwaters were diverted into the areas outside. Under normal circumstances, these areas would not have been severely flooded as they are not lower-lying area or along flood routes like the inner areas in Bangkok. while most districts in inner Bangkok with expensive land values are effectively flooded free, the flood dikes that protect them divert floodwaters to either the western or eastern side of Bangkok or both where most district that has flood risk

categorized as moderate to high or very high are located. This has inevitably generated public discontent and social unrest among people in these districts and conflict between people and government agencies. People who live in the eastern and western sides of Bangkok understand that their area should not be severely flooded because they are not situated in lower-lying areas or along flood routes as compared to those districts in inner Bangkok. In their view, it is unfair that the flood management and mitigation measures implemented by the government agency have resulted in floodwaters being diverted into their districts to protect inner Bangkok from damage, people living in the outer Bangkok destroyed many flood barriers (sandbags and temporary dikes) and/or opened some water gate to allow the floodwater to flow downstream along natural flood routes through low-lying areas to the sea. This experience has caused many people to lose confidence in the government agencies' existing flood management policies and mitigation measures. It thus needs to address these problems (while in Bangkok, this issue appears fraught) using a floodplain management framework

Governance structure of Bangkok's current flood management

According to the BMA's existing Disaster Prevention and Mitigation plan (DPMP) emergency command centers on flood prevention and mitigation were established at both BMA and district levels. The BMA governor acts as the center director at the BMA level with responsibility for (1) administrating and coordinating with the district's center and related agencies outside the BMA to manage a flood event and to assist the flood victims and (2) supporting the flood operation and prevention at the district level. Each district center has the duties to: (1) prevent and mitigate flooding and (2) respond to a flood event should one occur within its district. The centers at both BMA and district levels have similar structure comprising 10 functional divisions and supporting agencies outside the BMA (see in Figure.2) The supporting agencies for flood prevention and mitigation include the Ministry of Defense (army, navy, and Airforce that provide manpower and vehicles to evacuate flood victims), Metropolitan waterworks authority (Tap water for flood victims), Metropolitan Electricity Authority (electric security, resupply, and use), Metropolitan Police Bureau (safety for life, property and shelters of flood victims), TOT Public Company Limited (communication system in the flooded areas and shelters), Expressway Authority of Thailand and Bangkok Mass Transit Authority (transportation routes for evacuation of flood victims), and charity organizations.

Figure.2: Structures and role of the emergency command center on flood prevention and mitigation at Bangkok Metropolitan Administration (BMA) and BMA's district levels (Bangkok Fire Rescue Department)



Source: Nuanchan S., Jaya K. (2016) Natural Hazards : Developing a strategic flood risk management framework for Bangkok Thailand, Volume. 84, 938p., https://link.springer.com/article/10.1007%2Fs11069-016-2467-x

Lessons from the 2011 Thai Flood

The significant loss of lives and property during the 2011 flood highlighted major deficiencies in the BMA. First, the BMA clearly lacked the ability to evacuate many people from flooded areas. Second, there was no properly communicated public education on early warning of floods or flood evacuation. Third, The flood forecast and situation evaluation were not properly conducted, analyzed, and managed. These exacerbated the flood situation, particularly when affect people were evacuated to shelters that were later inundated. Flood-related processes (e.g., floodplain management plans, evacuation planning, flood warning, flood-related land use planning, community education, consultation and participation and feedback) have been overlooked and not integrated into the Bangkok's floodplain management governance arrangements. These functions need to be brought into the governance structure of Bangkok's current floodplain management

Bangkok is a member of the United Nations International Strategy for Disaster Reduction “Making Cities Resilient” campaign. Among the ten essential actions promoted by the campaign is the maintenance of critical infrastructure to reduce the risk of disaster. To reduce the risk of flooding in the future, the Thai government has launched a water management project. But the plan will take time to process. The master plan includes an allocation of 50 billion Baht ($1.6 billion) to build dams in four basins in the northern region of the country. Another 120 billion Baht ($3.9 billion) have been designated for the construction of floodways and flood diversion channels, with work scheduled to begin this year to enhance canals. Sixty billion Baht ($1.9 billion) have been allocated to convert two million rai (800,000 acres) of farmland along the Chao Phraya into water retention areas. This would require moving current residents elsewhere. A World Bank publication, “Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century,” is available free of charge and provides guidance on how to manage the risk of floods in the urban environment. Among the cautions in the document is the reminder that heavily engineered structural measures (such as the construction of dams) can be effective when used properly, but they reduce flood risk in one location and transfer risk to other areas upstream and downstream. Non-structural measures are usually designed to minimize rather than prevent risk. Effective flood risk management requires the cooperation of multiple stakeholders. Effective engagement with those at risk is key to successful implementation. Engagement increases a sense of involvement, increases compliance, and reduces conflict.

C: Problem statement and Cause of flood in Bangkok inner zone

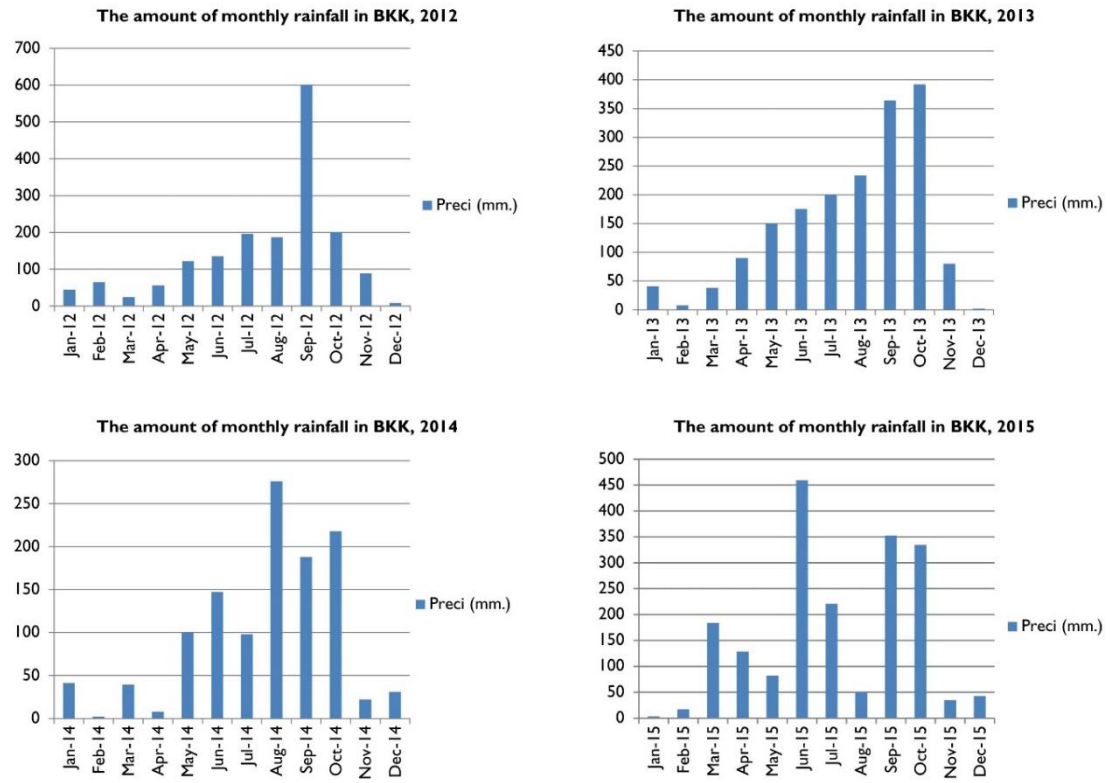
The flood problem in Bangkok. It has been a long time since the original physical condition of the city itself has led to flooding. Which is a natural cause? But The more for a long time. Flood problem has gradually Increasingly intensified. It became a national agenda. Another important cause. The rise of The wider urban context and Stimulating precipitation urban. This study included the factors affecting the drainage condition of Bangkok Metropolis. That covers all aspects. Which is the main cause? The flooding in inner-city Bangkok. To solve the problem in other chapters.

Factors affecting Bangkok's drainage are from the location of Bangkok as a water source. Climate change combined with rapid urban growth, resulting in ineffective flood control and preventive measures not successful due to poor flood management performance and non-building activities. Planned risk of flooding in the city. And lack of awareness and stakeholders. All factors are bound to become a problem that is very difficult to resolve. This can be explained by the following main factors.

1. Climate change

The key factor is the variability of climate and the rainy season is not normal anymore. As in March, the past. It's a drought but it's very heavy. The pattern of rain changed. Even in May, the more obvious variance some areas in Bangkok. In August there was hail in some areas. It reflects that the weather is very variable. From a study by Thailand's National Reform Council in 2015 (see in Figure.3) Showed Bangkok risks being submerged in less than 15 years. By the end of this century, the mean sea level is predicted to rise by almost one meter, according to the Intergovernmental Panel on Climate Change. And while the waters rise just as global warming is increasing sea levels. , The city is relentlessly sinking further, accelerating the process of living space disappearing.

Figure.3: The Monthly Rainfalls (mm) in Bangkok between 2012 and 2015



Source: Station ID 455201 of the Thai Meteorological Department.

2. Physical & Environment condition

Bangkok sits on low-lying plains, The city's vulnerability to flooding is attributable to its low-lying terrain with only an average of 1.50 m above mean sea level, water run-offs from the north, seasonal heavy rainfall, tidal bores and soil subsidence. Currently, Bangkok is only 0.5-2 meter. Above the water. The metropolitan area is sitting precariously on what was once marshland. That means the city is resting on a layer of soft clay that is highly compressible. Bangkok is facing a double whammy of challenges and also facing the problem of soil subsidence. The soil subsidence aggravates the flood situation, Especially during the rainy season and tidal bore. According to the BMA report (2016).

3. Rapid growth of urban

Bangkok is located in the lowlands with 1,000 canals. Originally would drain the flood quickly. Unfortunately, At now much of the city's area used to be paddy fields and wetlands. Rapid city expansion has reduced the uninhabited space earlier used to store rain water. For instance, Lat Phrao

which was used to be an open ground to hold rain water has now been taken over by housing estates and communities. The Impact from Rapid growth of urban follow as:

Land subsidence each year: Areas affected by the decline of the city. Despite the various measures taken to address the problem of groundwater pumping from the heavy aquifer system, the city continues to grow. Besides the natural land subsidence, Land subsidence from deep good pumping has been affecting Bangkok. The soil subsidence aggravates the flood situation, especially during the rainy season and tidal bore. According to the BMA report (2016), due to an excessive exploitation of groundwater at a much faster rate than the recharging water, the Bangkok ground has subsided 5–10 cm annually, especially in the capital's eastern districts of Bang Kapi, Huay Khawng and Pra Khanong. In addition, Bangkoker uses about 6 million cubic meters of water daily. It is difficult to drain the heavy load. If the rain falls, it's bad. The government does not understand the problem, for example, to build a condo in a city that is not thought carefully. Thousands of people live on high rise condos used water as one canal, This is one of the factors that Bangkok water drainage slow down

Retaining water and the drainage capacity is limited: water retention area in suburban Bangkok had been reduced by 40 percent as a result of urbanization, leaving the city with less water retention area. Not enough monkey cheeks to absorb excess water. Bangkok needs another 10 monkey cheeks in addition to the existing 25 to hold excess water of up to 25 million cubic meters. Existing monkey cheeks such as Makkasan swamp, Bung Gum, and Bung Ekamai are not adequate,

Land use & Building code not efficiency: construction blocking waterways, Continuous illegal construction activity including construction of residences obstructs the efficient drainage of floodwater. The unplanned building activity plays an important role in the flood management and the vulnerability to urban flooding. Housing estates as well as other development projects have been allowed to be built on these lands, depriving the city of areas to absorb floodwater. Even after the impact of uninhibited development became known, there were no efforts at all to contain it. Even now the remaining wetlands are being turned into concrete without pause. Due to an excessive exploitation of groundwater at a much faster rate than the recharging water, the Bangkok ground has subsided 5–10 cm annually, especially in the capital's eastern districts of Bang Kapi, Huay Khawng and Pra Khanong. Decades of excessive groundwater pumping and rapid development have put more pressure on the foundation. Nearly 5,000 tall buildings, nine million vehicles, roads and rail systems have contributed to the problem. Because Land use & Building code policy not efficiency

The infrastructure system and drainage system of Bangkok: Inefficient draining rainwater into the city sewage and draining canals that led to people grumbling about district officials' tendency to ignore the annual dredging of sewers and klongs (canals) until heavy rain forces BMA to pay attention, by which time it is too late. This led to some people asking, again, why sewage and rainwater didn't have separate conduits. As it is, both sewage and rainwater run into the same pipes that drain into larger sewage drains that used to be beautiful canals. The issue became a topic of discussion more than 20 years ago before the first wastewater treatment plant was built at Si Phraya. At the time, building two separate drainage systems were considered not practical because of a lack of money. So both sewage and rainwater go into the same drainage system even though it makes for an inefficient system. Currently, the city runs 7 wastewater treatment plants, taking care of about half of the more than one million cubic meters of sewage generated each year. Five new treatment plants are in the works and expected to come online possibly in a few years' time. Even with all of 12 plants operational, the volume of wastewater will be too massive to be handled. More new plants will be needed. New treatment plants will help alleviate the problem of annual floods somewhat because new drains will have to be built.

In addition to The city's drainage system could cope with only 60mm/ hour of rainwater because of the limited capacity of the drainage system. The infrastructure drainage system of Bangkok was built 20-30 years ago. These pipes were earlier than the canals. But today, when the city grows. The groundwater pumping was used to make the canal collapse. The water in the canal is below the level. Drainage from the pipes into the canal and from the canal to the river is more difficult, so the 'water is waiting' it can drain, but it takes quite a long time. Also, The pipeline diameter is 60 mm long, which is not just collapsed. But there are also sediments and lots of waste. Drainage is not good, so whenever heavy rain falls. Beyond the potential of the pipeline. The water was flooded with about 40-50 mm, it was flooded. But when the city eventually had enough resources to tackle the problem, officials' attentions were diverted elsewhere as Bangkok had been allowed to grow into a gargantuan sprawl. Any attempt to put it in order thus becomes futile.

The garbage blocking of drainage systems: The clogged drainage is attributable to the characteristic of the localities under study which are densely populated areas with large volumes of daily household waste in excess of the city's garbage collection capability. The uncollected garbage often ends up in the city's sewers, blocking the flood drainage. The issue of narrow drainage comes in second, Despite the replacement of the narrower sewers with the wider ones in some localities, the flooding persists as the new drainage is clogged by the uncollected garbage. The garbage problem blocking the drainage system. As many as 10-20 tonnes of garbage are retrieved every day from the city's klongs which are the main conduit for the draining of water into the Chao Phraya river. Also assortments of other trash, all helped to clog the drainage.

4. Institution & Governance flood management

The institutional framework is highly fragmented. There are at least 31 ministerial departments under 10 ministries, one agency and six national committees involved in Water Management. Some of the draft policies, other execute or monitor them. There is competition between institutions, as priorities and responsibilities are sometimes conflicting or overlapping. In general, there is a lack of unity and coordination and no sufficient long-term planning and vision on how to tackle water-related issues in a sustainable and integrated manner. This regularly leads to discontinuation of budget allocations and other obstacles to an efficient water management. Bangkok still lack integration between Institution & Governance flood management framework, Divide follow to

The absence of a single water agency and a national water law: Thailand does not have a single law governing integrated water management. National policies and laws have not been adopted due to a lack of shared vision between the institutions. The Water Act is supposed to become the main legislative framework on water management. However, the act has been in the process of drafting since 1992. Again The Department of Water Resources (DWR) is in charge of drafting the act. After the act is adopted, DWR would be authorized as the central organization for governance. It would also separate regulatory and operational tasks between institutions, and encourage active participation by locals and users.

No systematic coordination among departments: The current institutional arrangement of BMA. There is no systematic coordination among departments, and the lack of coordination makes it impossible to develop a comprehensive, coherent, and cost-effective plan. Each department potentially relevant to flood management measures is working in 'silo,' and Department of Drainage and Sewerage (DDS), is leading flood management with limited and indirect involvement of Bangkok Fire and Rescue Department (BFRD), and City Planning Department (CPD). As urban flood management is a highly cross-sectoral issue, the higher involvement of many departments and agencies is required.

Lack of awareness for peoples & stakeholder

The general problems observed in communities are a lack of appreciation of risk and a lack of motivation to participate in flood mitigation activities. At the same time, official agencies often do not appreciate the potential benefits of community participation and do not have the skills or experience in participatory activities. The Situation of the People in Bangkok and the Stakeholders It has awareness increased after the Great Flood crisis in 2011 has given many lessons to the people of Bangkok. Even today some people have adapted and learned more, but still a minority. There are some private sectors trying to raise awareness. But the government has not campaigned seriously and long enough to achieve a wide awareness.

D: Key words concept and Scope of Research

Key words concept*:* Floodplain inner zone in Bangkok / Analysis problem and symptom flood of Bangkok / The Weakness of the Master Plan and flood management measures / Efficiency of Non-structural measures / Non-structural measure solution / Improvement priority of Non-structural measures

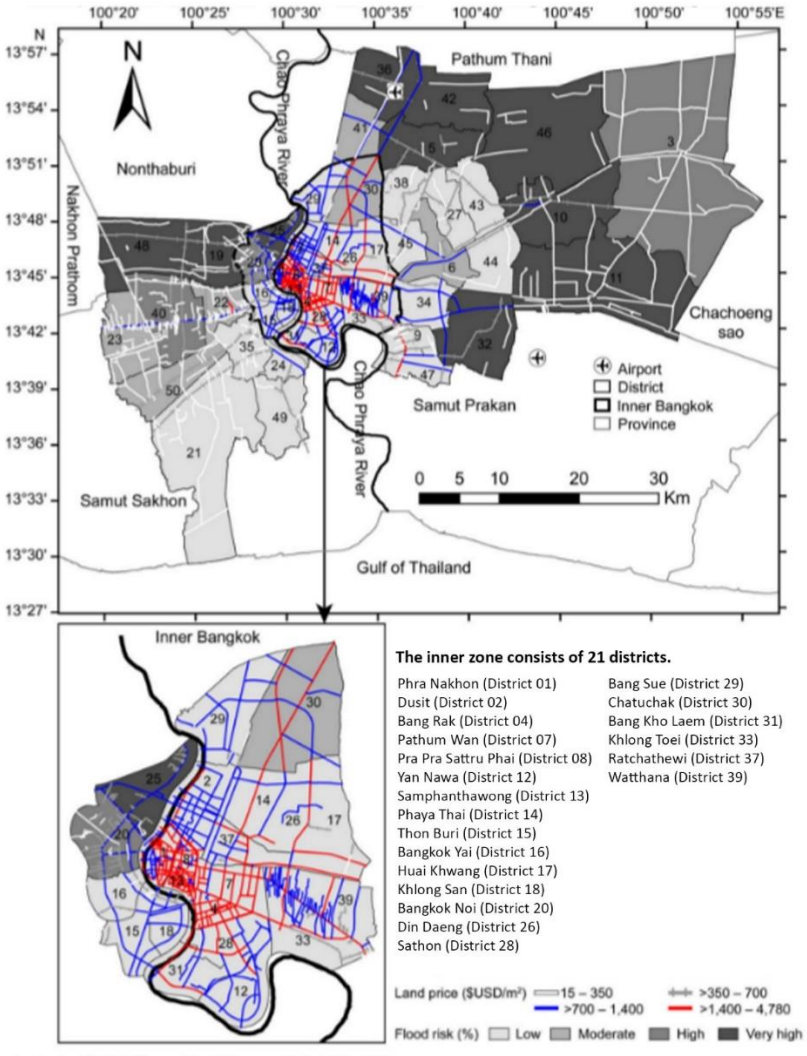
Scope of Research*:* To define the scope of research and study. Researchers have selected the areas and topics to be studied. Divide by Scope of research in terms of content and Scope of research in terms of areas follow as:

Scope of research in terms of areas

Bangkok, a capital city of Thailand, is renowned as a strategic location in ASEAN, as it is a hub of transportation, a hub of business and industry, a hub of art & culture, and a hub of tourism. The most promising developments in Bangkok are "Inner city of Bangkok". Bangkok's main mass transit lines (BTS sky train and MRT subway) running through the heart of Bangkok, where you see the most developed areas in terms of business, tourism, and education. Areas along the main mass transit routes have developed and changed dramatically, mainly due to a significant increase in Thai and expatriate populations in Bangkok. Many skyscrapers and mega projects by the public and private sectors as well as Thai and foreign business investments have led to a leap in growth in land prices along electric train routes and land in the inner core of Bangkok. These areas have high value for investment in the age when real estate prices never stop increasing and land plots in the heart of the city are hard to find. The increase in real estate prices results from the rental yield to rise 5-7%, higher than the interest rates today. The mega projects mentioned above will make the inner core of Bangkok as the center of living. Currently, The management of the Bangkok Metropolitan Administration is composed of the District Office and the Bangkok Metropolitan Area Office. The division of tasks into 16 divisions is the agency responsible for strategic management. In addition, Bangkok also has a district office. The district plays an important role in providing services to people in various districts. Currently, 50 districts are under the administration. District Director The county council is elected by the people as consultants.

The reason why This research choose inner city of Bangkok has interest to solve flood because of The role of significance for Bangkok inner city as mention above and after study The research Reference to **Natural Hazards: Developing a strategic flood risk management framework for Bangkok Thailand**, By assess flood risk and analyze land use and land price across 50 district of Bangkok. This is an appropriate precursor to formulating any additional floodplain management measures, practices, and procedures that are deemed appropriate by use Land use and Land price data were analyzed to portray how these variables varied with the estimated flood risk across Bangkok's 50 districts.

Figure.4: Magnitude of flood risk estimated across the 50 district of Bangkok were categorized into classes low (<10%), moderate (10%-20%), high (>20-30%), and very high (>30%). The maximum prices ($USD/sq.m.) for the areas situated along 834 streets across Bangkok (BMA GIS center 2015) were categorized into 4 groups: low (15-350), moderate (>350-700), expensive (>700-1400), and very expensive (>1400-4780)



Source: Nuanchan S., Jaya K. (2016) Natural Hazards : Developing a strategic flood risk management framework for Bangkok Thailand, Volume. 84, 947p., https://link.springer.com/article/10.1007%2Fs11069-016-2467-x

Result and discussion are In Bangkok, it is apparent that land values are an important consideration that influenced how the Thai government managed floods. Most of the very expensive area (>$1400-$4780 USD/sq.m.) situated mainly along the street in Bangkok are survived the flood in 2011 (see in Figure.3). Of these, the areas situated mainly along the street in the inner district including 21 districts is 1. Phra Nakhon (District 01) / 2. Dusit (District 02) / 3. Bang Rak (District 04) / 4. Pathum Wan District (District 07) / 5. Pra P Sattru Phai (District 08) / 6. Yan Nawa (District 12) / 7. Samphanthawong (District 13) / 8. Phaya Thai (District 14) / 9. Thon Buri (District 15) / 10. Bangkok Yai (District 16) / 11. Huai Khwang (District 17)12. Khlong San (District 18) / 13. Bangkok Noi (District 20) / 14. Din Daeng (District 26) / 15. Sathon (District 28) / 16. Bang Sue (District 29) / 17. Chatuchak (District 30) / 18. Bang Kho Laem (District 31) / 19. Khlong Toei (District 33) / 20. Ratchathewi (District 37) / 21. Watthana (District 39), Important precincts such as palace, historic/culture areas, the national museum and hospital is

located in the inner Bangkok area. Although these inner districts are located in the low-lying areas along the shortest flood routes to the Gulf of Thailand, flood event in this district is rare. These districts are protected by flood dike.

So to the inner city. The importance in many aspects. Especially the economy. Has the ability to cope with the flood. Which at present, the inner city need to rely on flood prevent construction and use strategy to make the suburbs both east and west, Get flooded instead. Which all these methods not fix the problem in the long term and also creates more problems. Therefore, The integration solution, By use Non-structural measures for support and serious enforce in the inner city. It is one in solution. To reduce the risk. Reduce conflict and reduce damage from the flood.

Scope of research in terms of content

This research focuses on Resolving floods suddenly due to heavy rainfall. In the inner city, Which an important economic hub, Transportation hub, business, industrial centers and tourist centers and proposes some non-structural measure flood management properly with flood condition problem in Bangkok by the focus on inner zone area And also Supported and consistent with existing structural measures. To promote the most effective flood management plan and reduce future damages associated with flooding

E. Aim and Objectives of Research

In Bangkok, it is apparent that land values are an important consideration that influenced how the Thai government managed floods. It can be seen that many of the construction works such as flood barriers, dikes, road and railway embankments, and many types of buildings, disconnecting water out of the polders, using pumping stations, water gates, tunnels and sewers, and improving drainage. canals by constructing dikes and dredging canals, etc. all that buildings can't solve In the case of heavy rainfall, Bangkok still has trouble draining water, as the lack of permeability of the land surface means that rainfall cannot be absorbed rapidly enough.

Action plan Prevent and solve flooding problems in Bangkok due to rain and flooding in the year 2017. (Department of Drainage and Sewerage under BMA). Even in the plan used both of structural measure and non-structural but still lack of integration by suitable for the area. Especially in densely populated areas it always floods in case of heavy rainfall. This research was developed to support non-construction measures for balance an important role as structural measures and to find Non-structural measure appropriate. Then propose which non-structural improvements should be achieved to enforce an efficient flood prevention policy in BMA. The objective is to reduce problem flood situation in Bangkok inner zone and To make The inner city zone can cope with flash flood with themselves more than rely to on prevention construction and less dependence or reducing the use of suburb zone or urban fringe areas obtain flood instead of inner city to reduce conflict and reduce damage from flood.

It is important to acknowledge that totally protecting urban areas from floods is impossible even with massive structural measures and that implementation of non-structural measures will have a great potential to reduce damage and losses with the same level of floods. But it had to optimal balance between structural measure and non-structural measure to manage flood, In urban area should mix non-structural measures compatible, so for know-how that is also how to justify on this research focus.

F. Literature Review

1. **Ivan A. (2001), IHP-V Technical Documents in Hydrology : Guidelines on Non-structural measures in urban flood management, 22p.–73p. http://unesdoc.unesco.org/images/0012/001240/124004e.pdf**

Non-structural flood control measures have attracted the attention of the general public and professionals after a report by local and federal governments that more money was spent on flood relief than to prevent such problems. However, there are also some concerns from stakeholders in urban water management to recognize and accept these measures (UNESCO, 1998). These guidelines offer generally accepted concepts that are beneficial to the application. These are stated but not limited to the following:

Stormwater management in urban environments is a multi-sector process that includes, in addition to flood mitigation, storm drainage, and pollution control.

- Traditional site planning needs to be replaced with a watershed (watershed) or spatial planning.

- The regional zoning must be in accordance with the hydrological principles.

- Flooding does not have to be a catastrophe, so pollution is as important as physical destruction.

- Urban water is a resource that needs to be managed and must be properly linked to the land use planning process.

- Four corners of the comprehensive management process is to find the facts. (Through data collection, database updates, and exchanges), master planning (Prevention or Correction) Unified Action Policy formed by government agencies. (Via Guidance Document Adequate legal support) and changing public attitudes. (By creating awareness, empowerment, and participation in decision making and practice)

- Information gathered by public sector funding must be fully implemented, which will help build people's confidence and participation in other alternative financing options, such as the cost of user

- The best engineering solution may not be the best because of social and institutional constraints, which means that traditional engineering codes reflect the criteria that are no longer allowed in politics. The origins and effects of flooding must be thoroughly understood. Especially in developing countries, respectively. (Conservation authorities), which should overcome existing institutional and political barriers. Promoting non-structural urban flood management measures should be implemented, especially at the local community level, where disaster-prone disastrous locations are due to budget cuts experienced around the world (UNESCO, 1998).

Summary No. 1: Non-revenue Flood Control Measures to Reduce Risk to Urban Flood Management Costs The purpose of this approach is to present a complementary approach to engineering that is already a structural rather than a ready-made solution. Introduction to the Introduction of Non-Structural Flood Management Measures in General Practices.

2. **Abhas K., Robin B., Jessica L. (2012), Cities and Flooding A Guide to Integrated Urban Flood Risk Management for the 21st Century, 50p.–582p. Washington, USA, World Bank., https://openknowledge.worldbank.org/handle/10986/2241**

Integrated Flood Risk Management: Structural Measures: Structural Measures Used to Control Water Flow in and Out of the City in the Context of Integrated Approach to Flood Risk Management in the Region city These measures include what constitutes structural engineering solutions such as drainage, as well as complementary or alternative natural and sustainable alternatives, such as wetlands and natural repositories. This chapter begins with a discussion of flood risk management approaches. The focus then turned to structural measures. The questions that are answered are: What are integrated approaches? What structural measures can policymakers take to reduce the risk of flooding in urban environments? / In what cases are structural measures?

The key message is: Integrated strategies often require both structural and non-structural / structural measures, ranging from heavy engineering interventions, such as floodways and reservoirs, to more natural approaches, such as wetlands and greening measures. Urban and urban water management/engineering measures that are heavily engineered to be highly effective. When used properly It is likely that the risk of flooding from one location to another. In some situations, this is acceptable and appropriate, while others may not.

Integrated flood risk management: Non-structural measures: Non-structural measures used to manage flood risks for cities and towns and their residents. These measures do not require extensive investment in structured engineering infrastructure, usually with structural measures. However, they have to rely on understanding flood risk and adequate forecasting systems. There are four main categories as follows: increased preparedness, flood avoidance, planning and emergency management, accelerated recovery and use of recovery to increase flexibility. Many measures, such as early warning systems, are part of the flood risk management program. They can be seen as the first step in protecting people in the absence of more expensive structural measures. However, the remaining risks need to be managed.

The key message is that engaging the community at risk and encouraging public readiness is critical to the success of flood risk management. So communication is a key element. Land use planning and new development regulations are important measures to reduce future flood risks, in particular, to accelerate the emergence of new economies. Over the role of flood management

Implementing Integrated Flood Risk Management: The integrated flood risk management strategy of the city incorporates structured and unstructured measures. In implementing the integrated approach, the role of well-run institutions, participatory stakeholder participation, and community involvement are important. The implementation also requires sustainable financing. Maintenance of the measures taken to prevent their failure and their evaluation is also key to successful ongoing operations.

The key message is that flood risk management in urban areas is defined internally and can be dynamically placed among national, regional, municipal and community decision-making/flood risk management needs. Public utilities include public utilities, NGOs, educational institutions, and private sectors. Community involvement in all stages of the risk assessment, by proceeding with the assessment, will affect the success of the measure and may increase knowledge and resources, as well as implement measures. Designed and run by the community. The source of funding for integrated flood risk management is broad and can benefit from a partnership approach, including participation by stakeholders and stakeholders. Donations from abroad

Summary No.2: 12 Principles of Integrated Flood Risk Management It is designed to test progress in integrating non-structural structures and structures that involve multiple stakeholders and within

broader urban management in the long run. This is useful for discussing future targeting for improving flood protection.

1. All flood risk situations are different: no flood management plans. 2. Flood management patterns need to cope with changing and uncertain future. Integration of flood risk management into normal city planning and governance. / 4 Integrated strategies require both structural and unstructured measures. Good indicators for "balance" / 5. Structural measures that are heavily designed to help upstream and downstream risks. / 6. Can not eliminate all flood risks. Flood management is more common than flood management. 8 It is important to consider the social and ecological impacts that arise from spending. Flood / 9 Clarity of responsibility for creating and implementing flood risk programs is important / 10. The use of flood risk management measures requires cooperation among stakeholders. There must be continuous communication to raise awareness and strengthen preparedness. 12. Plan to recover quickly after flooding and use.

3. **Norio S., (2014), Urban Climate : Challenges for adapting Bangkok's flood management systems to climate change, Volume. 9, 90p.–99p. www.elsevier.com/locate/uclim**

As a result of the recent floods in 2011, Bangkok's greatest exposure to climate change is flooding the city. Although Bangkok has been improving its flood management system over the past several decades, the flood is still ongoing and is a major risk that cannot be fully mitigated. This document analyzes how the flood management system in Bangkok has been improved, taking into account climate change and how the current approach should be adjusted to make the operation more efficient. And more flexible There are several important discoveries. Firstly, while most of the major flood management measures are implemented in Bangkok, several analyzes have not been used in the context of flood management. In spite of the measures being taken to improve the system, no clear climate change will be considered. Current practices focus on structural choices, such as raising the height of flood walls and enhancing drainage and pumping capacity, under the jurisdiction of the Department of Drainage and Sewerage. Uncertainty must be given to non-structural alternatives in line with structural options such as land use planning, building codes, and alarm systems. At the front, so that the overall intervention is even stronger in the future. Although the adjustment measures in Bangkok. Institutional arrangements for achieving these objectives will need to be transformed by creating a collaborative mechanism between relevant agencies in Bangkok. Must be led by a senior leader.

Summary no.3: Urban flood management is a serious and rapidly growing development challenge and a significant risk to Bangkok. There are many publications on flood management options. As literature shows, there is no fix menu to improve flood management in the city. Public participation requires the development of public awareness and past experience assessment. The government must set the public administration model for stakeholder and stakeholder in the community and the public as a whole. Channels and opportunities to participate. Recommendations for both structural and non-structural measures. More emphasis should be placed on non-structural measures.

4. **Liao K., (2012), Ecology and Society : A theory on urban resilience to floods—a basis for alternative planning practices, 48p., http://dx.doi.org/10.5751/ES-05231-170448**

A comprehensive theory of city resilience that encompasses the innate vitality and uncertainty of providing an unusual perspective on coping with the dangers of flooding. The problem of floods cannot be ignored anymore. This theory points to the adaptation of floods and challenges the traditional wisdom that cities cannot live without flood control. Developing the city's elasticity theory for flooding

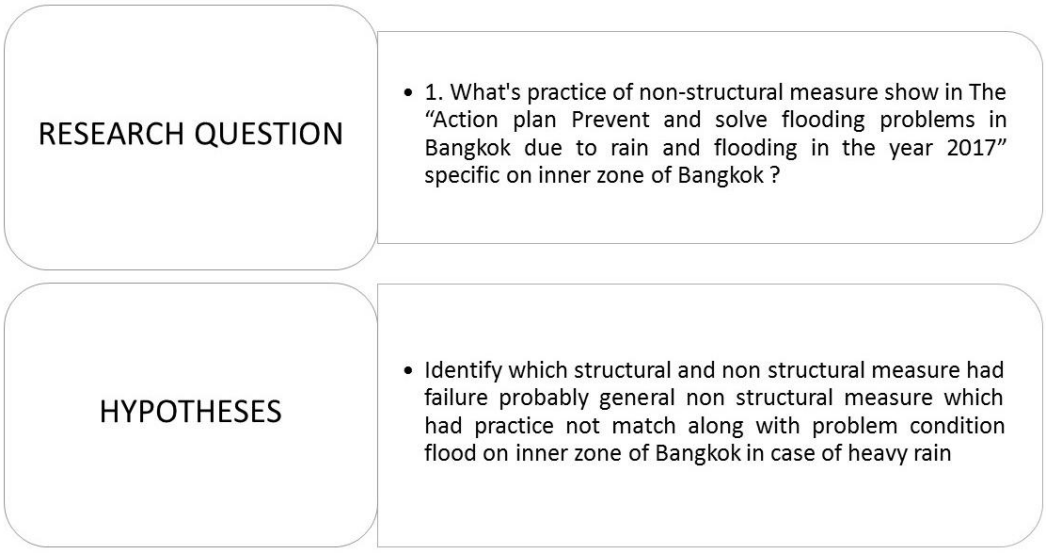
is an attempt to reinforce the existing flexibility theory by focusing on specific types of problems. Research on the flexibility of human-to-nature connectivity is still in the exploration phase, with little practical means for actual use in the world. The urban elasticity theory for floods, along with the flood measurement to assess the overwhelming capacity, makes it easy to apply field interdisciplinary research. Real-world challenges are no longer a means of increasing the resilience of cities to floods. But how does it stimulate change from a resilient city? The terrible problem is that the current flood control system is very flexible. Although disaster can be a catalyst for social change, change by choice will be very costly. It requires the ability to transform, which is the ability to create a new, basic system, which we know less than what makes the system flexible. Moving to a flexible city is a borderline of research.

Summary no.4: Government, the private sector, and civil society should be aware of the resilience of floods as an adaptation step, rather than fighting river-dwelling floods on a regular basis, enabling them to enter the city. To learn from them so will become elastic with the extreme. It is a paradigm shift from a resilient city with a changing agenda. "safety against floods" to "safety at floods"

G. Research questions and Hypotheses

The paper aims to address three core questions to answer and solve problem by analyzing which non-structural improvements should be achieved to enforce an efficient flood prevention policy in BMA:

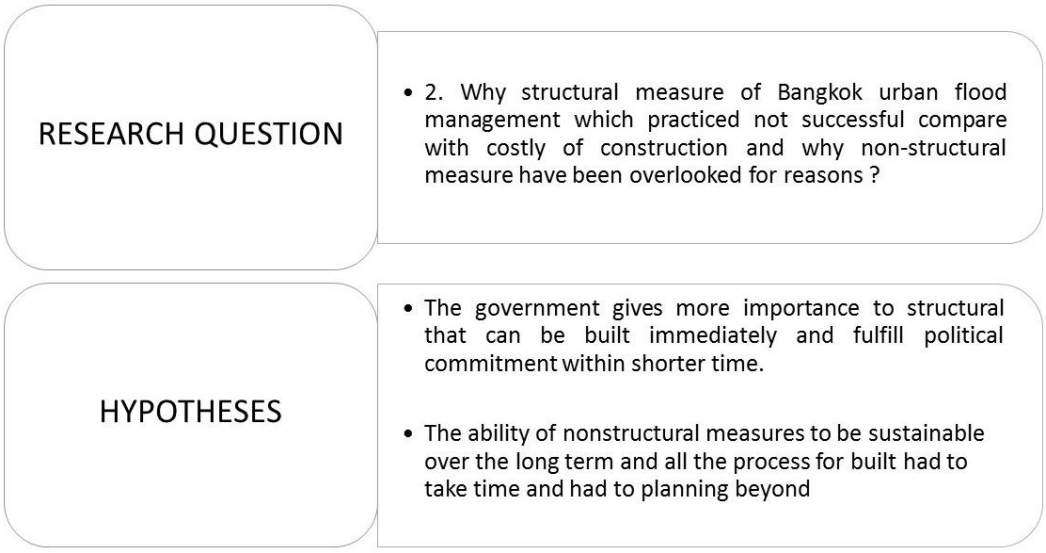
1. **What's practice of non-structural measure show in The "Action plan Prevent and solve flooding problems in Bangkok due to rain and flooding in the year 2017" specific on inner zone of Bangkok?**



Source: Author

HYPOTHESES : Find vulnerable of structural and non-structural measure from "Action plan prevent and solve flooding problems in Bangkok due to rain and flooding in the year 2017" to Identify which structural and non-structural measure had failure probably general non-structural measure which had practice not match along with problem condition flood on inner zone of Bangkok in case of heavy rain

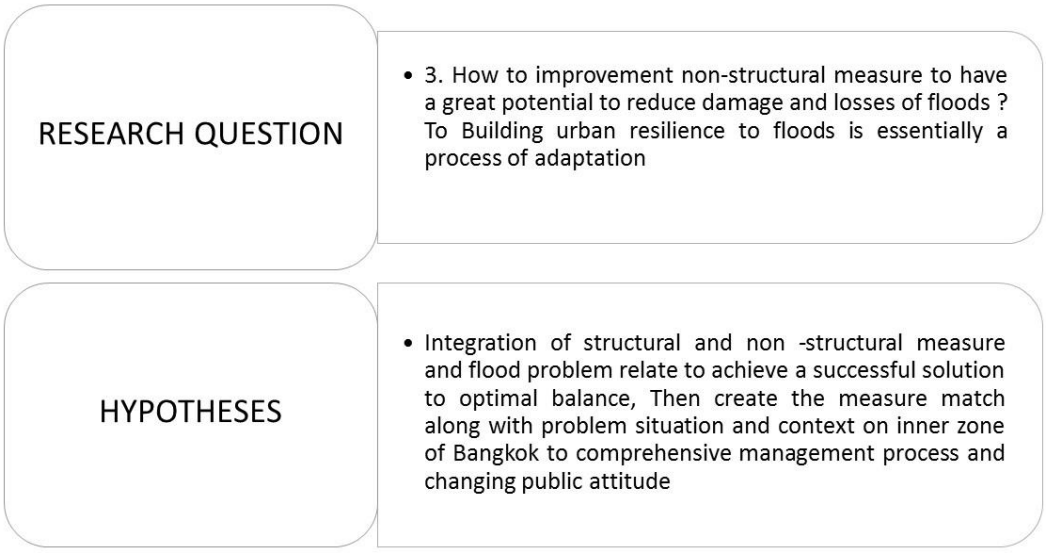
2. Why structural measure of Bangkok urban flood management which practiced not successful compare with costs of construction and why non-structural measure have been overlooked for reasons?



Source: Author

HYPOTHESES: The government gives more importance to the structure that can be built immediately and fulfill political commitment within a shorter time. Many structures have been approved shortly focusing on industrial estates on floodplains. But it does not eliminate future flood damages to that structure / The ability of nonstructural measures to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement. But at the same time, all the process for built had to take time and had to plan beyond by proven methods and techniques for reducing flood risk and flood damages incurred within floodplains.

3. How to improvement non-structural measure to have a great potential to reduce damage and losses of floods? Building urban resilience to floods is essentially a process of adaptation.



Source: Author

HYPOTHESES : Find all need to Integration of structural and non -structural measure and flood problem relate to achieving a successful solution to optimal balance between structural and Non-structural measure to manage flood, Then create the measure match along with problem situation and context on inner zone of Bangkok to comprehensive management process are: fact-finding (Through shared storage, database updates, and exchanges), master planning, unified operational policies that are affected by the authorities (Through guidance, inadequate legal and advocacy), and changing public attitudes. (By raising awareness, building capacity and setting up involvement in planning, decision making, and implementation)

H. Research Method

The purpose of this study is to consider non-structural measures to reduce urban flood damage. Literary investigations and surveys related to expert groups were conducted to obtain the appropriate measures. A literature review was undertaken to investigate the current flood prevention measures and the obstacles to the effective implementation of the flood-related policies. Specifically, this study relied on the information in the 2017 annual report published by the Bangkok Metropolitan Administration (BMA) on the floods, flood prevention measures, and its effectiveness.
This research will use the reason from the theory to the conclusion (Deductive Method). Then discuss the nature of the questions by choosing an appropriate methodological stance for answering and justify the research methods. The researcher using

- The analysis are primarily based on the review of the available literature, including documents made available by various departments of the Bangkok Metropolitan Administration (BMA). specific with “Action plan Prevent and solve flooding problems in Bangkok due to rain and flooding in the year 2017” to examine and identification of options were carried out in order to derive proper measures, prioritization for generate viable sustainable solutions

- Examining and surveys with a group of experts, collect information and identify issues

- Fact finding (through contemporary data acquisition, database updating and exchange), master planning (preventive or remedial), an unified action policy effected by the authorities (through guidance documents, codes of practice and adequate legislative support)

- This research is an extension of the results of other research. By the researcher has applied for permission and had allowed to refer their studies to point out that. How important of Non-structural measure flood management and Which Non-structural measure appropriate to solve and reduce flooding problems in Bangkok inner city.

To clarify this research will had Deductive Approach to Explanation and the Development of Theory, By Base on reference International Hydrological Program “ Guide lines on Non-structural measures in urban flood management ” and “ Cities and Flooding A Guide to Integrated Urban Flood Risk Management for the 21st Century ” (see in Figure.5)

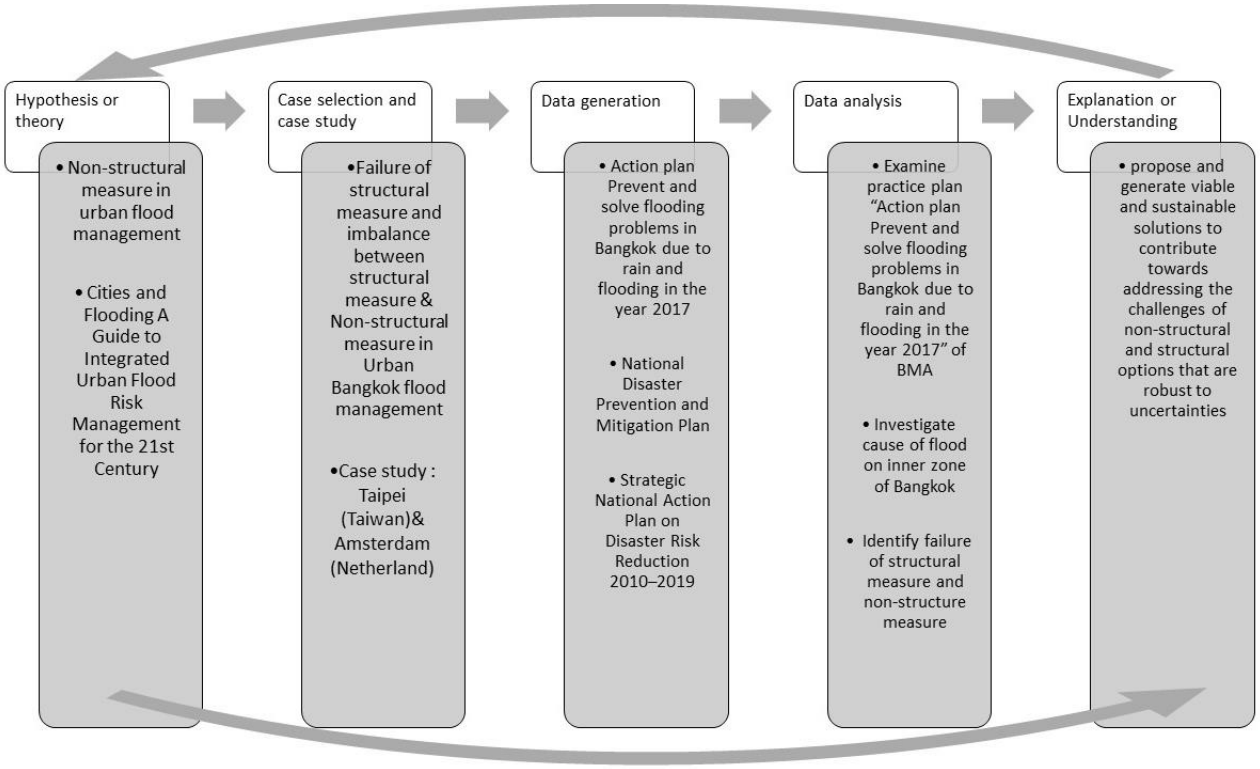


Figure.5: Deductive Approach to Explanation and the Development of Theory
Source: Author

II. DEFINITION MEASURE TO COPE WITH FLOODS

Following a line present day (e.g. Miller, 1997) the reduction of flood damage require a combined application of three different strategies to the problem of flooding.

A first approach, “keep the flood away from people”, has as objective to contain or reduce floods through measures such as the construction of dams and reservoirs, dikes and levees. In addition to these structural measures, soil and water conservation programs are also part of this strategy. In spite of its success in numerous applications over millennia of the history of humanity, it has become clear that this strategy is not sufficient to completely cope with the problem since considerable expenditure in flood protection works were not able to avoid substantial flood losses in recent times.

A second strategy approach recognizes that any structure to contain floods will be overcome by others of larger magnitude and attempts to avoid the use of flood-prone areas as a central thought “keep people away from flood”, In present time this simple prescription cannot be followed in full since much valuable development are located in areas which are subject to flooding. A practicable path corresponds to actions such as a specific consideration of envolved risk at the planning level, preventive minimization of potential damages, implementation of non-structural measures such as flood-proofing of individual objects, flood forecasting and the warning to minimize the opportunity for damage.

Finally, the third line of strategy is based on the acceptance of flooding conditions and concentrates on actions for the eventuality of floods to minimize damage and to promote a fast return to normality after the floods have occurred. Such an approach could be called “accept floods and clean up afterward”. It certainly can be realized that such an approach is basically unavoidable in flood-threatened regions.

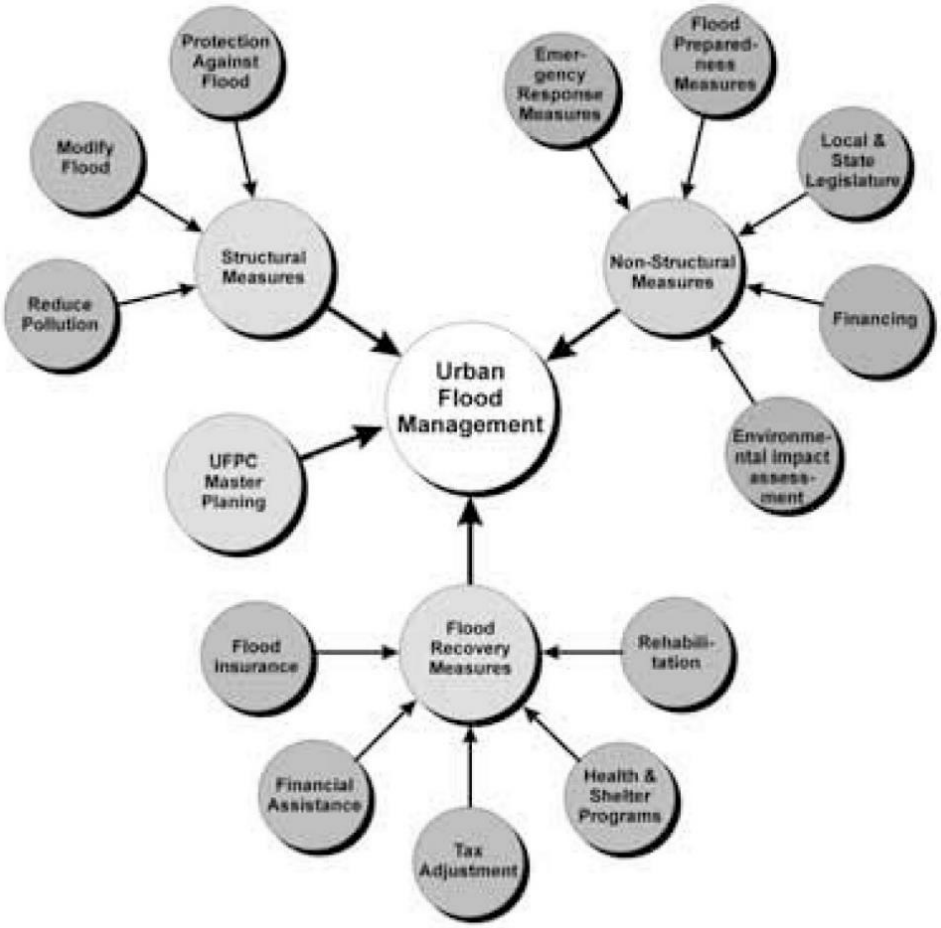
According to Ivan A., (2001), IHP-V Technical Documents in Hydrology: Guidelines on Non-structural measures in urban flood management, 9p.-22p.,
http://unesdoc.unesco.org/images/0012/001240/124004e.pdf

Unified urban flood management

The general approach to flood management is based on watershed plans and plans, which are needed during floods to reduce the impact on individuals and communities. These traditional programs are mainly managed by structural measures, which include some flood recovery activities. The urban environment may still remain limited within the scope of the flood protection plan. Most traditional approaches focus on correcting floods or preventing floods, such as dams, reservoirs, dams, floodwalls, flood diversion channels, and land treatment practices. Current concepts address flooding by considering the best flood management options available to both structural and non-structural measures. It is based on an integrated and eco-friendly approach that addresses all aspects of flooding in other city settings of the waters, cities, and lands that themselves are exposed to Stormwater too

However, for the sake of its use and to ensure its fulfillment, it will be necessary to take measures to reduce the damage from flooding and subsequent flood reduction, which is often a non-structural measure. Today, both structural and non-structural measures related to time and space are an important part of the contemporary urban flood management concept (Figure 6).

.Figure.6 Unified urban flood management



Source : Ivan A., (2001), IHP-V Technical Documents in Hydrology : Guidelines on Non-structural measures in urban flood management, 9p.-22p., http://unesdoc.unesco.org/images/0012/001240/124004e.pdf

III. CASE STUDY

Clear examples of the need to integrate structural and non-structural measures to cope with floods and the resulting advantages in doing so are found in the recent practice of flood management in urban areas. Example of efforts to integrate, at least to some extent, the full range of possible options can be found in many urban areas. Solution are complicated by the fact that urbanization has, in most case, been a process of historical development motivated by tendencies and driving forces which did not result in rational use of space and integrated planning. With the growth of urban center, highly complex situations arose in many case, even further aggravated by the need to correct adverse conditions, uprate and repair run down and non-operational infrastructure, create and promote zoning concepts and rational use of urban space in a continuous rush against time. Two particular situations are briefly presented here in view of their relevance and since they represent a good illustration of efforts being undertaken in urban areas.

1. Some policy aspects of flood management in The Netherlands

With half of its present land territory located below mean sea level of the North Sea, the fight against flooding has represented an objective of essential importance in the country. After centuries of development of protection work along the coast and along the main watercourses in the region

(Rhine, Maas, and Scheldt), two major projects implemented during the second half of the 20 th century strongly contributed to further advances in land reclamation and further progress in managing floods. These are the Zuiderzee Project in the northern coastal range and the Delta Project in the South (delta of the Scheld river). As an example, the linkages between water management, flood control and use of land are very strong in the country. Recent concerns have been motivated by a number of observations and thoughts such as:

- Changes in the local climate, the hydrology of the Rhine and Maas and the regime of storm surges in the North Sea.
- An accelerated rise of the sea level.
- increasing urbanization.
- The development of large-scale underground works for traffic, industry, and housing.
- The eventuality of a "superstorm" surge exceeding previous forecasts.
- The eventuality of "super flood" on the Rhine or the Maas also exceeding previous forecasts
- The possibility of joint occurrence of such storm surges and river floods.

Among the relevant aspects of present date flood management, the following are of particular interest:

- A promotion of extensive structural measures such as zoning and seasonal use of floodplain area as, for instance, along with the Rhine and the Maas;
- The consolidation of non-structural measures such as zoning and seasonal use of floodplain areas (e.g. along the Maas river);
- A review of flood-related policies and increase in safety requirements on the basis of probabilistic approaches and public consultations; the consequent enhancement of part of the intensive structural measure of the past as, for instance, the heightening of dikes along the coast and interior.

It appears certain that flood management policies and development in the future will still introduce modifications in the present day practices. It also looks likely that non-structural measures (and some of the extensive structural measure as well) will still gain further importance in the years to come.

The briefcase histories presented portray very different context of the environment, scope and specific flood management objectives to be reached. However, they have much in common. In the first place, they all underline the importance of combining intensive and extensive measures with non-structural measures to achieve an optimal strategy. In the second place, they provide a view of the synergies that can result from such an integration and harmonization of different flood control measures at planning, implementation and operation levels. Lastly, the cases also illustrate the fact that, in current flood management practice, there is still no recognizable applied methodology which takes into account the full scale of possible measures to cope with floods at an early stage of planning. Society response to the threats and risks of flooding has, in many cases, be more reactive than active and resulting strategies are often a composition of fragmented step.

The integration of structural and non-structural measures to achieve optimal strategies for flood management is certainly not a recent idea and has, in one way or another, been present in numerous water management practices. In a commonly adopted methodology the definition and implementation of flood management strategies can be seen as composed of the following logical sequential steps:

- Definition of flood management objectives and some general criteria;
- Identification of possible alternative for structure measures – mainly intensive, but also some extensive, at least marginally;

- The optimal choice of a solution based on a comparison between required expenditure and expected damages (implicitly a cost-benefit analysis involving risks);
- Consideration of non-structural measures completing the adopted solution.

Strategies and plan defined on these grounds can be review and updated whenever considered necessary as, for instance, in the case of modified objective and criteria adapted to changing scenarios. This systematization, although representing a workable way to go, fail to take full advantage of the potential synergies resulting from the broader integration of possible structure measures (intensive and extensive) and non-structural measures (regulation, flood defense, insurance) already during the planning and implementation process. A few selected examples are presented in the sequence to illustrate synergies which can be achieved in an integrated approach.

2. Waste charging system in Taipei, Taiwan

During the political and economic transition of 1989-1980, Taiwan tried to push for democratic rule and strengthen the industry and tourism sectors. People from other provinces poured into the Taipei capital. One of the problems that comes with the concentration of the population is the waste management or the waste of daily life. In the past Disposing of garbage is easy. By dumping waste to the road. According to the bins prepared by the government. And at that time, the garbage trucks will come and collect those rubbish. But the problem follows. Excessive garbage and toxic to the environment when waste is discarded without cleaning and sorting. And cause the drain to clog. Flooding in case of heavy rain. But only a few decades. Taiwan has transformed itself into a recognized world leader in global management. Through cooperation from the center and from the people themselves. By changing garbage from garbage to rubbish, the waste is dumped into the garbage truck itself. Or in the public space, the trash does not have a lot. To get people to recycle them. Or recycle at home. A Maiden's Prayer or Fur Elise was installed as a signal to remove the garbage. A white garbage truck is a waste bin. Yellow Garbage Truck waste bin that cannot be recycled. In the work of garbage trucks. The garbage is divided into 3 parts together.

1. Waste that cannot be recycled, such as plastic bags
2. Bio trash at the end of the garbage truck, there are two tanks attached to the food to feed the livestock. Another part of fresh leaves. To make compost or biological fermentation. The government can be used in parks. Or bring back the sale again.
3. Recyclable waste Disposers must separate and clean the waste before disposing of it, such as plastic cans, paper mugs (recycling of waste). There are 13 types of observations available at the university dormitories. Some dormitories also have garbage disposal facilities.) In addition to being forced directly through junk cars. Shopping at a convenience store or major stores. To buy a plastic bag. The price will vary depending on the size of the bag.

On July 1, 2000, Taipei has launched. The garbage collection fee, combined with other recycling measures, 1991, when the municipal government of Taipei began charging fees for garbage collection. Initially, the amount collected depends on the amount of water consumed per household, assuming that higher levels of water use are associated with higher levels of waste. Since fees do not relate to waste reduction, water use is reduced, which in turn drives the change in charging patterns. In 2000, PAYT was levied on water collection fees. The amount of waste is estimated. (see in Figure.7)

Currently, the government of Taiwan. The public announcement is clear: "By 2030, plastic waste must be completely managed." Taiwan's interesting waste management model

- The government has a strict policy and strict waste management practices.

- Implanted the idea of separating and recycling garbage from elementary school children.

- Home People dump garbage at garbage trucks only. It is time to get the garbage quite. There are 4,000 parking spots in Taipei.

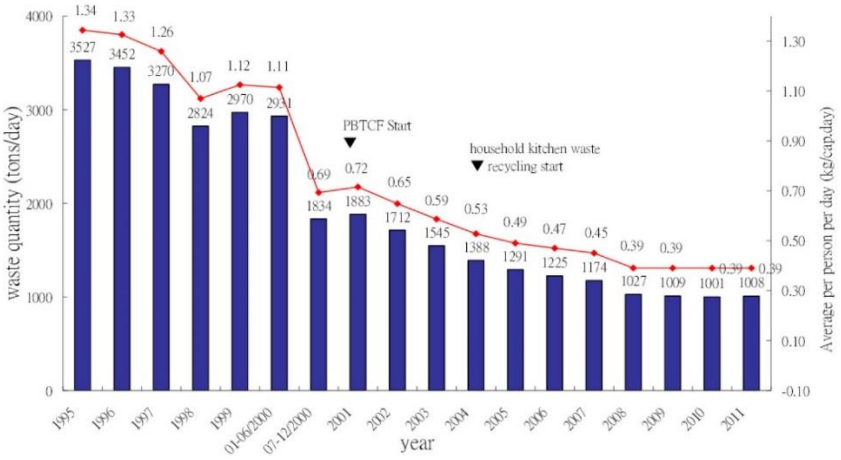
- Unplug the trash in the living area. It is forbidden to place garbage bags on the public floor.

- People's garbage dump There will be staff to see that. Are garbage dumps cheap?

- People must separate waste before disposing of. And use a state-owned garbage bag, which only has barcodes.

- 13 types of recyclable waste cannot be recycled. The public must be divided into two parts, the food waste to be used as animal feed. And for raw food. To make organic fertilizer.

Figture.7: Taipei City PAYT system and changes in household waste volume



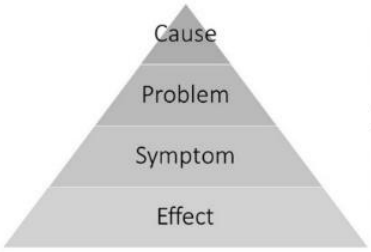
Source: retrieved on TDEP - Taipei Department of Environmental Protection (2012). Total recycling, zero landfill policy introduction: http://english.dep.taipei.gov.tw/public/Attachment/27231626521.pdf

Current government of Taiwan Waste can be disposed of more than 55% recycled. With the help of waste separation. Along with the punishment of the offender strictly. Taiwan has reduced its garbage collection by nearly three times from 1.14 kilograms per capita per day in 1998 to 0.38 kilograms in 2015, while garbage recycling has increased from 5.9% to 55%, to Taipei and Taiwan. Become a model of the world in waste management.

V. DATA ANALYSIS

The research project consists of four main components. For the sake of clarity. Need to hierarchize and prioritize flood problems inner zone of Bangkok and solutions. They are some family of problems which may require certain actions. By analysis follow as this diagram:

PROBLEM PART



State of problem

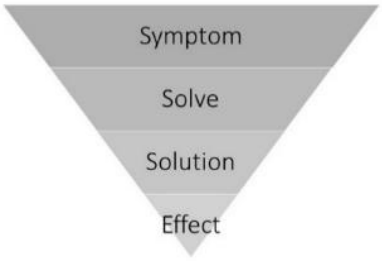
Problem analysis Flooding in Bangkok's inner lands Because heavy rain. Analytical tools need to be used. The cause of the flood. And the floods that occur. In this diagram. The sequence of analysis. Starting from
Part 1 is the cause of the problem.
Part 2 is an important issue. The specificity of the problem.
Part 3 is a symptom of the problem.
Part 4 is a the effect of the problem.

Source: Author

PART 1: <u>Reviewing plans, policies and urban management with structure and non-structure measures</u>

1.1 Collect land use and building use data, including plan, policy and ordinance regulations for analyzing and estimating.
1.2 Collect water management data and guidelines, including plan, policy and ordinance regulations for analyzing and estimating.
1.3 Analysis of potential and limitations of each plan and/or policy

SOLUTION PART



State of Solution

Solution analysis Flooding in Bangkok's inner lands Because heavy rain. Analytical tools need to be used inverse with problem analysis.To find solve and solutions for Chronic flooding problem To be sustainable. In this diagram. The sequence of analysis. Starting from
Part 1 is a symptom of the problem
Part 2 is a solve of the problem
Part 3 is a solution of the problem.
Part 4 is the result of solve the problem.

Source: Author

PART 2: <u>Assessing non-structural measure</u>

2.1 Assessing the relative importance of structural & non-structural causes
2.2 Assessing the potential for removing or at least alleviating these causes for adaptive actions with a focus on non-structural aspects
2.2.1. Cause-specific problems. The flooding in the inner city of Bangkok.
2.2.2. Review all non-structural measures used in flood management in Bangkok.
2.2.3. Analyze/assess the potential to find solutions. The focus is on the use of non-structural measures Comply with Structural elements are available in Bangkok.

PART 3: <u>Propose which non-structural measures improvements should be achieved to enforce an efficient flood prevention policy in BMA.</u>

3.1 The first scenario: Develop Zoning and Building code in risk area zones
3.2 The second scenario: Defined catchment and drainage and add more permeability surface
3.3 The third scenario: Propose develop some of nonstructural measures

PART 1: Reviewing plans, policies and urban management with infrastructure and non-infrastructure measures (specific important area on inner zone of Bangkok)

1.1 Collect land use and building use data, including plan, policy and ordinance regulations for analyzing and estimating.

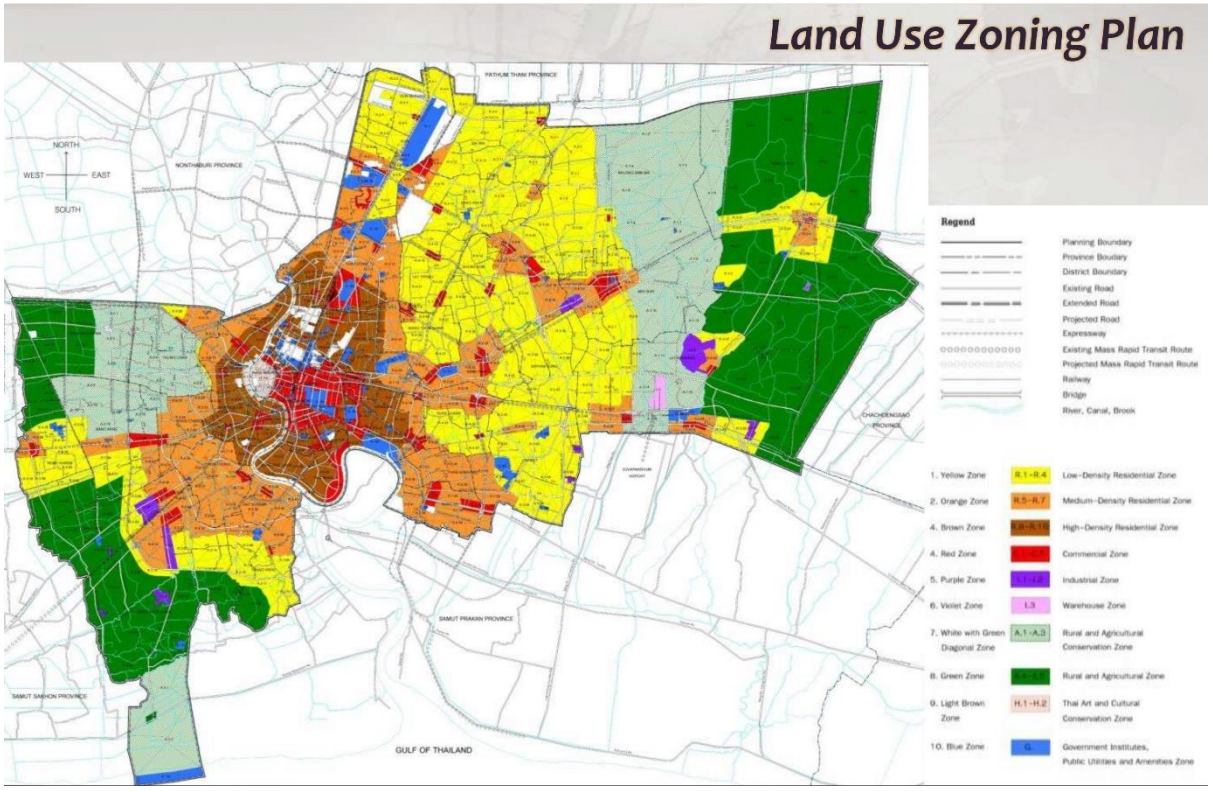
Urban Planning system in Bangkok city and Characteristics of the urban planning system in Bangkok city, urban planning is control and organization by the City Planning Department Bangkok Metropolitan Administration (CPD) and a special local government in accordance with the Bangkok Metropolitan Administration Act 1985 be responsible for the management of the city of Bangkok. There have 4 offices, 15 departments, and 50 district offices. The fifteen departments mostly cover the BMA's functions specified by laws. CPD is responsible for city planning and prepares the Bangkok plans including the Bangkok Comprehensive Plan, the Specific Plan and area development plans and etc. Moreover, spatial plans which are not enacted under laws and regulations its can classify follow Regional Scale and Urban and Community Scale. The BMA had to promulgate the regulations enacted as the overlay control for the land use, building use, activities, and the height of building in some certain areas Similarly, urban planning law aim to control and limit the activities and land use in urban areas by use the rules and regulations as The Land Use Zoning Plan and Land Use Control as follows, Land Use Control / Activities Control : Permitted Uses, Prohibited Uses, Conditional Uses and Bulk Control : Floor Area Ratio (FAR), Open Space Ratio (OSR), Minimum Lot Size, Maximum Height of Building, Building Setback

Comprehensive Plan Specific Plan : 5 years cyclic with 2 times in each 2 years extended, Charged by provincial office of the Department of Public Works and Town & Country Plan (DTCP), Consist with elements: Land use plan / Open space plan / Infrastructure plan/transportation plan, Specific Plan reviewed and approved by The Board of Town and Country Planning,

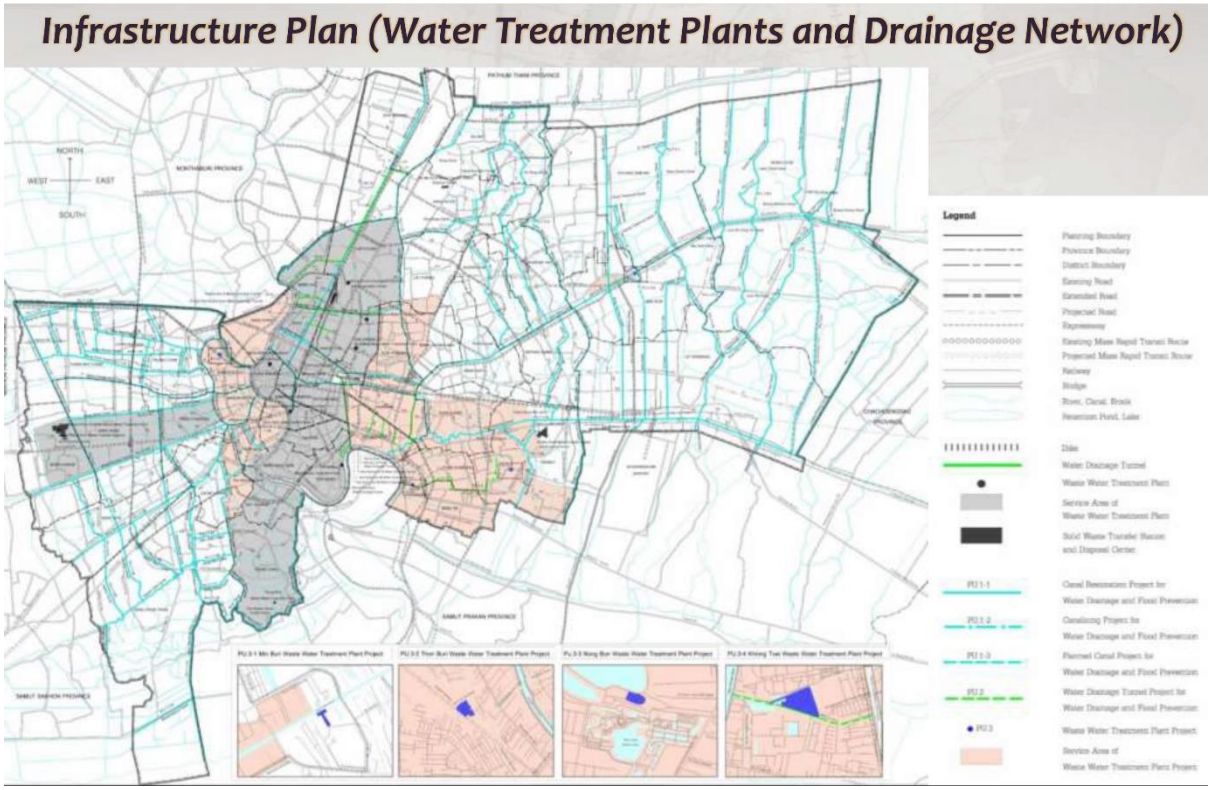
Thailand's comprehensive plan is utilized as a land management instrument in conjunction with the city planning code on land usage. The comprehensive plan and its regulatory family are goals at controlling urban development. However, the plan is considered ineffective because of the volume of regulations and inadequate enforcement, which are further worsened by the inadequate implementation of future land use zoning map. Land management uses three tools planning, regulation, and fiscal instruments. Within planning, zoning is displayed through colored maps that segregate land into residential, commercial, agricultural, industrial, cargo, conservation, and floodway areas. The colors are further divided into different density and land use requirements. However, the zones and blocks tend to cover large areas. Small communities and neighborhoods with different land use patterns can be incorporate into one large zone.

Regarding legal mechanisms, important landmarks in land registration include the zoning ordinance, floor area ratio, and open space and open space ratio. These act as the large control structure, but are not blueprints for urban development. Lastly, the fiscal tool remains underutilized as a mean to reshape land use. The levies that have been put in place, such as the local development tax, housing, and land tax, are not effectively utilized to produce the targeted land use outcomes, A positive development in recent years is the publication of Bangkok's 2013 comprehensive plan. The occurrence of a disaster is one aspect that causes land use policy within areas to change. Nonetheless, most of the land use in these areas is agricultural and residential areas. This suggests the limitation of land use system and its control. While Bangkok has a strong potential adaptive capacity, its urban planning system may nevertheless find that it fails to keep pace with the increasing threat and exposure brought about by climate change and rapid population growth.

The Bangkok Comprehensive Plan 2013 (B.E.2556)



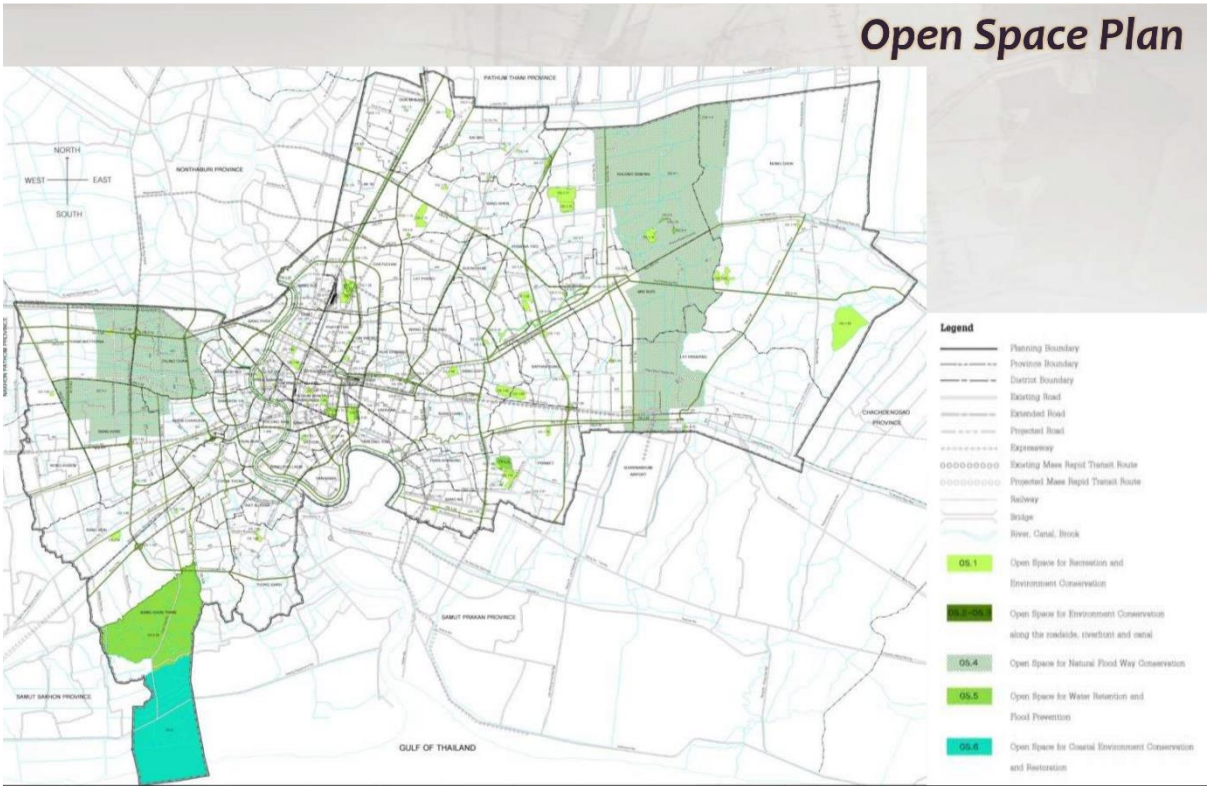
Figture.8: Land use zoning plan
Source: The Bangkok Comprehensive Plan 2013, City Planning Department (BMA)



Figture.9: Infrastructure plan (water treatment plants and drainage network)
Source: The Bangkok Comprehensive Plan 2013, City Planning Department (BMA).

The Bangkok Comprehensive Plan 2013 (B.E.2556)

Figture.10: Transportation plan (Road network)
Source: The Bangkok Comprehensive Plan 2013, City Planning Department (BMA)



Figture.11: Open space plan
Source: The Bangkok Comprehensive Plan 2013, City Planning Department (BMA)

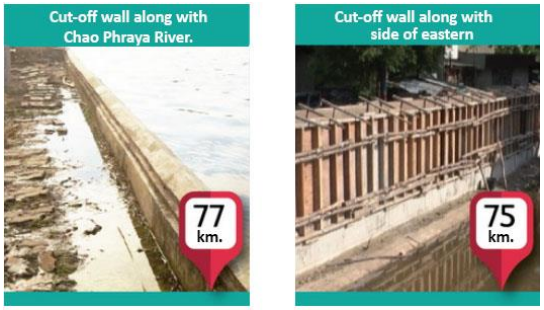
1.2 Collect water management data and guidelines, including plan, policy and ordinance regulations for analyzing and estimating.

Bangkok The area of about 1,568 sq.m., located on the upper river basin of the Chao Phraya River near the Gulf of Thailand. Altitude is about 0 + 0.00 m to +1.50 m above sea level. Some areas have moderate sea level. Drainage from the area using natural flow. (Gravity Flow) made it difficult because Bangkok is low. The drainage of the pumping station and the main drainage canal are limited. And cannot improve the width of the canal. Bangkok is prone to two types of flooding. The first type is pluvial (overland) flood, sometimes referred to as urban flood. A high amount of rainfall is not absorbed into the land and flows over land and through urban areas before it reaches drainage systems or watercourses. The type of flood usually occurs in urban areas due to the lack of permeability of the soil surface, meaning that rainfall is not rapidly absorbed, sufficient to support circulation. The second type is river (fluvial) flood. Located at the mouth of the Chao Phraya River (which has a catchment area of 159,000 km2), a large volume of water passes through the middle of Bangkok. River floods occur when the surface water runoff exceeds the capacity of the river to accommodate the flow. In The "Action plan Prevent and solve flooding problems in Bangkok due to rain and flooding in the year 2017" (Department of Drainage and Sewerage under BMA) They had the policy in action plan divided into 2 types for the Specific situation by :

- Action plan to prevent and solve Bangkok flood due to rainfall (pluvial (overland) flood): The operation will drain rainwater in the protected area and nearby areas to drain out of the flooded area as soon as possible. In order to avoid flooding or occur a little in a short time.

- Action plan to prevent and solve Bangkok flood due to high tide (river (fluvial) flood): It is an action to protect the flood because the water in the Chao Phraya River is high. By building a water barrier along the river. The canal is directly influenced by the water level in the Chao Phraya River. The water barriers must be sufficiently high to prevent overflowing water. Both drainage and outflow control. In protected areas, keeping the internal water level and external water level at an appropriate level. By using a floodgate and pumping station to control the system. Bangkok flood prevention and solution by using enclosed space system. With the flood protection construction surrounding the area. To prevent water from flooding outside the area. Inside the enclosed construction area drainage system. To drain flood to the Chao Phraya River. By Bangkok Border Protection and solve the flood problem is 2 systems.

1. Flood Protection System By building flood protection barrier enclosed area to protect the water and high sea. To prevent flooding due to water from the Chao Phraya River and water runoff from the Bangkok Metropolis. The flood protection as follows.



Figture.12: Dike / Dyke along with Chao phraya River
Source: Infographic http://www.realist.co.th/blog/

2. The drainage system to solve flooding due to rainwater. In response to floods in the enclosed areas, Bangkok has constructed a drainage system to expedite floods in the area to the Chao

Phraya River and the Gulf of Thailand. The capacity of the drainage system can accommodate no more than 60 mm. / hr. of rainfall including drainage system as follows.

Figure.13: The drainage system to solve flooding due to rainwater
Source: Infographic http://www.realist.co.th/blog/

Purpose of Large drainage tunnels to improve drainage efficiency in flooded areas. For drain water from flooded areas to drain into the Chao Phraya River directly due to without the canal system as usual. It also reduces the water level in the drainage canal to low level quickly to increase drainage efficiency in the canal. Currently, Bangkok is under construction of one giant tunnel and four other projects underway in Phranakhon area will be more progress than the Thon Buri Tunnel. Total tunnel length is 40.25 km. Total drainage capacity is 260 sq.m.

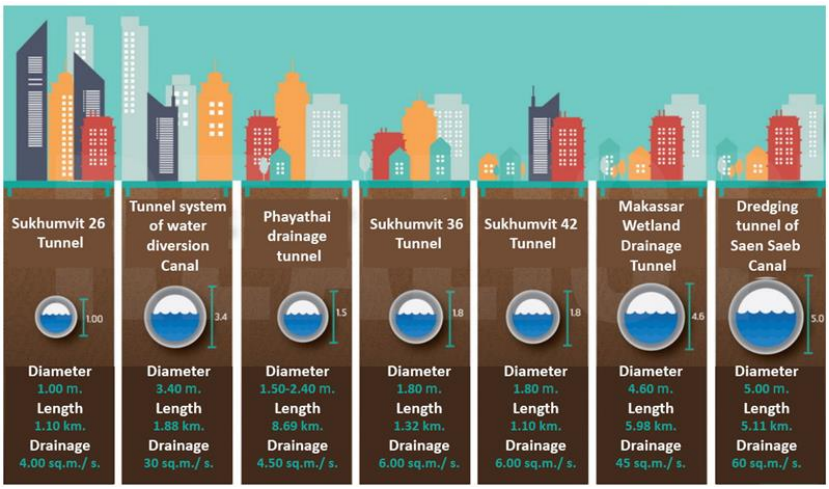


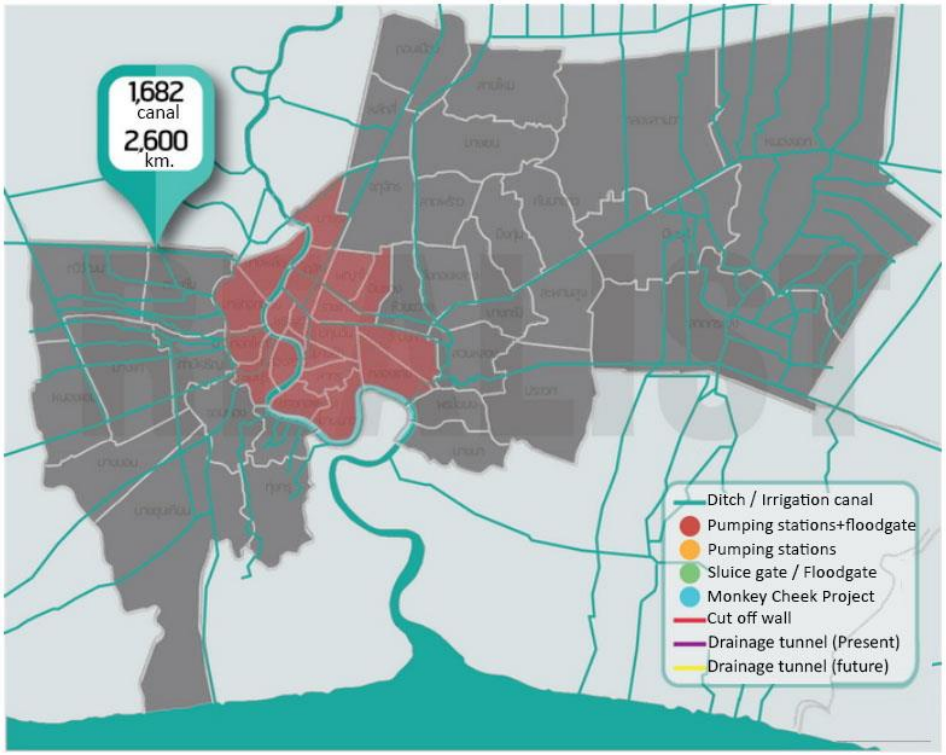
Figure.14 :Section Detail of Drainage tunnel in Bangkok drainage system
Source: Infographic http://www.realist.co.th/blog/

The fact of Large drainage tunnels

In case of Heavy rainfall, Bangkok always faces with Flash Flooding occurs so quickly and sometime over the night still inundation shut in until morning Although, BMA try to solve the problem by relying on structural measure continue such as The giant tunnel is using the failed budget. Located near the tide. Pumping from underground canal to down river. Even drain the canal. It is lower than the river. It requires a tremendous amount of pressure. Ten more tunnels to be built. But all drainage systems were not modified. So it cannot solve the flood problem.

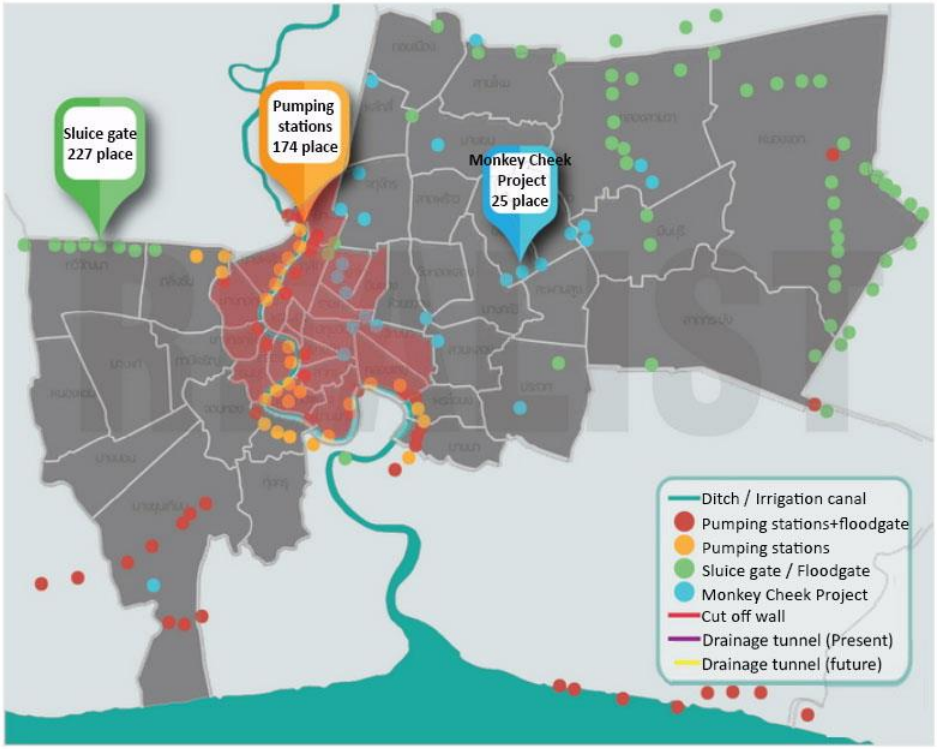
Map of Bangkok drainage system

- Ditch / Irrigation canal



Figture.15: Map of Ditch / Irrigation canal in Bangkok drainage system
Source: Infographic http://www.realist.co.th/blog/

- Pumping station + floodgate + Monkey Cheek Project



Figture.16: Map of Pumping station + floodgate + Monkey Cheek Project in Bangkok drainage system
Source: Infographic http://www.realist.co.th/blog/

- Flood protection (Cut-off wall)

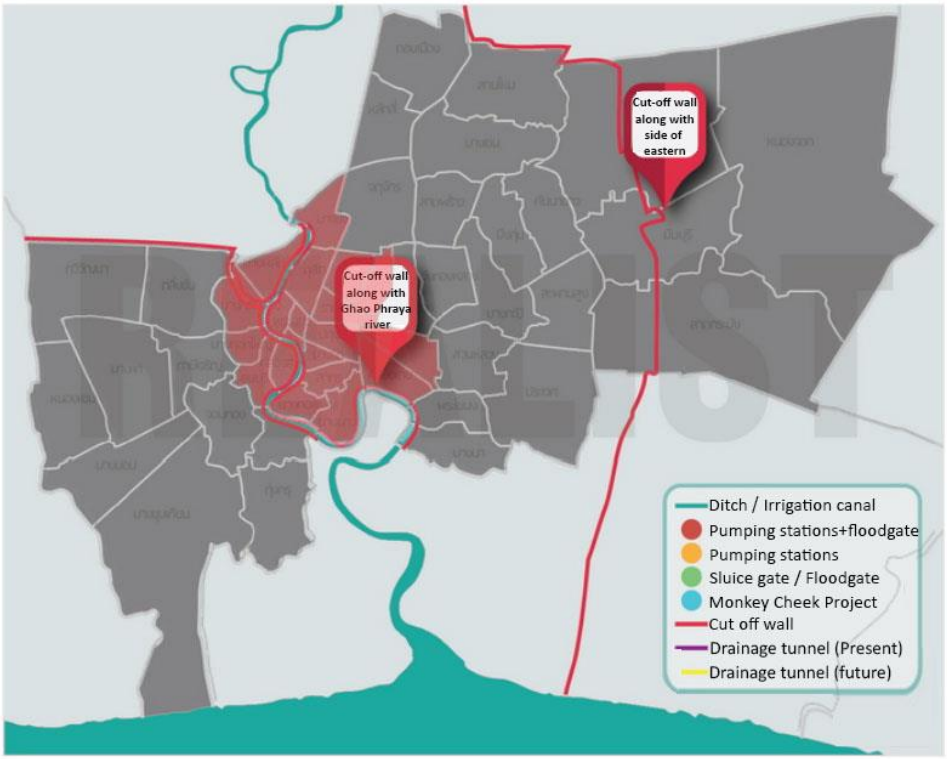


Figure.17: Map of Flood protection (Cut-off wall)
Source: Infographic http://www.realist.co.th/blog/

- Drainage tunnel

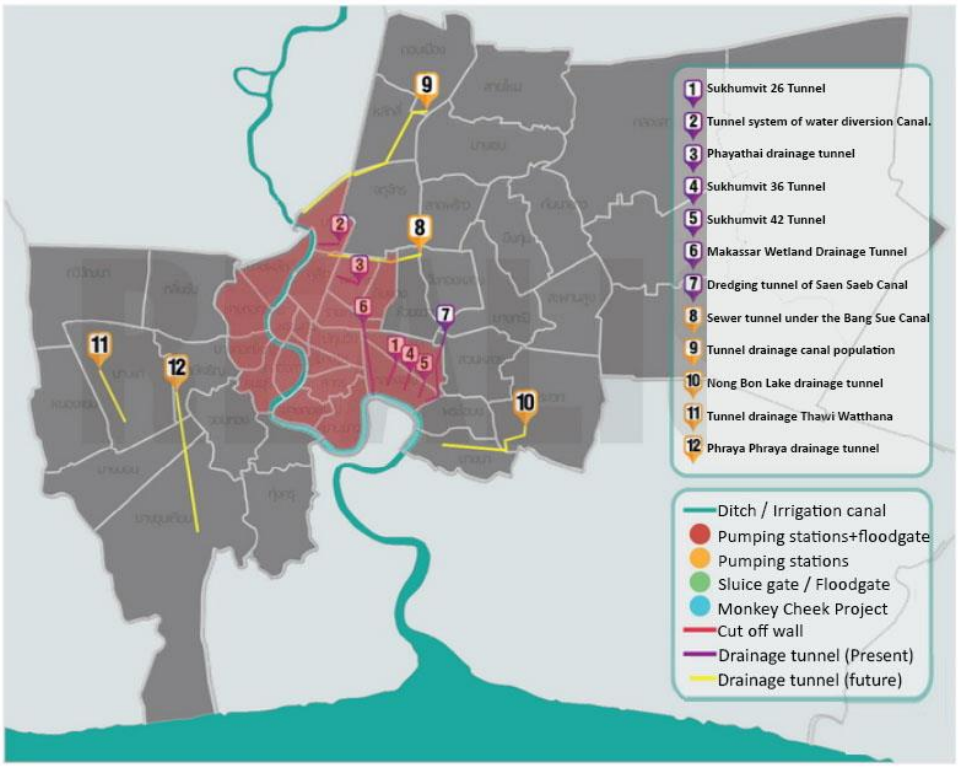


Figure.18: Map of Drainage tunnel in Bangkok drainage system
Source: Infographic http://www.realist.co.th/blog/

1.3 Analysis of potential and limitations of each plan and/or policy

Analysis of Master plan flood management in Bangkok

According to Article **"Flood risk management in Thailand: Shifting from a passive to a progressive paradigm"** The relevant plans and measures for managing flood risk in Thailand have been carried out by the assigned government agencies, whereas the public and private sectors in the flood risk areas are rarely involved. Working under the Ministry of Interior, the Department of Disaster Prevention and Mitigation (DDPM) is the main government agency responsible for all kinds of disasters as indicated in the current National Disaster Prevention and Mitigation Plan (NDPMP) 2015. Key elements of the NDPMP include

(1) Implementing and promoting disaster risk reduction,

(2) Integrating multi-sectoral cooperation in emergency management,

(3) Enhancing measures in recovery, rehabilitation, and reconstruction,

(4) Developing and strengthening international cooperation in disaster risk management.

Table 1: Existing plans and proposed framework and their characteristics relevant to flood risk management for the Chao Phraya River Basin.

Plans/framework	Time period	Response		Communication		Measures		Community	Type of flood risk considered		
		Passive	Progressive	One-way	Two-way	Structural	Non-structural	participation	Existing	Future	Continuing
Existing											
• National Disaster Prevention and Mitigation Plan (NDPMP)	Past-present	√	O	√	O	√	O	O	√	O	O
• Strategic National Action Plan on Disaster Risk Reduction 2010–2019	2010–2011	√	O	√	O	√	O	O	√	O	O
• Comprehensive flood management plan for the Chao Phraya River Basin	2013	√	O	√	O	√	O	O	√	O	O
• Strategic plan for flood management 2015–2026	2015-present	√	O	√	O	√	O	O	√	O	O
Proposed											
• Flood risk management framework	Future	√	√	O	√	√	√	√	√	√	√

√ = available or emphasize, O = not available or not emphasize.

Source： Nuanchan S., (2017), International Journal of Disaster Risk Reduction : Flood risk management in Thailand: Shifting from a passive to a progressive paradigm, Volume 25, 92p.-100p., http://dx.doi.org/10.1016/j.ijdrr.2017.08.003

The NDPMP has been used as an umbrella for all relevant plans to manage flood risks at a local level. It is a master plan that contains top-down policies (i.e., one-way communication policies), emphasizes passive responses (e.g., emergency responses to an existing flood event and recovery after the flood ends), and relies mainly on structural measures (e.g., dams or dikes for controlling floods). The NDPMP lacks any aspects of community participation (communication and consultation) and progressive responses to deal with future and continuing flood risks (Table 1). Consequently, few operational plans formulated under the NDPMP's umbrella could be effectively implemented at a local level and have attracted criticism, for example: too broad or general, inappropriate for applying to local conditions, and so forth. Following the 2007 National Disaster Prevention and Mitigation Act (NDPMA), the National Disaster Prevention and Mitigation Committee (NDPMC) was set up as a national multi-sector body for policy formulation and planning for disaster preparedness, mitigation, and representatives from line government agencies.

After the 2011 flood, the Thai Government's Strategic Committee for Water Resources Management (SCWRM) was set up with the responsibility for developing plans to prevent future floods. The SCWRM

is under the Secretariat of the Prime Minister. The committee assigned the Japan International Cooperation Agency (JICA) to conduct a comprehensive flood management plan for the Chao Phraya River Basin (Table 1) under a supervisory panel including representatives from the Royal Irrigation Department and the Department of Water Resources. Most of the sub-projects initiated as a result of the plan emphasized structural measures to prevent or mitigate floods in the Chao Phraya River Basin, but did not consider the impacts on neighboring areas. For instance, there was a project to build a water diversion route to take future floodwaters from the Sakae Krang River Basin (located to the northwest of the Chao Phraya River Basin) to the Chin and Mae Klong River Basins (located to the west of the Chao Phraya River Basin). This is a type of passive response to flooding that tends to shift the problem spatially and temporarily to nearby river basins. In addition, it may adversely affect people living in those river basins and lead to public concern and disapproval of the project's development. The strategic plan for flood management 2015–2026 was later launched by the current Thai government of General Prayut Chan-o-cha (22 May 2014 – present). This plan focuses on the Chao Phraya River Basin and it still emphasizes structural measures and passive responses to flooding. The plan comprises feasibility studies and environmental impact assessments in the short-term (2015–2016) and mega-project developments (e.g., water routes or dikes) in the medium- term (2017–2021) and long-term (2022–2026). Upon the initiation of the plan, 185 flood projection systems are planned to be developed in Nakhon Sawan Province (located in the upstream portion of the river basin). The major weakness of these measures include

(1) allowing development in areas with a high flood risk,

(2) stimulating new developments that may increase the flood risk in these areas,

(3) causing significant damage to areas with sensitive environments

(4) diverting flooding to, and increasing flooding in neighboring areas

These impacts need more investigation and mitigation. Other characteristics of the strategic plan on flood management 2015–2026 are included in Table 1. Overall, various aspects of the existing plans and measures relevant to flood risk management of Thailand need to be reviewed and improved for robust flood risk management; with fewer overlapping responsibilities and more community participation.

Analysis of Major flood management measures in Bangkok

According to Article **"Challenges for adapting Bangkok's flood management systems to climate change"** It is important to assess if the flood management system improvements in Bangkok are effective in coping with not only the current flood risks, but also the increasing level of risks in the future with climate change. Key flood management measures are analyzed from three viewpoints: (i) whether and to what extent the measures are practiced or are planned to be practiced in Bangkok; (ii) whether the measures incorporate climate change considerations in their design and planning; and (iii) whether climate considerations are incorporated appropriately, if climate change is taken into account. A summary of the analysis and status of implementation is given in Table 2, together with the main agencies and departments responsible for the selected flood management measures in Bangkok. The results of analysis for each type of flood management are discussed below.

Table 2: Summary of analysis, and status of practice of major flood management measures.

Flood management option	Main responsible agency/dept	Q1	Status of practice	Q2	Q3
Flood management and drainage infrastructure improvement	DDS	Y	Improvement work ongoing. Intends to achieve a level of protection to cope with a flood equivalent to the 2011 flood	Y (implicit)	N
Natural buffers	DDS; RID	Y	The current four-year plan targets to increase their size by 0.5 million m^3. Only 2 areas with a capacity of 0.24 million m^3 have been identified. DDS has a much more ambitious plan to increase the capacity by 6.13 million m^3	Y (implicit)	N
Groundwater management and rainwater harvesting	DGR, MONRE; MWA	Y	Groundwater abstraction is being reduced, and land subsidence has slowed down	N	..
		N	Rainwater harvesting is not pursued	N	
Reducing social vulnerability	MWA; DSD, PWD	Y	Water access is provided by MWA. BMA, through DSD and district offices, is supporting community development of LICs	N	..
Land use planning and zoning	CPD	Y	Updated in 2013. Some consideration to flood risk reduction	Y (implicit)	N
Building codes	PWD	Y	Building codes exist, but no updates in recent years	N	..
Early warning systems	DDS; TMD; RID	Y	A flood control center is in operation, and there are plans to strengthen it	N	..
Emergency planning and rescue	BFRD	Y	The Bangkok Public Disaster Prevention and Mitigation Plan 2010-2014 is in place. Plans are available for pre-, during, and post-disaster including floods	N	..
Awareness-raising	Various departments	Y	Programs implemented by various departments, including preparation for floods	N	..

Source *:* Norio S., (2014), Urban Climate : Challenges for adapting Bangkok's flood management systems to climate change, Volume 9 , 92p.-94p., http://dx.doi.org/10.1016/j.uclim.2014.07.006

Key note : Q1 = Whether and to what extent the measures are practiced or are planned to be practiced in Bangkok. / Q2 = Whether the measures incorporate climate change considerations in their design and planning. / Q3 = Whether climate considerations are incorporated appropriately, if climate change is taken into account. / N = No, Y = Yes, .. = not applicable. / BMA = Bangkok Metropolitan Administration, CPD = City Planning Department, DDS = Department of Drainage and Sewerage, / DGR = Department of Groundwater Resources, DSD = Department of Social Development, BFRD = Bangkok Fire and Rescue Department, LIC = low income communities, MONRE = Ministry of Natural Resources and Environment, MWA = Metropolitan Waterworks Authority, PWD = Public Works Department, RID = Royal Irrigation Department, TMD = Thai Meteorological Department. BFRD, CPD, DDS, DSD, and PWD are the departments under BMA.

The implementation plan of DDS clearly indicates its emphasis on structural measures. BMA (2013) discusses that structural measures will be mainly used in densely-populated areas, while non-structural measures will be mostly used in under-populated and agricultural areas. In densely-populated areas, measures are discussed for preventing water from outside flowing into the polder system, draining water out of the polder, and drainage inside the polder.

The analysis has revealed that various departments of BMA are taking actions with a view to preventing and mitigating flood problems in Bangkok. However, none of the measures have explicitly taken climate change into account in their analyses or the design of the interventions. Therefore, the third question in the analysis – whether climate considerations are incorporated appropriately

According to Article **"Urban Flooding and Climate Change: A Case Study of Bangkok, Thailand"** Bangkok has 20 flood-prone localities in the 4 flood-sensitive districts of the capital: the districts of Don Mueang and Bang Khen (in the north of Bangkok), Bangkapi (in the east) and Wattana (in the

capital center). Specifically, the research objectives are threefold. The first objective is to investigate the causes of persistent flooding in the capital through a documentary review. The second objective is to identify the factors contributing to urban flood and the ineffectiveness of the flood alleviation and prevention measures in the capital. To this end, a questionnaire survey was conducted with a sample of 400 residents of the 20 localities in the capital's four districts and the statistical analysis was performed. The third objective is to assess the satisfaction levels with the adequacy and effectiveness of the flood alleviation and prevention measures of the city's administration. Moreover, also suggestions for dealing with flood risks and the ineffectiveness of flood-related measures.

Table 3 : The Satisfaction Levels by Weight Average Index (WAI) with the Adequacy and Effectiveness of the Flood Alleviation and Prevention Measures in the Capital

		Weighted Average Index (WAI) of the Satisfaction Level				
Item	Specifics	Bang Kapi	Don Maeung	Wattana	Bang Khen	Overall Average WAI
1	Satisfaction with the construction of giant drainage tunnels for flood alleviation	0.4848	0.4353	0.3889	0.3916	0.4258
2	Satisfaction with the drainage efficiency in times of torrential rains	0.4035	0.3544	0.3755	0.3665	0.3727
3	Satisfaction with the adequacy of pumps for flood alleviation	0.4080	0.4299	0.3554	0.3653	0.3921
4	Satisfaction with frequency of sewer maintenance and clean-up	0.4734	0.5496	0.3399	0.3460	0.4287
5	Satisfaction with the readiness of the city administration before and during floods	0.3416	0.4115	0.3400	0.3478	0.3621
6	Satisfaction with the extent of the enforcement of city planning and land utilization regulations	0.3825	0.4134	0.3462	0.3518	0.3748
7	Satisfaction with the timeliness and reliability of advance flood warning	0.3364	0.4134	0.3597	0.3699	0.3724
8	Satisfaction with the existing flood prevention concrete structures	0.3425	0.3395	0.3645	0.3640	0.3525
9	Satisfaction with the current drainage capacity	0.3328	0.3540	0.3499	0.3567	0.3500
10	Satisfaction with the BMA's plan to establish the capital-wide flood relief centres	0.3304	0.5598	0.3571	0.3891	0.4171

Source: Survey during August 2016 to October 2016.
Notes: 0.00–0.20 = least satisfactory, 0.21–0.40 = somewhat satisfactory, 0.41–0.60 = moderately satisfactory, 0.61–0.80 = satisfactory and 0.81–1.00 = very satisfactory.

Source *:* Nawhath T., Sangam S., Indrajit P., (2018) Environment and Urbanization ASIA : Urban Flooding and Climate Change: A Case Study of Bangkok, Thailand, Volume 9 Issue 1, 94p.-95p., http://journals.sagepub.com/doi/abs/10.1177/0975425317748532?journalCode=euaa

Table 3 tabulates the weighted satisfaction levels (WAI) of the participating residents with the adequacy and effectiveness of the flood alleviation and prevention measures in the capital. The respondents were asked to rate their satisfaction on a scale of least satisfactory to very satisfactory on a total of 10 points, and then the WAI was calculated. Overall, the findings indicate the satisfaction levels of between 'somewhat satisfactory' (WAI of 0.21–0.40) and 'moderately satisfactory' (0.41–0.60). The low level of satisfaction reflects an ineffectiveness of the flood alleviation and prevention measures of the state agencies. In Table 4, Items 1, 4 and 10 are in the 'moderately satisfactory' range (0.41–0.60) while the rest (Items 2, 3, 5, 6, 7, 8, 9) receive the 'somewhat satisfactory' scores (0.21–

0.40). The low overall satisfaction scores of Items 5 and 7 (0.3621 and 0.3724) suggest a lack of communication and coordination between local residents and the city administration. This is consistent with Saito (2014), who documented that the absence of active public participation impedes the efficiency and effectiveness of the flood-related measures. public participation in the formulation of the flood prevention policies helps mitigate the vulnerability to floods, especially in the flood-sensitive areas, and also increase the effectiveness of the flood-related measures. social support and public participation are imperative to the success of the flood-related measures. Moreover, the respondents in the districts of Wattana and Bang Khen are dissatisfied with the flood drainage and prevention measures implemented by the city administration, as evidenced by the low WAI scores (WAI < 0.40) in all 10 points. The satisfaction with frequency of sewer maintenance and clean-up (Item 4) receives the lowest WAI scores of 0.3399 for Wattana and 0.3460 for Bang Khen districts. Since Bangkok generates huge volumes of garbage and waste on a daily basis, the regular maintenance and clean-up of the sewers to minimize the problem of clogged drainage is essential to the effective flood prevention.

What is the Weakness of the Master Plan and Major flood management measures?

Master plan flood management in Bangkok

The most challenging issues are how to create effective coordination of more than 40 government agencies with overlapping responsibilities, and what is the appropriate combination of single command authority and decentralization of power. There are also some important policies that are lacking, such as policies that will facilitate the adjustment of farmers in floodplain areas and water management institutions. The plan is also silent on adaptation to climate change, which includes drought management. There are, therefore, research needs in the areas of adaptation strategies, water management institutions, and compensation measures. It is also important to bring attention to the enforcement of work plans and consistency in carrying them out because practical strategies can only be effective when they are enforced in a consistent manner. Though the master plan nominally consists of both the master plan for infrastructural investment, rehabilitation and maintenance, and the non-infrastructural management plan, the government does not give much attention to the latter. No concrete policy or measures have been provided, such as

(a) There are no concrete proposals on how to compensate farmers in floodplain areas

(b) Inadequate attention to the complex long-term issues of fragmented water management and required institutional changes in integrated water management to cope with extreme weather conditions, plus the appropriate combination of a single command authority and decentralization.

Major flood management measures in Bangkok

(c) None of the measures have explicitly taken climate change into account in their analyses or the design of the interventions. Whether climate considerations are incorporated appropriately – is not yet relevant in Bangkok.

(d) None of The specific measure match along with problem criteria of Bangkok flood condition and effectiveness of the flood-related measures. Only general measures to cope with the flood which not success for long-term.

(e) The absence of active public participation impedes the efficiency.

PART 2 : Assessing non-structural measure

2.1 Assessing the relative importance of structural & non-structural causes

The conceptual inadequacy of any of these approach considered in an isolated manner as well as the accumulated past experience demonstrate that sustainable and effective solution to flood problem have necessarily to incorporate a balanced view of strategy options and the use of an adequate combination of structural and non-structural measure to be implemented before, during and after the occurrence of floods. A comprehensive integrated strategy should be linked to existing urban planning and management policy and practices. Structural and non-structural measures do not preclude each other, and most successful strategies will combine both types. To show the relative importance of structural & non-structural measures, By comprehensive assessment follow as:

Distinction of Structural measures and Non-Structural measures

Structural adaptation measures : Constructed permanent facilities to reduce the damage risk. Collective: e.g. dikes, drainage systems / Individual: e.g. wet or dry proofing

Non-structural adaptation measures : Responses to urban water problems that may not involve fixed or permanent facilities. Their positive contribution to risk reduction is most likely through a process of influencing behavior, usually through building capacity in all stakeholders through active learning and appropriate and effective engagement between stakeholders. Collective: e.g. contingency plans, legislation / Individual: e.g. risk consciousness, insurance

Criteria for evaluating Structural measures and Non-Structural measures

The following criteria with according methods have been indicated and described: Effectiveness · Efficiency · Sustainability · Reliability · Robustness · Flexibility · Acceptability. The presentation puts emphasis on effectiveness and efficiency.

Indicators of effects for Structural measures and Non-Structural measures

Indicators are the units of measuring effects obtained by SM and NSM. Thus they are the basis for evaluation. Thematic groups for comprehensive evaluation: Hydrological/hydraulic indicators · Socio-cultural indicators · Economic indicators · Ecological indicators With the exception of the first indicators group, a common currency for measuring effects of SM and NMS is needed.

Proposed definition

The definition of strategies and policies for flood control is not an easy task and still represent an important challenge at present and for the future. Consideration has to be given to many aspect such as local conditions, awareness and concerns of population involved, availability of resources, advantages and negative impacts of adopted measures and the variable nature of social and economic perceptions and awareness. Relevant improvements aiming at gains of effectivity and efficiency in the development and implementation of flood management systems are still commonly needed. Such improvement needs include:

- Technical and scientific research as, for instance, in the context of environmental relations and impacts involving floods, flooded areas and populations living in such areas;
- Advance in flood forecasting, warning and emergency preparedness systems;

- Further development and enforcement of legal and institutional frameworks favourable to the support of integrated flood management practices;
- Increase of public participation in flood management;
- Allocation of more resource to extensive structural measure such as reforestation, erosion control and other soil conservation practices;
- Development of better established flood insurance policies and insurance systems for flood damages.

Non-structural measures (NSM) are all other interventions: The systematization is recommended not to include the intended effects but functions and mechanisms. / Rationale: It is scientifically not sound to use the effects for classification and then to comparatively investigate them. / An additional reason is that risk reduction effects should be measured on the basis of the common currency “risk”, Flood management measures which used in Bangkok.

Table 4 : Risk as common currency of Structural measures and Non-Structural measures

Functional group	Types of measure	Measures (Examples)	Targeted effects	Common currency
Structural Measures				
Flood control	Flood water storage	Flood polder	Reduction and retardation of peak	Reduction of flood risk
	River training	By-pass channel	Reduction of water	
	Flood protection	Dike	Limitation of inundation (water level)	
	Drainage and pumping	Urban drainage system		
Non-Structural Measures				
Flood control	Adapted land use in	Conservation tillage	Reduction of runoff	Reduction of flood risk
	River management	Dredging of sediments	Reduction of water level	
Use and retreat	Land-use of flood-prone area	Avoiding land use of floodprone	Reduction of elements at risk and their susceptibility	
	Flood proofing	Adapted construction		
	Evacuation	Evacuation of assets		
Regulation	Water management	Flood protection standards; restriction of land use	(indirect effects via measures)	(indirect effects via measures)
	Civil protection	Civil protection and disaster protection act		
	Spatial planning	Building		
Stimulations	Financial incentives	Investment Programme (e.g.for river works)		
	Financial disincentives	Insurance premiums according to flood zones		
Information	Communication/ Dissemination	Information events		
	Warning/Instruction	Hazard and risk map		
Compensation	Loss compensation	Public relief	Reduction of economic damage and market disturbance	

To explain thereby showing that non-structural measure aspect are very important but have been overlooked for some reasons (see in Table 5), Then identify Empirical results on the influence of selected context factors on “Balancing Structural measures and Non-Structural measures” (see in Table 6)

From the Table 5, It can be seen that possibly almost of Bangkok Flood Prevention plan which had decision-makers emphasize structural measure for many reasons behind with context condition. There may be other reasons besides budget constraints where leaders are more likely to choose non-

structural over structural solutions. When a natural disaster occurs in a country, emergency action will be taken immediately.

Table 5 : Context conditions influencing the choice of Structural measures and Non-Structural measures – a set of hypotheses

Condition	Decision makers emphasize structural measures	Decision makers balance structural and non-structural measures	Decision makers emphasize non-structural measures
Internal context conditions			
(1) Internal condition: Consistency	Decision makers have low capability due to difficulties in combining decision criteria and measures from different policy realms (e.g., spatial planning, water management).	Decision makers have high capability due to intensive communication, shared frameworks, and effective conflict management tools.	Decision makers have low capability, but forceful policy entrepreneurs in favour of non-structural measures.
(2) Internal condition: Response repertoire	Decision makers are interested in restoring order and a "control belief" quickly after a flood disaster.	Decision makers believe that a fundamentally new way of reducing flood risk through considering the full range of measures is necessary.	Decision makers believe that a fundamentally new way of reducing flood risk through "breaking from the past" is necessary (= overcoming traditional flood protection).
(3) Internal condition: Risk perception	Decision makers explain flood risk mainly through referring to the flood hazard. Consequently, they pay no or only very limited attention to non-structural measures (especially for reducing damage potentials in flood-prone areas).	Decision makers perceive flood risk as a function of probability and consequences which fosters a comprehensive understanding of flood risk and the full range of measures.	Decision makers perceive flood risk mainly as a man-made disaster caused through unwise use of flood plains for urban development
(4) Internal condition: Belief in measures	Decision makers believe in keeping structural and non-structural measures distinct to consider an established "division of labour" (e.g., sticking to specialization of knowledge, considering institutional constraints).	Decision makers believe in portfolios of structural and non-structural measures to develop effective and efficient programmes for pre-flood risk management.	Decision makers believe that portfolios of structural and non-structural measures increase difficulties in evaluating the specific net benefits of each. They believe in a clear nonstructural approach to pre-flood risk management.
External context conditions			
(5) External condition: Legal and political context at national level	There are no legal requirements that demand from decision makers to consider non-structural measures.	There are legal requirements that demand from decision makers to consider nonstructural measures.	There are legal requirements that demand from decision makers to consider non-structural measures.
(6) External condition: Availability of criteria, indicators, and so forth	Valid indicators and "tried and true" methods for evaluating structural measures are available	Valid indicators and "tried and true" methods for evaluating and comparing structural as well as non-structural measures are available	Valid indicators and "tried and true" methods for evaluating non-structural measures are available
(7) External condition: Site-specific economic, social, and ecological conditions	Economic conditions (e.g., high development pressure on floodplains) and social conditions (citizens want to restore a "sense of safety") motivate decision makers to consider structural measures and to neglect non-structural measures.	Urban regime with a collective preference for a "smart growth" strategy that considers natural hazards as limiting (hazard-prone areas) and enabling factors (hazard-free areas as growth areas).	Economic conditions (e.g., high costs of additional structural measures) and social conditions (e.g., likely protest of residents) motivate decision makers to consider non-structural measures.

Decision makers emphasize structural measures (which practice in flood management of Bangkok)

Decision makers balance between structural and non-structuralmeasures

Disaster creates a critical situation for citizens. If government assistance is urgent, people will be grateful to the leader. This may increase support for the country's leaders. One option to solve the problem is by using a structural solution that protects the lives and property of the people. But resolving these issues often conflicts with stakeholders and third parties. Of course, this project is time consuming and expensive. If the construction is finished. People may show their appreciation once, even if it does not take long. Forgetting is the nature of man. In addition, foreign funding and

emergency response assistance may come as a subsidy, which will not affect the country's budget. Emergency response immediately after a disaster through a non-structural solution is a popular "investment" to provide good support without any financial costs.

Table 6 : Empirical results on the influence of selected context factors on “Balancing Structural measures and Non-Structural measures”

Context factor	Conclusions regarding a change towards ‘balancing SM and NSM’
Risk perception	It is unlikely that risk perception is a major limiting context factor.
Perception of responsibility	Change requires a broad understanding of responsibility among politicians and officials.
Beliefs about measures	Change needs unlearning that only “big solutions” with SM can solve “big problems”.
Response repertoire	Enlargement will probably develop only over a considerable time span.
Leadership and networks	Change requires multi-level networks with relationships between different policy fields.
Availability of guidelines, indicators and methods	Change requires new guidelines, indicators, and methods to reduce uncertainty on evaluating NSM relative to SM.
Funding	Change requires new funding mechanisms that are more suitable for NSM.
Formal institutions	Decentralization within the public sector could facilitate change.
Informal institutions	Informal institutions (like e.g. culture) are difficult to change.

Structural measures will only be effective when training and site preparation and construction are in place. (Rules and regulations are maintained).

1. The potential scope of flood risk reduction options by far exceeds the traditional flood protection approaches. A common systematization could facilitate communication.

2. New approaches allow for evaluating and comparing the effectiveness and efficiency of a number of NSM with SM using risk as a common currency.

3. ‘Balancing SM and NSM’ in Decision making is not just a matter of evaluation capabilities.

4. Other important context factors are (i) a broad responsibility of Decision making, / (ii) unlearning on the size of a solution, / (iii) multi-level networks, / (iv) new funding mechanisms and / (v) decentralization in the public sector.

5. Challenges arise from further measures and evaluation criteria (e.g. sustainability, robustness).

2.2 Assessing the potential for removing or at least alleviating these causes for adaptive actions with a focus on non-structural aspects

This section will summarizes the problem specific causes. Then review whether flood management measures are being prepared or practices in flood management of Bangkok. Then reviewing whether the selected flood management measures are being implemented or planned in Bangkok, And finally analyze / assess the potential to find some solutions by focus on the use efficiency of non-structural measure which comply with existing Structural measure are available in Bangkok. And more effective by dividing the analysis into the following.

2.2.1. Cause specific problems. The flooding in the inner city of Bangkok.

2.2.2. Review all non-structural measures used in flood management in Bangkok.

2.2.3. Analyze / assess potential to find solutions. The focus is on the use of non-structural measures Comply with Structural elements are available in Bangkok.

2.2.1. Cause specific problems. The flooding in the inner city of Bangkok.

In order to solve the problem or find a cause. It is important to identify and focus problems (refer to C: PROBLEM STATEMENT AND CAUSE OF FLOOD IN BANGKOK INNER ZONE") which can analysis by define main problem follow as:

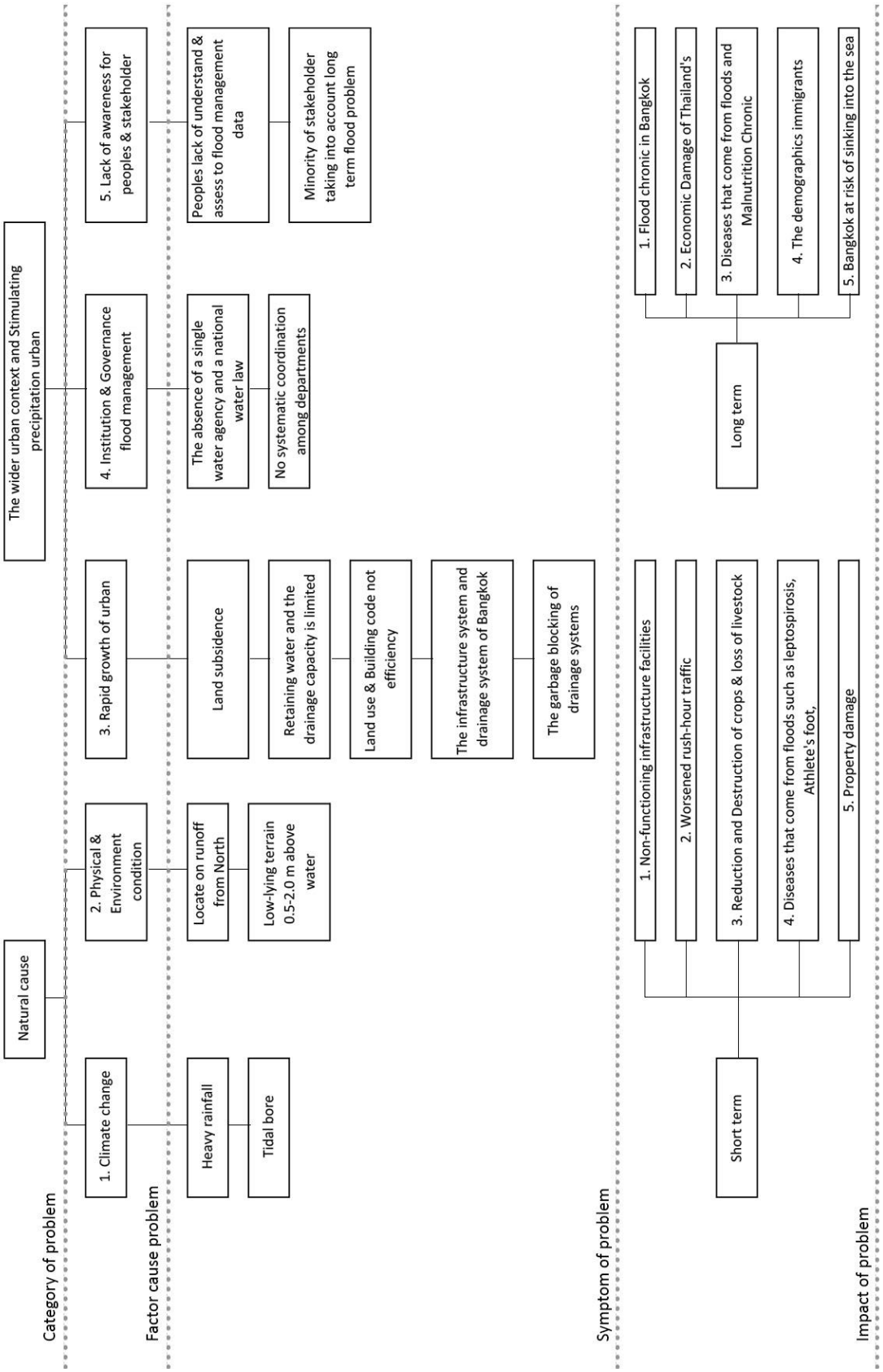


Figure.19: Cause specific problems. The flooding in the inner city of Bangkok.

2.2.2. Review all non-structural measures used in flood management in Bangkok.

Bangkok has 2 type is structure measure and non-structure follow as 1. Flood management and drainage infrastructure improvement / 2. Natural buffers (e.g., wetlands, retention ponds) / 3. Groundwater management and rainwater harvesting / 4. Reducing social vulnerability / 5. Land use planning and zoning / 6. Building codes for flood proofing / 7. Early warning systems / 8. Emergency planning and rescue / 9. Awareness campaigns

But in this part will mention on non-structure measure which practice in flood prevention plan of Bangkok is **Groundwater management and rainwater harvesting** / **Reducing social vulnerability** / **Land use planning and zoning** / **Building codes for flood proofing** / **Early warning systems** / **Emergency planning and rescue** / **Awareness campaigns**

Reference to Norio S., (2014), Urban Climate : Challenges for adapting Bangkok's flood management systems to climate change, Volume 9 , 93p.-96p., http://dx.doi.org/10.1016/j.uclim.2014.07.006 Reviewing whether the selected flood management measures are being implemented or planned in Bangkok, it is important to understand All of the Non-structural measures which practice flood management in Bangkok follow as:

Groundwater management and rainwater harvesting

Though land subsidence has not reduced to a fully satisfactory level, Bangkok is considered a success case in reducing groundwater abstraction and hence land subsidence (World Bank, 2012a). The Groundwater Act of 1977 introduced licensing for groundwater activities, and the groundwater tariff was gradually increased from 1.0 Baht per sq.m. in 1984 to 8.5 Baht (about $0.28) per sq.m. in critical zones in 2004. By combining a strict pricing mechanism with expansion of public water supply (cheaper than groundwater), total abstraction was reduced from 2700 million liters per day (MLD) in 2000 to 1500 MLD in 2005, and land subsidence was significantly reduced (World Bank, 2012a). The Metropolitan Waterworks Authority (MWA), a water utility for Bangkok and its vicinity, stopped groundwater pumping in 2002. Rainwater harvesting reduces peak outflow and lowers flood risk by storing rainwater. The harvested water can be used for purposes which are less sensitive to water quality (such as irrigation, washing or toilet flushing), but could be used for drinking with necessary treatment. It can also be used to recharge groundwater systems. However, no information was available on rainwater harvesting practices in Bangkok. While MWA is responsible for the water supply in Bangkok, their publications and publicly available information does not indicate any promotional activities with regard to rainwater harvesting.

Reducing social vulnerability

The Department of Social Development of Bangkok Metropolitan Administration maintains a detailed list of low-income communities. According to their latest statistics (June 2013), there are 2054 low-income communities in Bangkok, comprising 460,000 households with a total population of 2.1 million, including 692 slum communities with a population of 0.7 million. Population, number of households, and houses in each low-income communities are regularly updated by Department of Social Development, and the location of low-income communities is available on ward-level maps. These low-income communities are receiving community development support in the areas of physical environment, public health, and human resource development. The Public Works Department implements infrastructure improvement in these communities. Low-income communities may be vulnerable to flood impacts, because of high sensitivity due to poor infrastructure and housing, and low adaptive capacity due to limited financial resources and possible lack of land security. However, due to lack of a hazard map and vulnerability assessment, the level of

vulnerability is not known. Support to these low-income communities is currently being provided not in the context of disaster (or flood) risk reduction, but general community development. Preparation of a hazard map and vulnerability assessment should clarify the level of flood risks in low-income communities, and offer suggestions as to how vulnerability can be reduced in the low-income communities by improving livelihood.

Land use planning and zoning

Bangkok Metropolitan Administration (BMA) finalized its Comprehensive Land Use Plan in 2013 by updating the plan formulated in 2006. The City Planning Department of BMA led the work of land use planning, based on which the Ministry of Interior issued a regulation. The regulation has a clause to promote establishment of water retention/ reservoir areas with a view to strengthening flood prevention and mitigation: if a building provides space for water retention of 1 m3 or larger per 50 m2 of land, floor area ratio (FAR) can be increased by 5% from the assigned value; if such facilities can retain more than 1 m3 of water, the FAR can be increased proportionately up to 20% of the assigned value. In addition, the 2013 Comprehensive Land Use Plan introduced a new provision that requires at least 50% of the open space, in accordance with the open space ratio of each land use category, to have a pervious surface, where trees need to be planted. This is intended to increase green space and reduce flooding from heavy rains. Therefore, although implicitly, impacts on climate change have been taken into account, in terms of offsetting increasing flood risks. On the other hand, limitations are also observed in the updated Comprehensive Land Use Plan. The Comprehensive Land Use Plan in 2013 is very similar to that of 2006, and it is not clear what lessons have been learned from implementation of the 2006 plan, including the 2011 flood. Introducing a measure to promote water retention capacity through a higher FAR and requiring permeable surface in open space is certainly an improvement, and the enforcement and effectiveness of these measures needs to be monitored. These measures do not take account of different flood risks in different areas, while they are regarded as an important first step to reduce flood risks through land development control. Areas identified as retention/detention ponds remain small, except that a large area just upstream (north) of the coastal conservation zone in Bang Khun Thien District3 has been newly designated as a retention area. Effective conveyance systems such as floodways to smooth the water flow from upstream to downstream without causing overflow into city centers, are not designated. The Comprehensive Land Use Plan has been prepared within the BMA's administrative boundary, and coherence with neighboring provinces is another.

Building codes for flood proofing

The Thai Ministerial Regulations on Building Control are laid down under the Building Control Act by several Ministries. There are currently over 200 ministerial regulations related to building control. The most important ones are those outlining requirements for: structural design and construction; fire protection, sanitary, lighting and ventilation; water and waste treatment; and earthquake resistance. Local administration agencies may issue local ordinances with stricter requirements. BMA for example issued the Bangkok Ordinances on Building Control, providing additional details on issues including drainage, water, and waste treatment (UN-ESCAP and AIT, 2012). However, according to a BMA official, there have been no changes in the ordinances in recent years, and building codes are not discussed either in the context of flood management or climate change.

Early warning systems

The flood control center of BMA, has been in operation in Bangkok since 1990.The center has one master station with a weather radar which is located in Department of Drainage and Sewerage office, and 75 remote terminal units scattered around Bangkok connected on-line to the master station. The

center monitors and collects hydrological data (rainfall and water level) inside BMA. In addition, there are 52 weather stations, 71 flood detectors on major roads, and 40 stations to monitor water flow of canals in BMA. Data are disseminated through websites, Facebook, and twitter. The systems are operated in cooperation with the Thai Meteorological Department and Royal Irrigation Department. Department of Drainage and Sewerage, plans to install additional two radars in the near future.

Emergency planning and rescue

In accordance with the Public Disaster Prevention and Mitigation Act 2007 and National Public Disaster Prevention and Mitigation Plan 2010–2014, BMA formulated a Bangkok Public Disaster Prevention and Mitigation Plan 2010–2014. The Governor of BMA served as chairperson of a committee formulating the plan, which the Bangkok Fire and Rescue Department (BFRD) took the lead in drafting (BMA, 2010). Its vision is ‘‘Bangkok has preparedness in prevention and mitigation of public disasters to ensure safety of life, and assets of people and the public.’’ The plan specified operations that need to be accomplished and procedures that need to be adopted to provide a clear-cut framework and well integrated operations before, during, and after a disaster including a flood (BMA, 2012a). It has four strategies, i.e., (i) prevention and mitigation, (ii) preparedness, (iii) emergency management, and (iv) post-disaster management, and measures and activities are specified under each strategy. The plan identifies of natural and anthropogenic disasters including flooding and tropical storms, and three additional security threats that cause public hazards in Bangkok (BMA, 2012b), BMA established an ad-hoc flood solution and prevention operation center in October 2011. When parts of Bangkok became flooded, Bangkok Fire and Rescue Department dispatched rescue teams to repair fortifications (such as sandbag walls), and evacuate community members, especially children, sick and elderly people. All households including low income communities.

Awareness campaigns

Various awareness programs are being implemented for the public to be better prepared for, cope with, and recover from, floods. For example, Department of Social Development of Bangkok Metropolitan Administration, issued a brochure which includes 20 points to prepare before flooding. Bangkok Fire and Rescue Department also distributes information to the public on procedures before, during, and after a disaster through brochures, seminars, and training programs, although its focus is on fire.

2.2.3. Analyze / assess potential to find solutions. The focus is on the use of non-structural measures Comply with Structural elements are available in Bangkok.

Based on the analysis of the problems and review The use of Non-structural measures which practice flood management in Bangkok. To identify that The measures are not taken seriously. And no use the specific measure to solve the problematic areas. Non-structural measures that appear in the current plan are not consistent with the problem floods that occur in Bangkok. The researcher has Analysis base on try to match between the problems that have been analyzed and The propose specific Non-structural measure which suitable with flood problem in Bangkok follow as (see in Table.7) Non-structural measures which are The selection was presented for support a specific problem flood condition in Bangkok. The researcher selected the appropriate section and improvement priorities with the Institutional and legal framework, Implementation of insurance systems and coverages and forecasting/warning systems. which no concrete details mention in The Action plan Prevent and solve flooding problems in Bangkok due to rain and flooding in the year 2017. So, in order to understand each Non-structural measures was selected. Description of the measures and Method will show after Table 7, By groping topic of Non-structural measures follow as

Table.7 : Analysis of The use of Non-structural measures which practice flood management in Bangkok and The propose specific Non-structural measure which suitable with flood problem in Bangkok

Main Factors affecting Bangkok's flood	Non-structural measure (which practice in flood management of Bangkok)	Status of practices (flood management of Bangkok)	Support existing structural measure	Status of action (current)	Propose specific Non-structural measure to relate with problem	Status of practices	Support existing structural measure	Status of action (propose)
Natural cause								
1. Climate change	–	–	–	✓	The development of updated methods to assess climate change	specific study tackling climate change	✓	✓
2. Physical & Environment condition	–	–	–	✓	Environmental assessment and Development planning for disaster reduction	Assessment is a preventive activity that reduces potential risks to the well of the natural environment.	✓	✓
The wider urban context and Stimulating precipitation urban								
3. Rapid growth of urban								
3.1 Land subsidence each year 3.2 Retaining water and the drainage capacity is limited	Groundwater management and rainwater harvesting	Groundwater abstraction is being reduced, and land subsidence has slowed down, Rainwater harvesting is not pursued	✓	O	Source control measures,Land acquisition, Land erosion control, Landslide prevention and Land subsidence prevention	control water consumption measure, open space programe, zoning ordinances for limiting types of land use, add more green area for more permeability, etc.	✓	✓
3.3 Land use & Building code not efficiency	Land use planning and zoning, Building codes	Updated in 2013. Some consideration to flood risk reduction, Building codes exist, but no updates in recent years	✓	O	Land acquisition, Flood proofing in building, Construction sites regulation, Increasing the total area ratio (FAR), Transfer of Development Right (TDR),Land Readjustment Plan for Land Development	Avoiding land use of floodprone area, zoning ordinances for limiting types of land use, changes of material characteristics when immersed in water, raised above the average flood level, preserved green area between structures	✓	✓
3.4 The infrastructure system and drainage system of Bangkok	Reducing social vulnerability	Water access is provided and district offices, is supporting Low income community development	✓	O	Flood proofing of infrastructure, Pump facilities	All infrastructure, raised above the average flood level, changes of material characteristics when immersed in water, etc	✓	✓
3.5 The garbage blocking of drainage systems	Awareness-raising	Programs implemented by various departments, preparation for floods	✓	O	Awareness-raising campagne, Public information education and Mobilisation	The government has a strict policy and strict waste management practices, Plastice bag for sale only	✓	✓
4. Institution & Governance flood management								
4.1 The absence of a single water agency and a national water law	–	–	–	–	Special stromwater management agency and Legislation	create basin-wide management approach depend largely on the nature of the ownership of land (government or private), legislative powers to achieve management goals.	✓	✓
4.2 No systematic coordination among departments	–	–	–	–	Role of government and Role of local agencies	set the area of responsibility to make sure no overlab duty and set common law&goal enforce to use	✓	✓
5. Lack of awareness for peoples & stakeholder								
5.1 Peoples lack of understand & assess to flood management data	Awareness-raising,	Programs implemented by various departments, preparation for floods	–	–	Public participation, Public information, and education and Social effects of flooding	information campaign repeated on regular basis and transferred to community members through channels they trust.	✓	✓
5.2 Minority of stakeholder taking into account long term flood problem	Awareness-raising,	Programs implemented by various departments, preparation for floods	–	–	Traditional financing and User charge concept of financing	Insurance premiums according to flood zones, Investment Programme (e.g.for river works),Charges to individual ratepayers must be fair	✓	✓
	Early warning systems	A flood control center is in operation, and there are plans to strengthen it	–	O	Flood forecasting, Flood warning, Communications	It is an early warning process based on regular review.	✓	✓
	Emergency planning and rescue	Plan 2010-2014 are available for pre-, during, and post-disaster including floods	–	O	Mobilisation, Risk and hazard assessment and mapping , Flood relief measures, Flood fighting legislation and Evacuation	preparation and stand-by and dismissal. Organisation and training of search and rescue teams are done locally, regionally or nationally	✓	✓

(blue) Non-structural measure (which practice in flood management of Bangkok)
(green) Propose specific Non-structural measure to relate with problem
– Not appearing in the action plan.
✓ Available or emphasize
O Not Available or Not emphasize

NOTE : All The propose specific Non-structural measure, The researcher analysis By Base on reference International Hydrological Program "Guidelines on Non-structural measures in urban flood management"

Development and land use policies

Regulation of floodplain

The flow of the city does not flow along the vertical lines of the natural landscape, because there are many objects and infrastructure that are urban environments. Formation of the flood plain naturally improves the vulnerability of neighboring areas to flooding. Unfortunately, city streets, secondary traffic lanes, side streets, and parks are typically used in conjunction with front yards, basements, homes, and other low-lying spots to serve as evacuation flash flood and storm water. (see in Figure. 20)

Figure.20 Urban floodplain

Source: Ivan A. (2001), IHP-V Technical Documents in Hydrology : Guidelines on Non structural measures in urban flood management, 36p., http://unesdoc.unesco.org/images/0012/001240/124004e.pdf

Traditional flash flood and storm water drainage in city practices include the "minor" subsystem, with a generally accepted risk tolerance. On the contrary, contemporary design practice takes the time to analyze urban plains with a high degree of sophistication. The purpose of the Floodplain Regulations is to promote public health, safety, and general welfare and to minimize public and private losses due to flood conditions in specific areas by provisions designed to:

1. Prohibits or prohibits the use of hazardous, health, safety or property due to water hazard or corrosion or causes increased corrosion or elevation or speed of flood.
2. The risk of flooding, including facilities in use, is covered by flood damage at the start of construction.
3. Control change of natural floods, straits, and obstacles in natural protection related to flood supply.
4. Control of grading, dredging and other developments which may increase the erosion or damage caused by flooding
5. Prevent or control the creation of flood barriers, which would result in unnatural floods or the danger of flooding to other lands.

Land use and zoning plans

This program includes identifying types of activities, limiting population density, changing the pace of development, tax measures, government action on land acquisition by compulsory acquisition, and changes to existing land use. The implementation of protection agencies in the watershed area includes the application of mandatory legal measures, zoning, density and growth rates. Taxation measures may be a guideline for developing remote areas. Hazardous area and government land administration. Land use policies and zoning cannot reduce the impact of a hazard. Additional measures, such as buildings and other practices, specify requirements for the design, operation, and maintenance of buildings and infrastructure facilities. However, the use of building codes and other codes is a necessity, as the use of codes can be very expensive. Building codes generally deal with the following issues: the purpose of building criteria for structural strength to withstand the action of water requirements for the adequate height of the basement and the first floor. The development and use of land for flood management in various forms such as:

Immigration, utilities, permanent evacuation, open space programs, boundary orders to restrict land use, regional planning, building demarcation rules, code of practice, housing codes, hygienic practices,

and other operational guidelines. Renovation policy, such as proper design, utility, pollution control, the source of purchase. The public and the flood protection. The use of land use and development policies and other non-structural measures can provide the following flood management solutions for the various scenarios in the land development process:

(i) To protect existing developments: flood control, flood and evacuation alerts, flood proofing
(ii) For the removal or alteration of existing developments: public sector acquisition, new urban development, nonconformity, conversion, use or possession, establishment Public Convenience.
(iii) Development: public information, warning broadcasts, tax assessments, financial policies, the extension of public utilities, fire insurance premiums.
(iv) For the control of plains use Boundary ordinance, flood regulation, waste disposal regulations, groundwater quality regulation, building rule law, building density, population density, regulation of settlers in the area.

The danger of flooding prohibits the sole function of land, moving the housing to higher places, state-controlled insurance policies. of support

Land acquisition

Governments may buy by purchasing land and property to ensure that unreasonable costs in the future will not occur in the reconstruction of buildings and communities after major flood events. It is difficult to adjust the economy and should be used as a last resort after the conclusion that no suitable flood management program can improve the situation. In developing countries, the impact of acquisition is difficult to sustain due to permanent social pressure on staff to provide low-cost residential land. In many places in the world, those places become uncontrollable. Migration is often required for flooding. Permanent relocation can only be achieved when dealing with high sensitivity.

Landslides prevention

Water is the main factor in the uncertainty of the slope. Determining the origin, movement, volume, and water pressure are as important as identifying different layers of soil and rock layers. In addition, seasonal fluctuations in groundwater flow and pressure may cause periodic slide activation. Plant cover often improves stability. Hazard assessment and mapping are important components in the preparation and reduction of landslides.

Land erosion control

Prior to the approval of the development or building of a building, a land development plan and construction plan must be prepared for inspection to demonstrate compliance with plant classification, drainage, erosion and sedimentation controls. No places will be assigned except in accordance with approved plans to meet drainage requirements. During development and construction, adequate precautions should be taken to minimize surface water damage to excavation or sloping surfaces. Fills shall not intrude into natural waters, floodplains or floodplains. Create channels in a way that will negatively affect other features. Positive drainage. Corrosion and precipitation control measures should be coordinated with the sequence of construction sequence and construction progress. Control measures are recommended to be effective prior to any incremental development or construction phase. Damage to crops and streams banks must be reduced. Existing trees must not be cut or destroyed or destroyed within certain parts of the property to be used for open space. This exclusion may include road and water rights of the pits and the improvement of drainage systems. Do not cover concrete tiles, asphalt or non-absorbable materials within the area of the tree to be preserved. However, every ditch at 3% level, or steep, requires crab or grass. It is recommended to install permanent crops on the construction site as soon as the utility

system is installed. Storage facilities and drainage structures should use natural locations and natural vegetation. Ventilation must be designed to prevent overflow from receiving water.

Land subsidence control

Although, Bangkok is considered a success case in reducing groundwater abstraction and hence land subsidence (World Bank, 2012a). By the groundwater, the tariff was gradually increased and The Metropolitan Waterworks Authority (MWA), a water utility for Bangkok and its vicinity, stopped groundwater pumping in 2002. But this policy should concern for future consumption by continuing always increased the groundwater tariff and intensive control all residence construction especially inner city

Source control measures

The concept of controlling flood and pollution sources presents measures that mimic the natural ways of reducing and purifying water before arriving in problem areas. In addition, the spatial distribution control approach Source control measures do not eliminate the traditional structural techniques. Additional efforts to improve drainage maintenance methods, including the behavioral monitoring procedures, are needed. In urban conditions, low-cost structural measures are effective in wet weather conditions. The planning and promotion of these low-cost structural measures can be classified as non-structural.

Pumping facilities

Drainage from protected areas behind dams and floodwalls may be left by the flow of gravity during periods of low river flow and by pumping at the time of the flow of gravity. Limited by water, flood protection in lowland areas (Bangkok inner city). All inner-city drainage systems must be considered in a protected area. The efficient operation of the pumping plant requires the determination of the required water removal rate, storage facilities to reduce the pumping capacity of the pumping plant and the location of the plant.

Flood proofing

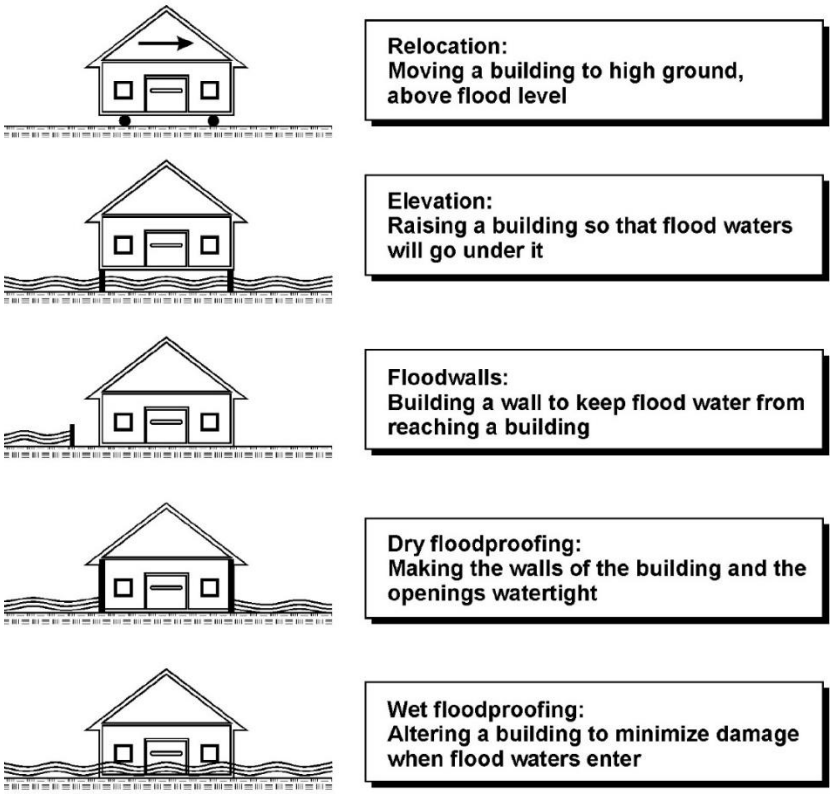
Floodproofing of infrastructure

Flood damage to infrastructure components may be caused by direct water erosion by erosion or by a combination of the two. Most of the techniques that prevent river erosion from adhering to the streams by damming. (By brick or plant), the problem of water contamination can be easily rectified by building a pipe above the flood level. The same principle applies to electrical equipment, drains and telephone lines. Elevation above the flood level allows continuity in the operation of those systems. High-rise applications help increase access to critical public housing and buildings, such as flood shelters. For proper operation, these paths must be raised above the average flood level.

Floodproofing in buildings

Vulnerability analysis of buildings is categorized by type of building. It includes assessing the resistance to water stress (water load, lifting, hydrodynamic loading) and the change of material characteristics when immersed in water. (Quality of sand, fine sand, and clay at the foundations). Public buildings used for shelter must be above flood levels expected. This can be done by building a natural or artificial highland by placing the building on a pole or pillar or by providing an entrance from the outside through the stairs to the upper floor (Figure 21). Slow moving, temporary barriers that contain sandbags may be used to protect each building.

Figure.21: Examples of flood proofing (UNESCO, 1995)



Source: Source: Ivan A. (2001), IHP-V Technical Documents in Hydrology : Guidelines on Non structural measures in urban flood management, 60p., http://unesdoc.unesco.org/images/0012/001240/124004e.pdf

Legal and institutional issues

Role of governments

A variety of flood mitigation measures should not prevent local governments from organizing activities and measures that are necessary between institutions. At least 4 important documents should be prepared and updated, for example.

(1) Urban flood mitigation plan and pollution control based on environmental sustainability principles to control future development or address existing problems.
(2) Flood Preparedness Program, which will determine what needs to be done before flooding, to develop programs for public awareness, land use policy and forecast development. Flood warning, institutional strengthening, emergency simulation and training etc.
(3) Flood Disaster Plans, which define emergency response measures to be taken during floods and during operations, including relocation and evacuation, search and rescue coordinated coordination Food management and supply, information dissemination, etc.
(4) Flood recovery programs, including measures and activities that people have to receive after floods, such as financial assistance, rehabilitation measures, health and shelter programs, employment programs, etc

All four should have the organizational form and training of responsibilities, as well as the necessary resource planning, in particular finance and human resources. In addition, documentation should be prepared. The "Manual for State Officials" will help to interpret local drainage and flood control policies. Among the documents listed, the documents should be very specific in each area, expected to receive full support in both financial, institutional and legal aspects by local governments. It must

coordinate with the country's flood relief program and not be able to plan or execute it without outside assistance. Non-governmental organizations may play an important role in disaster relief, rehabilitation, and rehabilitation, as well as public awareness and training.

Role of local agencies

Institutional management of responsibility and control of urban waters is generally fragmented. One agency is responsible for collecting and treating wastewater from the municipality for drainage and flood control and another for drainage of highways and urban areas. The fragmentation and overlapping of power have resulted in the reduction of power, conflicts, benefits, and protection of integrated watershed management. The overall coordination of flood management activities should be entrusted to one of the leading organizations responsible for law, administration and finance. The organization should have the technical and institutional expertise required to set standards, provide technical advice, and ensure that the optimum use of both structural and unstructured measures is used.

Special stormwater management agency

Watersheds often extend to more than one community. Many physical problems exist and may affect two or more local jurisdictions. In this situation, planning, design, financing, coordinating and all necessary oversight may be directed by agencies established by the state government on behalf of local government. This agency may be held for the sole purpose of managing rainwater or may have multiple functions, such as wastewater disposal and flood control. Generally, a stormwater control agency may carry out one or more of the following activities: monitoring, acquisition, and processing, planning, policy coordination, policy setting, financing, construction, operation, maintenance, updates. Database The current major way to have stormwater control through independent agencies is to single agency. When the decision to create an organization in the area has been made a single objective, rather than a multi-purpose agency is popular. The responsibility of the drainage unit must be defined in terms of a specific geographic area, which is called the catchment basin, does not correspond to the existing municipal boundaries. The program of the agency must be approved by the local government. However, countries and cities that use non-structural measures as the primary means of flood management may experience problems in the policy setting and in the implementation phase. Proven success in practice at multiple multi-disciplinary committees, reviewing and improving guidelines will be helpful in resolving the problems of efficiency and the combination of proposed measures. The drainage framework can be summarized as follows.

- Acts as a centralized management organization. Coordinate drainage activities of local authorities related to the management of soil, water, and vegetation resources to achieve the best possible results in the area.

- Final policy determination after consultations with local jurisdictions.

- Responsible for maintaining major outfalls for storm drainage systems under its jurisdiction.

Legislation

Legislation required to comply with the law for the implementation of the guidelines and stormwater projects should include:

- Provisions for temporary storage of runoff excess

- Requirements for sewerage drainage from sanitary sewers - Requirements for zoning and control of highland areas.

- Requirements for flood protection of buildings.

- Requirements for developing a compatible and coordinated stormwater drainage system.

- Requirements for conducting source control.

The scope of the watershed management approach depends on the nature of land ownership. (Public or private) and the authority that the drainage divisions may impose on development. Experience shows that voluntary regulation of lowland development does not produce good results either in urban or rural areas. It is imperative to have the legal authority to achieve management goals.

Direct public involvement

Public participation

Coordination between community agencies representing citizens and municipal officials is important. Specific work is vested in the community, while others are in the municipality's jurisdiction. The community's ability determines how outsiders should behave. When coordinated, everyone involved must develop knowledge and skills that can reduce damage. Practice in learning while doing is acceptable in community involvement. However, there should be formal training. The following participants may be expected to participate:

(ii) Youth groups, environmental groups, religious organizations, creators and local artisans, housing cooperatives, volunteers

(ii) In local government or district planners, architects and engineers, building inspectors, contractors, health officials, medical personnel, public officials, social workers,

(iii) Politicians and lawyers, government officials, mapping agencies, development agencies, faculty, universities, research institutions, professional organizations, trade unions, non-governmental organizations, mass media, banks, insurance companies, water meteorological services

(iv) At international banks, international organizations, relief agencies, investors, multinational corporations, charitable organizations;

Community involvement should be ensured in many areas, such as its targeting and priorities, clarifying public debate issues about the proposed approach, monitoring the process of master planning on the basis of bi-directional communication. Physical surveys of areas and structures, surveys (including data collection), socio-economic surveys followed by state mapping Economic, social and community skills in the management and administration of community leaders to assist in areas such as labor, materials, and transport, identifying local. These include items such as sand, bags, labor, pumps, boats, generators, etc. It is intended to create a partnership between the government and the people to prepare for disasters. It is a shared responsibility.

Public information and education

One of the most useful activities is the active involvement of the general public, officials and planners in the information campaign to meet the needs of the community. Various media can be used, such as local radio and television stations, Internet newspapers, leaflets and posters, schools and exhibitions. Local community centers or main intersections may be the most effective communication medium. These messages are easier to believe when repeatedly spoken and relayed to community members through channels they trust. Recognized that by disseminating information, risks, confidence, and stability among the people have been established. It should focus on the following: What are the dangers to the community? What are the vulnerabilities of the settlement? How can vulnerabilities be mitigated? How can residents respond to flood warnings? How can residents protect themselves in the event of a disaster? How to access help Where to stay in places with less risk. Public

communication means the use of contemporary electronic media such as electronic bulletin boards, mailboxes, and websites with frequently asked questions. Users of open electronic communications methods must agree to follow the rules of electronic communication methods.

Financing flood management

Traditional financing

Accelerating flood management today requires increasing public funding in times of increased pressure for public funding in other areas of the community. There is competition between public services that serve the public. Continuing such as transportation, healthcare, education, etc., there must be additional mechanisms for raising funds to prevent flooding.

User charge concept of financing

Urban utilities do not have the incentive to make a profit. But it is the long-term stability and quality of operations. Inland conversion from rural to urban, the increase in land value is largely due to public sector investments. Any gains in land are made by the buyer and the taxpayer. Increased community capital resulting from changes in land use can be used as a cost of land acquisition, which is higher in line with the flood protection program. The proceeds from the imposition should lead to the cost of additional funding. Charges will only be levied on properties affected by floods and collection will end when the project is completed. User costs remain after finalization of the capital to cover operating and maintenance costs. The purpose of drainage is beneficial in stormwater drainage. The cost of utilities must be divided so that each owner contributes to the drainage problem to the same extent that he produces. Such a problem. The monthly drainage fee for each accommodation should be related to the amount of water that flows out of the accommodation. This is different from the most commonly used stormwater drainage concept, through drainage and wastewater treatment services. Utilities of traditional municipalities will analyze service costs by considering the unit cost of delivering goods (e.g. water) or providing services such as waste treatment and disposal. The key to cost-effective cost analysis is not just determining the amount of cost of the program. The origin of the service needs to be identified, which results in costs. The most appropriate way to begin the cost of drainage is to set the basics of the water flow concept. The "flow of water" of each area, although it is not possible to measure precipitation precisely. This concept can replace conventional fundraising of traditional tax collectors, known as local fundraising. Landowners who voluntarily agree to take control measures at the level of their property should receive a financial incentive. There are several reasons for developing urban fundraising ideas. All the way to deal with development level estimation using.

1. Land use classification and zoning
2. Coefficient of runoff corresponding to the rational formula, as measures of the rate of development, or by determining the contribution to runoff from each property on the basis of gross area of each property and the area of impervious coverage or the percentage of impervious cover.

The numeric value for the development level is assigned to each property, along with a numeric value for the total area. The data are then processed through an algorithm that generates a number of billing units for every property. The amount charged per billing unit is determined by dividing the total number of billing units into the total revenue requirement. The user charging concept covers more than flood control. It is a financial method for managing stormwater drainage as well.

Flood forecasting and warning

Communications

It is clear that recipients and non-senders should define their format. To mobilize more resources in other areas of flood management, it is necessary to ensure that messages are understood and accepted. The seven principles apply when communicating public information about floods: The message must be confirmed, not a conflict/simplicity in translation/redundancy, and the consistency of the warning builds trust/content. Another closely related to The value of the recipient's / audience's / audience's behavior, knowledge, and knowledge of the audience should be taken into account.

Mobilisation

Mobilization is an intensive effort to organize people together and to stimulate their participation. The key factor for fundraising is motivation, which makes training and appeal for worthwhile participation. The recent flooding experience provides the most possible education and incentive to reduce flooding. The new community is becoming weaker due to its declining knowledge. Fundraising can be political, religious, cultural, professional, ideological, and ethical. The purpose of fundraising is to provide food distribution, riverbank protection, community law and regulation, publicity, flood warning, food distribution, property protection, immigration, the provision of drinking water.

Evacuation

The key to successful evacuation projects is the effective flood warning system. Immigration is a short-term measure. But after the flood, there must be a measure of relief and rehabilitation. When it is time to allow evacuation alerts, it is often the most successful response to a threat. Evacuation must be carefully planned. Before the evacuation begins, care must be taken to ensure that time is complete and that all community members can leave. Personal evacuation plans must be prepared for institutions such as schools, hospitals, and childcare centers. The responsibilities and activities of civil society organizations must be clearly defined by law. Choosing an evacuation route is important. Routes should be linked to the transit corridor in an alternative way and free from potentially damaging objects. The evacuation plan should have a clear map of evacuation routes. It must be clear whether evacuation is necessary and what can be excluded.

Disaster management

Risk assessment

Risk assessment is the process of diagnosing the balance of risks to an existing resource. The process begins with vulnerability analysis and hazard mapping. Hazard Mapping shows areas at risk of flooding. Data is required in terms of space and time and includes location, frequency, duration, and severity. When this information is available, can develop a shape that reflects the severity of the risk. A vulnerability assessment determines the vulnerability of an element at risk to a person or property exposed to a hazard that has been mapped. This analysis applies only to sites. Resource analysis is often referred to as capacity assessment, dealing with community coping mechanisms to help people survive, local leaders and institutions, community facilities, cash, credit, location, and the number of goods that may be available. Needed in case of emergency Acceptable risk design is a political process. Political leaders prioritize and make decisions that are always difficult to deal with, what is acceptable, whether they are affordable or political. An acceptable level of risk should be based on both quantitative analyses, such as flood damage assessment and qualitative analysis. For a detailed explanation of vulnerabilities and risk issues.

Development planning for disaster reduction

Development of trade and production of population figures and distribution of life expectancy as identified by literacy, water supply and energy, sanitation, distribution of medical services, and Access to education Development also refers to good government, efficiency, accountability, human rights,

equal distribution of resources between sectors and between social groups, and sustainable sustainability of the environment. There are a number of program development and reporting programs that are not interested in evaluating the above development features regarding the potential for disasters and the recurrence of disasters. The reason for this is the separation of existing institutions, mostly in every current government. Generally, special offices, agencies, or agencies separate from development management are recommended, focusing on disaster impacts and only on short-term rehabilitation. Traditional methods do not take into account the political, social, cultural, economic, and physical factors that are the main causes of the risk of natural disasters. Contemporary approaches assume that disaster management must be shared by all sectors and activities related to development and change at all levels of policy. In this approach, vulnerability is reduced by integrating survival, rehabilitation and rehabilitation measures into development planning. Disaster / perceived causes, incidents and impacts of environmental hazards/perceptions of overall development policies, which means the development of a development manual to reduce/assess all developments. Suggestions for development approaches The development plan determines where people and structures are located, what materials and methods are used in the construction, changes in terrain, what changes are made to the emergency system, and what resources are maintained. Maintaining what communication and transport systems are. The planning process may be cyclical to emphasize the need for continuous improvement.

Flood fighting legislation

Flood fighting means carrying out emergency measures during storms and floods. Effective flood fighting is based on well-planned and coordinated activities that must be governed by local and state laws. Legislation to prepare for disasters should determine the status of flood combat forces, which are responsible for planning and operating flood protection in flood settlement settings. State and local regulations should cover the following areas: Scope of Responsibility, Functional / Reconnaissance, and Waterproofing / Communications / Transportation / Procedures in Water Supply / Funding Procedures. Co-ordinate procedures/equipment and inventory with equipment and materials required for operation/identification of community flood management capabilities. Alarm systems, partially prevented dams, etc.) / Public education/start-up procedures

Flood relief measures

Flood relief measures typically, governments will provide and provide financial assistance to assist local authorities. The aim of flood relief is to overcome immediate difficulties. Including home repairs and necessary infrastructure. These measures will help reduce the impact of floods in the future. Private organizations can also provide assistance.

PART 3 : **Propose which non-structural measures improvements should be achieved to enforce an efficient flood prevention policy in BMA.**

By choosing to analysis some (related floodplain management) Elements of Comprehensive Plan Specific Plan Charged by provincial office of the Department of Public Works and Town & Country Plan (DTCP) is Land use plan / Open space plan / Infrastructure plan and set Scenario Analysis using urban planning guidelines under the following three scenarios:

3.1 The first scenario: Develop Zoning and Building code in risk area zones

3.2 The second scenario: Defined catchment and drainage and add more permeability surface

3.3 The third scenario: Propose to develop some of nonstructural measures

To solve the flood problem with the highest efficiency. In addition to the proposed some of Non-structural measures which important, consistent and comprehensive with the main factors of the flood problem. To fix the problem more directly. Researchers analyzed by examine The current practices master plan such as Mapping of water and land levels in Bangkok, land use zoning plan, open space plan and infrastructure plan (water treatment plants and drainage network) by analyze with the flood situation on the inner city, then propose some conceptual solutions to the problem by put on the current map plan base on the use of Non-structural measure with structural measure, For guide Decision maker Take this concept to consider and develop more in future. The objective is to make inner city zone can cope with the flash flood or inadequate with themselves more than rely to on prevention construction and less dependence or reducing the use of suburb zone or urban fringe areas obtain flood instead of the inner city.

3.1 The first scenario: Develop Zoning and Building code in risk area zones.

Overview of the inner city of Bangkok. The incoherence between, Map of water barriers and land level in Bangkok(Figure.22), Land use zoning plan(Figure.23), Open space plan)(Figure.24), and Infrastructure plan (water treatment plants and drainage networks)(Figure.25), are important in flood cause in the case of heavy rainfall, From Map of water barriers and land level in Bangkok shown that the area along the Chao Phraya River below 0 m and the next area to 0.5 m respectively, the lowest point is The Thai art and cultural conservation zone (see Land use zoning plan). There is a high risk of flooding in the case of high tide. In the area of Phranakhon had some open space for recreation and conservation and there is no open space for natural flood conservation, to receiving and retaining water to keep flood slow drainage to chao phaya river. It is very difficult to find the place in the old town which is the conservation zone. The next area had the height of 0.5 - 1.0 m which is a business district very dense residential area and land price is very high value, Currently, BMA just had the only prepares approach by dredge the pipelines regularly to make sure no obstruction and easy drainage when heavy rainfall. But the solution in this way. It's just getting ready to deal with the flood with existing limited potential. It's not an integrated solution to dealing with the flood in the long run. BMA need to announce official of flood risk assessment plan in Bangkok area for public and all stakeholders. Can be centralized from the same information source. For example, The one page project management (OPPM) principal concept by simplifying all information to a visual report that can help the stakeholder to consider relevant tasks in the water management and flood situations. the whole picture of the system, the consequent impacts as well as the planned activities for coping with the flood over the area. To propose appropriate modifications to develop Zoning and Building code in risk area or defined catchment area and drainage etc. This is an important finding since local and regional stakeholders have more control over the distribution of land use Conclusion The social vulnerability maps can be a useful tool for decision-makers to decide on which areas to focus when designing technical measures from the social perspective (reducing flood risks). In addition, when it is not

resource-efficient to protect these vulnerable areas from flooding, the maps can be used for appropriate information dissemination and emergency management (reducing social vulnerability).

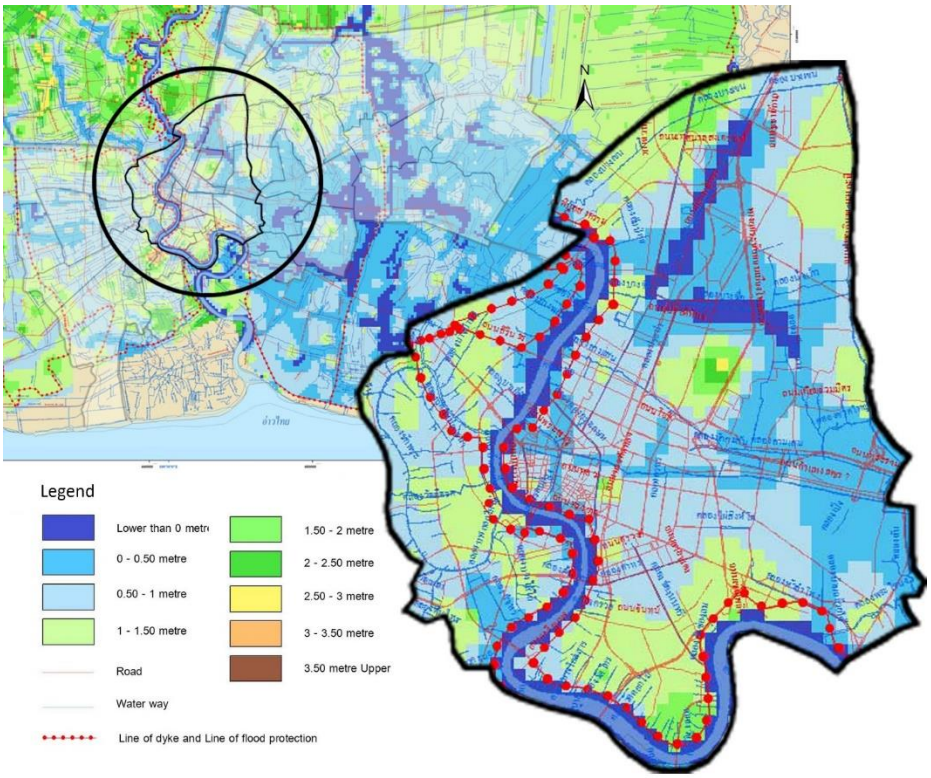


Figure.22: Map of water barriers and land level in Bangkok
Source: Author

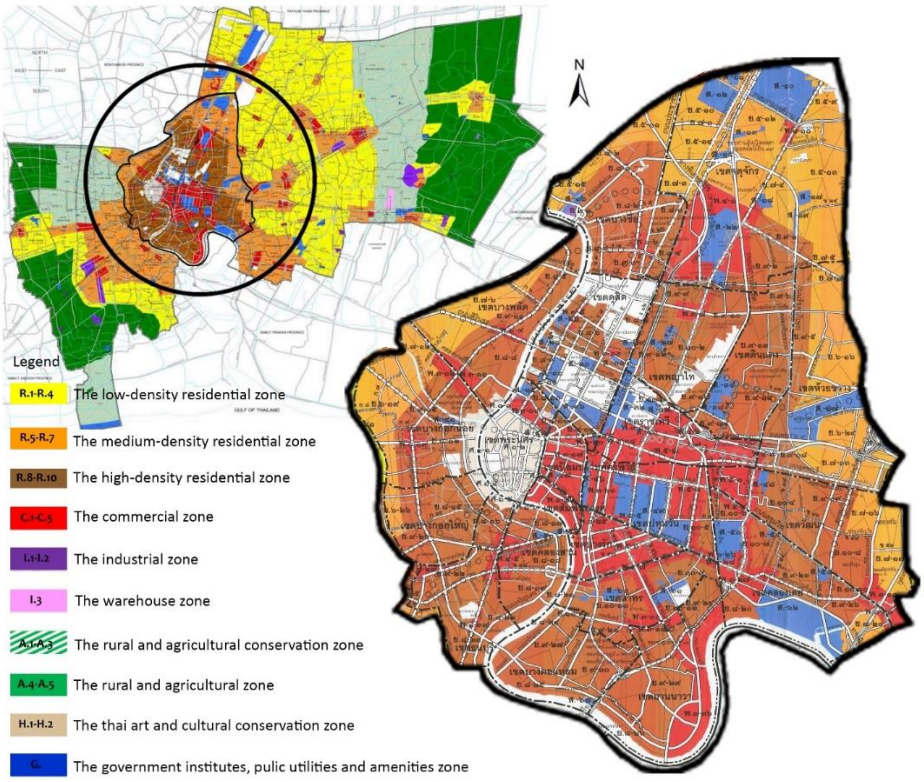


Figure.23: Land use zoning plan
Source: Author

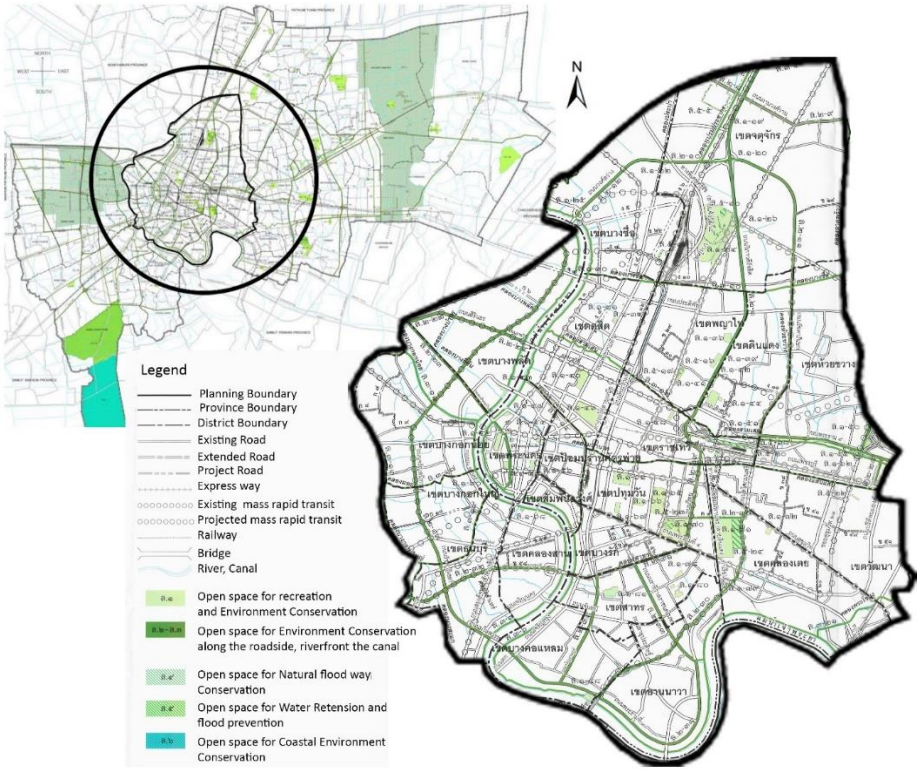


Figure.24: Open space plan
Source: Author

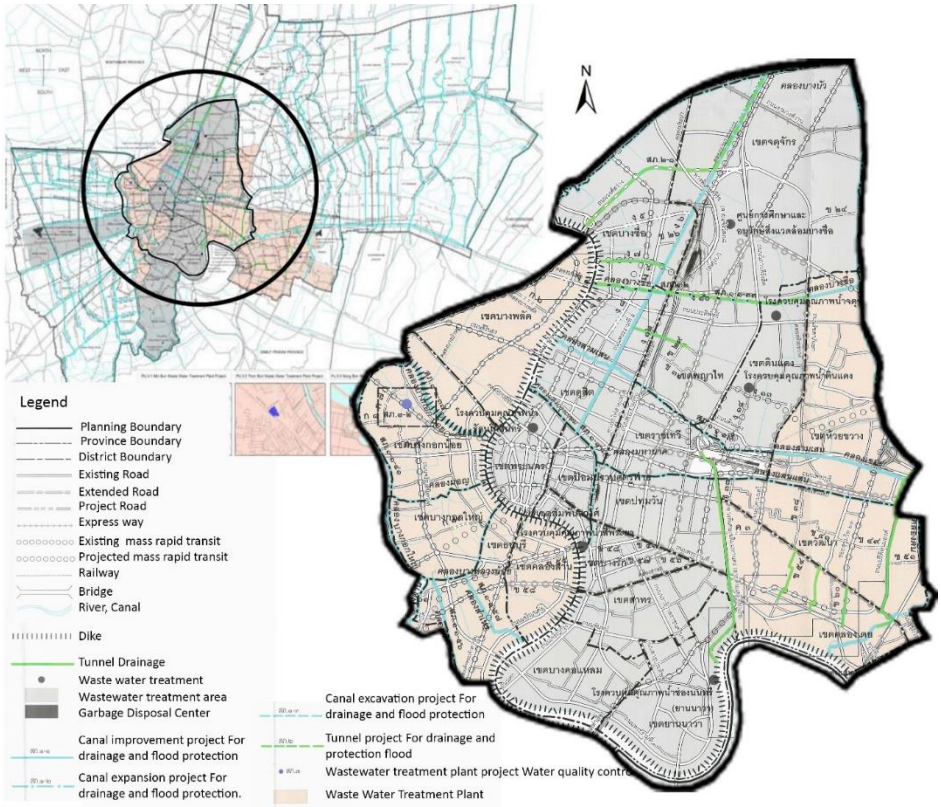


Figure.25: Infrastructure plan (water treatment plants and drainage networks)
Source: Author

3.2 The second scenario: <u>Defined catchment and drainage and add more permeability surface</u> in Bangkok inner city.

Bangkok Inner city zone there is no open space for natural flood conservation, to receiving and retaining water to keep flood slow drainage. It is very difficult to find the place. which is a business district very dense residential area and land price is very high value, To find big place enough to Defined catchment area is not easy, The Government had to Breakeven analysis for investment in Land expropriation or use Land acquisition to create green area or catchment area in city center, whether it is breakeven or not, by comparison with an assessment of potential damage from future floods and benefit quality of life. So, for defined catchment and drainage and add more permeability surface in Bangkok inner city to reduce damage flood inner city by proposing to add more condition follow as Bulk Control such as Floor Area Ratio (FAR) / Open Space Ratio (OSR) and Land Use Control / Activities Control

<u>Bulk Control</u> :

- Increasing the total area ratio (FAR)

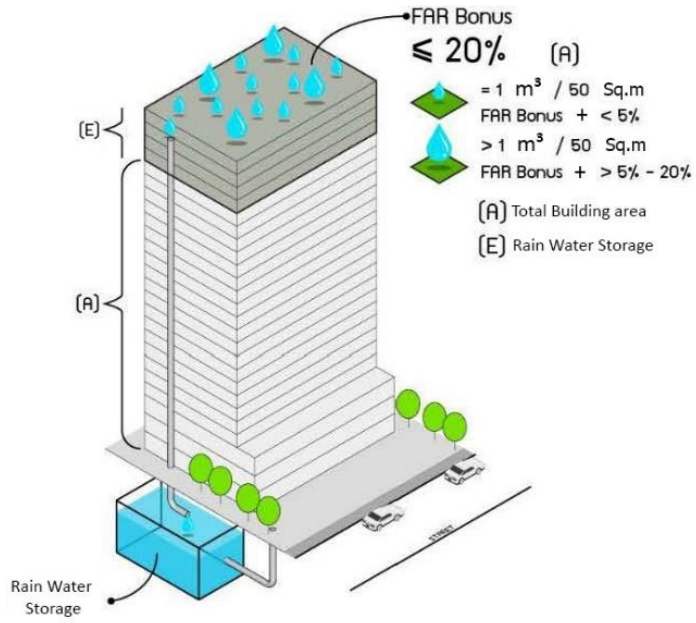


Figure.26: Provide energy-saving buildings and provide water supply

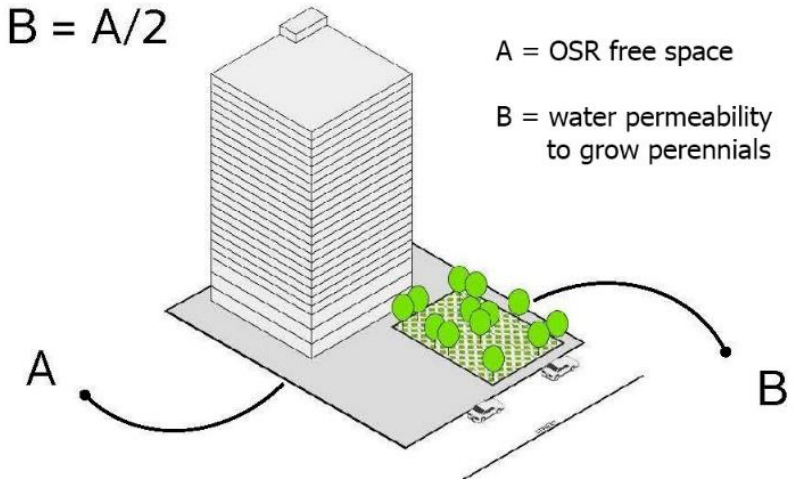


Figure.27: Land Use Requirements of Integrated Town Planning, A minimum of 50 % of vacant space is required to be planted per acre. (Open space ratio = OSR)

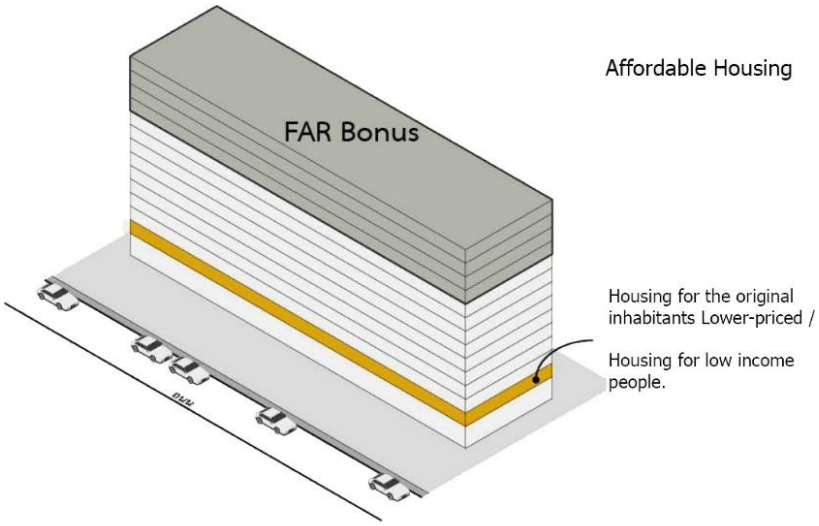


Figure.28: Provide or develop housing for low income or existing residents within the project area.

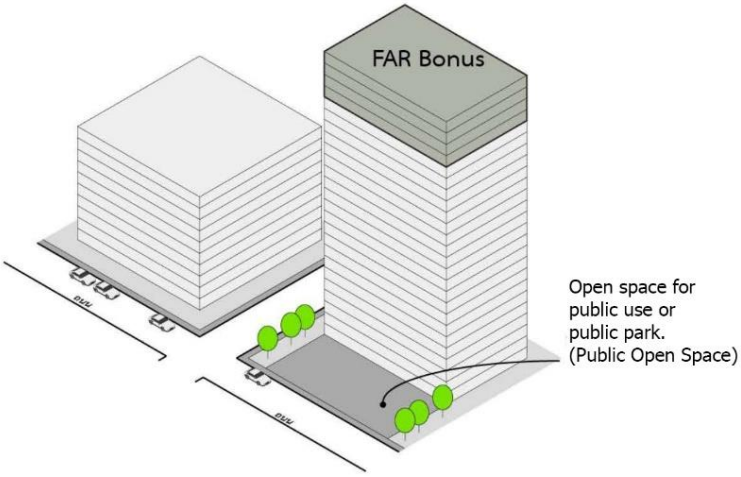


Figure.29: Provide space for public benefit or park

- Transfer of Development Right (TDR): The transfer of the ratio of the total area to the land to the development area. From the plot of land in the area of conservation and rural areas. The transfer (development) of development rights from rural and agricultural conservation areas to development promotion areas.

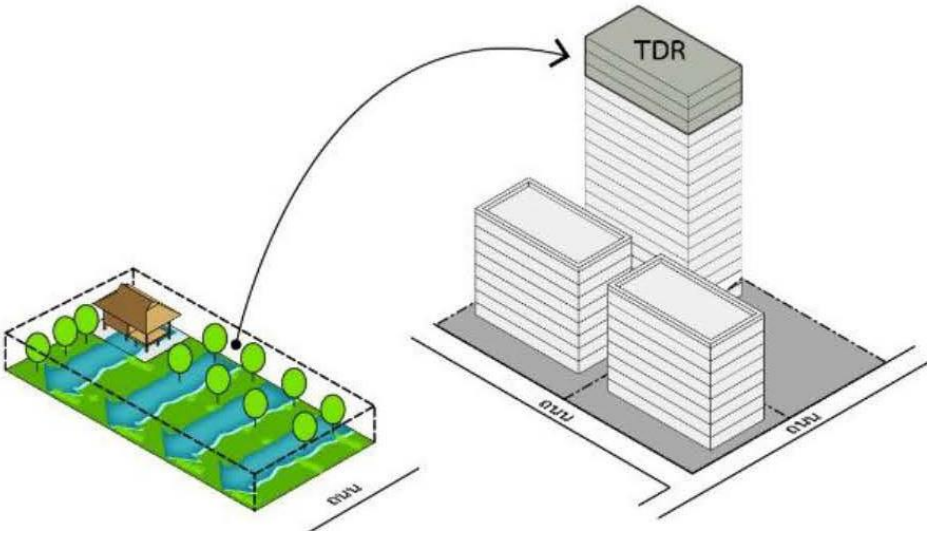


Figure.30: Provide space for the collection of rainwater in the building or plot of land of the project area.

Land Use Control / Activities Control :

- Land Readjustment Plan for Land Development

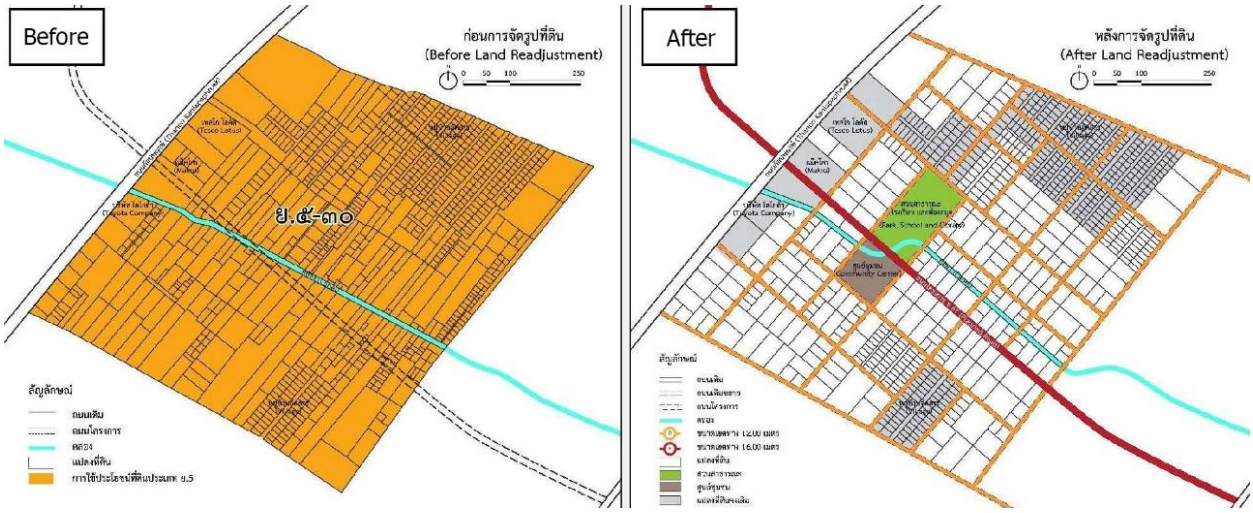


Figure.31: Example of Land Readjustment Plan To develop the residential area of Kalapaphruek Road.
Source: BMA's Plan for Improvement - (Revise.4th, study status) http://plan4bangkok.com/index.html

- Placement and Development of Housing Redevelopment Project by National Housing Authority

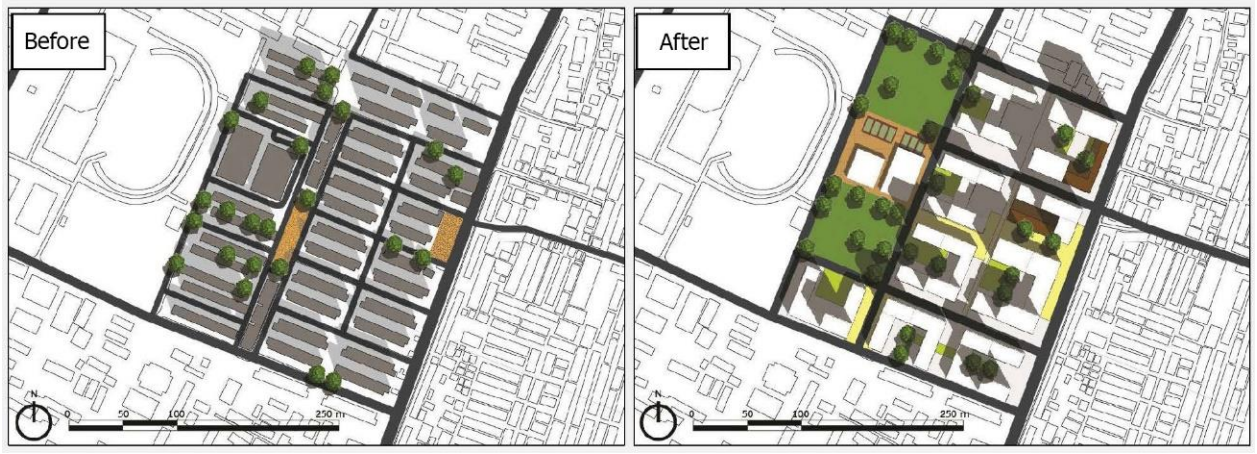


Figure.32: Example of Din Daeng Community Housing Project
Source: BMA's Plan for Improvement - (Revise.4th, study status) http://plan4bangkok.com/index.html

- Improvement of the area under the Expressway

Figure.33: Example of an improvement project under the Expressway by the District Office.
Source: BMA's Plan for Improvement - (Revise.4th, study status) http://plan4bangkok.com/index.html

- Placement and implementation of Community Development Project (Community Development) by Community Development Institute BMA Social Development Agency (BMA)

Figure.34: Example of community improvement in Rajthevee district
Source: BMA's Plan for Improvement - (Revise.4th, study status) http://plan4bangkok.com/index.html

3.3 The third scenario: Propose develop some of nonstructural measures. Which not appearing in action plan

From Study and Analysis of The use of Non-structural measures flood management in Bangkok, are inefficient and do not support the existing structural measure in Bangkok, Found as result The non-structural measures has three major vulnerabilities, which should be improvement priority in the following as

(1) Regulatory measures such as standards laws, flood protection, public awareness and education, flood warning systems and flood insurance. Most of these categorization measures are possible. Even though the flood insurance system is in its early stages in Bangkok but no any standards of risk assessment and no any various incentives are established.

(2) Inconsistent with urban planning measures such as land-use the ineffectual execution of flood-related policies. There are some problems with lack of legal support, lack of techniques, and limited case studies.

(3) Lack of serious enforcement infrastructure and architectural planning measures such as elevating the building basement or site, dry and wet flood-proofing techniques, facility maintenance and repair, structural retrofitting or reinforcement, building greening and pavements with water permeability not enough for cope with the future flood.

Non-structural measures are tools that reduce the risk and reduces the intensity of floods. This research has proposed Non-structural measures to solve flood problems in the inner city of Bangkok.

Each section There are different techniques in detail. This research had shown some examples of technical modifications include in term of control parts such as Bulk Control and Land use control. However, the most important non-structural measures which are The key to leads to the solution of technical problems is public awareness.

The order in which the mitigation measures are applied is of primary importance. The best order is to develop the public awareness that leads to political will, followed by drafting and passing laws and regulations, and secondly, proposing risk reduction measures and offering education and training.

Develop public awareness and public participation

Since the flood protection system, which guarantees complete safety, is an illusion, it must be replaced paradigmatically. It is necessary to be aware of the possibility of flooding and to accommodate them. Governments, the private sector, and civil society should be aware of the potential for flooding. The process of adaptation, rather than fighting the river, is often accompanied by floods. They enter the city to learn from them. In order to become flexible with the extreme. "Safe to Flood" and "Safety for Flood Victims" by all stakeholders, through active learning and appropriate and effective participation among stakeholders. The risk of floods requires cooperation between stakeholders. Involve local communities in flood risk management. Community involvement in flood risk management will help ensure that the true needs, priorities, resources, and potential of the people are met. Be considered Experience shows that the risk of flooding is likely to decline. When the community is fully involved. Participation increases the sense of participation, increases consistency and reduces conflict.

A step-by-step approach to effective community engagement in flood protection is as follows. Communities should be involved in flood risk management processes, including assessment, planning, use, monitoring, and evaluation. Community involvement means that flood risk management is more effective and proactive. The situation is different from one area to another, as defined by the social, economic, political and cultural contexts. It is important to make sure these factors are taken into account when working with the community.

1. Raise awareness about flood risk and motivate the community.

2. Strengthen relevant community institutions.

3. Check the integration.

4. Realistic Planning Encourage participation in sustainability,

Propose mitigation measures

Eventually, market conditions should be set for the flood insurance industry to diversify the cost of potential flood damage and for many people. It may be a non-structural measure for advanced disaster protection policies, if the objectives, risks, and incentives are set. Insurance is a tool that can help manage the risk of flooding by reducing or reducing the financial risk of flooding. This tool can be targeted at individuals, such as homeowners and farmers, or organizations such as corporations, organizations, and governments.

6 ways of insurance may lead to a reduction in physical risk Flood:

1. Provide assistance in identifying areas at risk.
2. Disaster Modeling
3. Economic incentives to prevent construction in the watershed.

4. Collection of information on the cost of flood damage to enter into cost estimates for flood management plans.
5. Promote quick recovery techniques after floods.
6. Promotion of temporary preventive solutions.

Applies to the context of developing countries in disaster insurance in developing countries, identifies the level or level of direct linkages between risk transfers and mitigation:

1. Initiatives to raise awareness on risks, such as providing information related to risk and knowledge transfer, to educate policymakers and the public on preventive measures.
2. Empowerment by transfer of knowledge and educational elements.
3. A clear incentive structure for risk mitigation, such as risk-based pricing, where premiums reflect risk, such as local flood risk premiums.
4. Reducing the risk required, for example, requiring policyholders to apply protection measures as protection conditions.

The flood insurance schemes which Compendium of Disaster Risk Transfer Initiatives in Bangkok inner city such as Property Catastrophe Risk Insurance Pool, Sovereign Disaster Risk Financing & Agricultural insurance (index-based), and Business Interruption Insurance. Flood insurance as a ‘surrogate regulatory tool’ also an alternative solution which can enforce using in flood condition on land value like Bangkok inner city

Bangkok Metropolitan Administration's Plan for Improvement - (Revise.4th study status)

Department of City Planning Evaluating the results of applying the Ministerial Regulations to the Bangkok Metropolitan Administration in 2013, there have been many changes, especially in terms of accommodating population density in many areas that exceeded the standards set by the Town and Country Planning. And public development projects, especially the mass transit project has built several lines. And many of the projects have expanded beyond the original plan. Large-scale private sector projects have taken place in many areas. These factors have affected urban transformation. In addition to the planning and implementation of urban planning, there are steps that must be taken to achieve the integrated urban planning that is in accordance with legal procedures and is accepted by all sectors of society. The City Planning Office had should agree to consider placing and preparing the city plan. (4th update), to provide integrated urban planning that is consistent with changing urban conditions and environment and can serve as a framework for effective urban development. It also helps to enhance Bangkok's competitiveness with other parts of the world Guidelines and planning for the city plan.

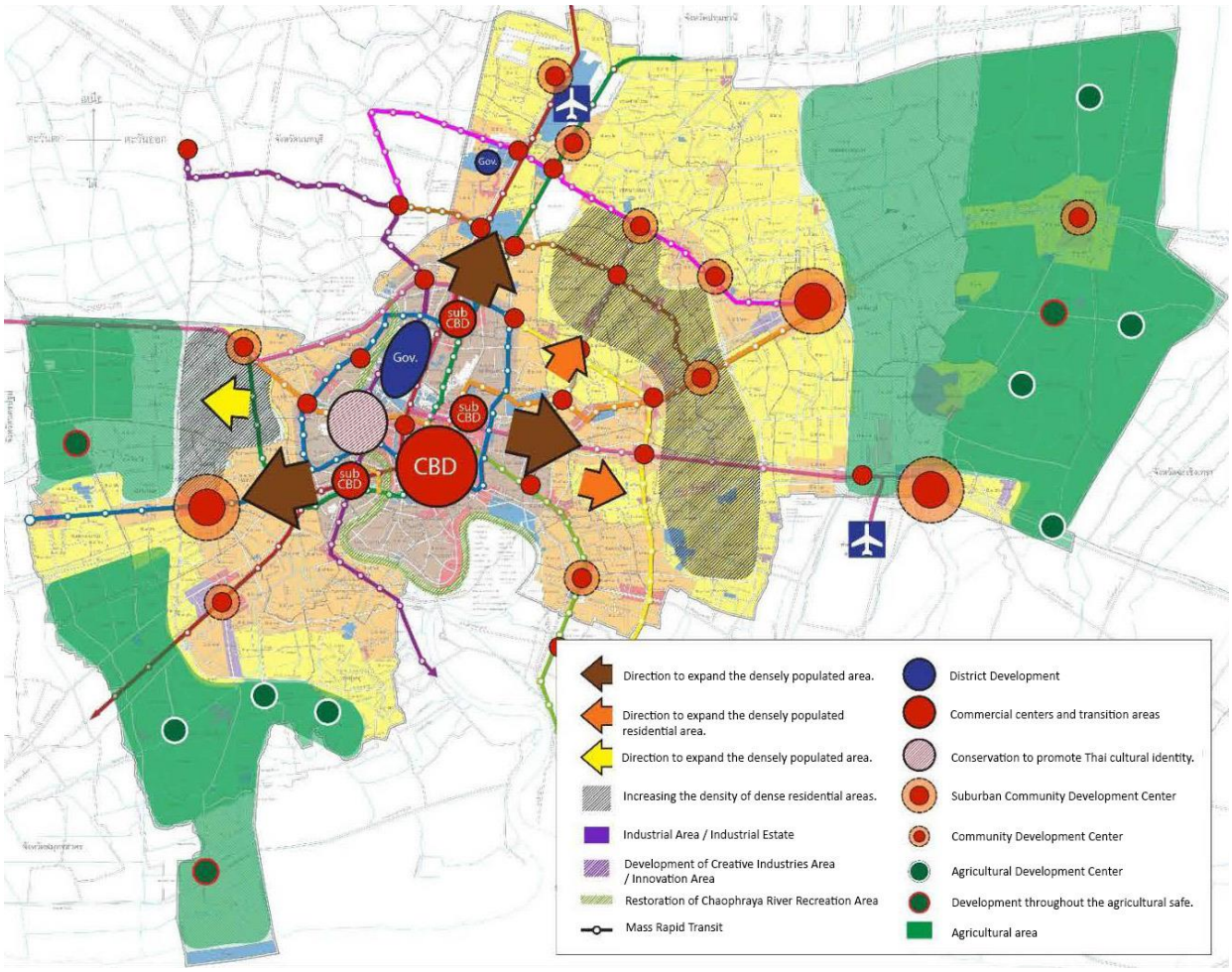


Figure.35: Land Use Structure Plan of Bangkok 2037, Used in consideration to prepare a draft city plan (Revise.4th study status) http://plan4bangkok.com/index.html

Source: Department of City Planning, (CPD) under Bangkok Metropolitan Administration (BMA)

VI. SUMMARY AND CONCLUSION

The implementation plan of Department of Drainage and Sewerage clearly indicates its emphasis on structural measures. Bangkok Metropolitan Administration in 2013 discusses that structural measures will be mainly used in densely-populated areas, while non-structural measures will be mostly used in under-populated and agricultural areas. In densely-populated areas, measures are discussed for preventing water from outside flowing into the polder system, draining water out of the polder, and drainage inside the polder.

Which made city had conflict chronic for a long time. It is important to acknowledge that totally protecting urban areas from floods is impossible even with massive structural measures, and that implementation of non-structural measures will have a great potential to reduce damage and losses with the same level of floods. From Study and Analysis of The use of Non-structural measures flood management in Bangkok, are inefficient and do not support the existing structural measure in Bangkok, Found as result The non-structural measures has major vulnerabilities as regard mention.

Currently, Bangkok started to change and increasing recognition that transformational adaptation, rather than incremental adaptation, While incremental adaptation refers to extensions of actions and enforce some policy / behaviors that already reduce losses, As can be seen from Department of City Planning Evaluating the results of applying the Ministerial Regulations to the Bangkok Metropolitan Administration in 2013, due to there have been many changes, The City Planning Office had should agree to consider placing and preparing the city plan. (4th update). But still in process study project for consideration. It is not widely known in the general public, Just only aware and well known of some of accomplice and experts.

To cope with future flood The modern flood mitigation is increasingly non-structural. Well-established, an alternative solution. Traditional non-structural measures such as demarcation, building codes, flood monitoring, early detection and warning, emergency planning, flood protection, etc., appear to be an indispensable addition to the engineering structure. Advancement of computer sciences and communications provides an opportunity for further broadening of the context of non-structural flood mitigation. Such as flood management virtual database and flood management decision support system. This work is a way to make the flood management process more transparent and effective in reducing the damage caused by economic, environmental and social floods in the future.

Although, Thailand still far from sustainable and contemporary flood management system development. But Bangkok is a potential city. To be a prototype model, It can start by adjusting paradigm shift in addressing complex flood problems such as the inner city in Bangkok. By Based on the idea that an integrated strategy requires the use of both structural and Non-structural measures and good metrics for "getting the balance right" and the need to understand that every flood risk scenario is different: there is no flood management blueprint. It will be a good starting point. To change whole water management system of The country.

Disclosure statement

The views expressed are solely those of the author, and do not represent those of BMA, The author alone should be responsible for any errors and misunderstanding in the paper.

Acknowledge

The author acknowledge the collaboration of Assistant Professor Dr. Nuanchan Singkran, Faculty of Environment and Resource Studies, Mahidol University, who provided valuable information related to

flood management of Bangkok city, and Thank you to Thai government agencies (Bangkok Metropolitan Administration, Department of Disaster Prevention and Mitigation, Land Development Department, Royal Irrigation Department, and Thai Meteorological Department) for supplying the relevant data.

VII. REFERENCES

1. Ivan A. (2001), IHP-V Technical Documents in Hydrology : Guidelines on Non-structural measures in urban flood management, 22p.–73p. http://unesdoc.unesco.org/images/0012/001240/124004e.pdf
2. Abhas K., Robin B., Jessica L. (2012), Cities and Flooding A Guide to Integrated Urban Flood Risk Management for the 21st Century, 50p.–582p. Washington, USA, World Bank., https://openknowledge.worldbank.org/handle/10986/2241
3. Norio S., (2014), Urban Climate : Challenges for adapting Bangkok's flood management systems to climate change, Volume 9, 90p.–99p. www.elsevier.com/locate/uclim
4. Liao K., (2012), Ecology and Society : A theory on urban resilience to floods—a basis for alternative planning practices, 48p., http://dx.doi.org/10.5751/ES-05231-170448
5. Taipei Department of Environmental Protection (2012). Total recycling, zero landfill policy introduction, 1p.–4p. http://english.dep.taipei.gov.tw/public/Attachment/27231626521.pdf
6. Nuanchan S., (2017), International Journal of Disaster Risk Reduction : Flood risk management in Thailand: Shifting from a passive to a progressive paradigm, Volume 25, 92p.–99p. http://dx.doi.org/10.1016/j.ijdrr.2017.08.003
7. Nuanchan S., Jaya K. (2016) Natural Hazards : Developing a strategic flood risk management framework for Bangkok Thailand, Volume. 84, 934p.-957p., https://link.springer.com/article/10.1007%2Fs11069-016-2467-x
8. Nawhath T., Sangam S., Indrajit P., (2008) Environment and Urbanization ASIA : Urban Flooding and Climate Change: A Case Study of Bangkok, Thailand, Volume 9 (1), 86p.–97p. http://journals.sagepub.com/doi/abs/10.1177/097542531774853 2?journalCode=euaa
9. Holling C. S. (1996) Engineering resilience versus ecological resilience. Schulze, editor. Engineering within ecological constraints. National Academy Press, 31p.–43p., Washington D.C., USA.
10. López-Marrero T., and P. Tschakert. (2011) From theory to practice: building more resilient communities in flood-prone areas. Environment & Urbanization, Volume 23(1), 229p.–249p. http://journals.sagepub.com/doi/10.1177/0956247810396055
11. Walker B., C. S. Holling, S. R. Carpenter, and A. Kinzig, (2004) Resilience, adaptability and transformability in social–ecological systems. Ecology and Society, Volume 9(2), 5p., https://www.ecologyandsociety.org/vol9/iss2/art5/

12. Berkes F., (2007) Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. Natural Hazards, Volume 41(2), 283p.–295p. https://link.springer.com/article/10.1007%2Fs11069-006-9036-7

13. Tingsanchali T., (2012), Flood disaster and risk management in developing countries. water & Thailand "Joint Conference on 3G IWRM" 171p.–193p., Bangkok, Thailand., https://www.sciencedirect.com/science/article/pii/S1877705812012647

14. Petry B., (2002), Flood Defence, Keynote lecture: Cope with floods: Complementarity of structural and non-structural measures, Science Press, 60p.–69p., New York Ltd.,USA, https://fenix.tecnico.ulisboa.pt/downloadFile/3779571681931/keynote%20lecture%20-%20coping%20with%20floods.pdf

15. N. Jukrkorn, H. Sachdev, O. Panya, (2014), Community-based flood risk management: lessons learned from the 2011 flood in central Thailand, WIT Trans. Environ., 75p.–86p. https://pdfs.semanticscholar.org/7ac6/1c59a8e33ba98a3c4c956a82a59dabbba984.pdf

16. S. Kittipongvises, T. Mino, (2015), Perception and communication of flood risk: lessons learned about Thailand's flood crisis of 2011, Appl. Environ. Volume. 37 (1), 57p.–70p., http://www.thaiscience.info/journals/Article/APER/10972777.pdf

17. Hydro and Agro Informatics Institute, (2017), The 2011 mega flood record (in Thai), http://www.thaiwater.net/current/flood54.html

18. DDPM, Thailand's national disaster prevention and mitigation plan 2015 (in Thai)., http://www.disaster.go.th/th/dwn-download-7-1/

19. S. Surminski, D. Oramas-Dorta, Flood insurance schemes and climate adaptation in developing countries,(2014), 154p.–164p., https://doi.org/10.1016/j.ijdrr.2013.10.005

20. Surajate B., Sutat W., Ole M., (2002), Conference Paper, Modeling of Urban Flooding in Bangkok,1p.-14p., https://www.researchgate.net/publication/268596115

21. JICA (Japan International Cooperation Agency), (2013), Project for the comprehensive flood management plan for the Chao Phraya River Basin, Bangkok, 1p.–546p., http://open_jicareport.jica.go.jp/617/617/617_122_12127221.html

22. BMA. 2013. Implementation plan for preventing and solving the problem of floods in Bangkok in 2013 under the responsibility of the Department of Drainage and Sewerage (in Thai). Department of Drainage and Sewerage.
23. BMA. 2012a. Trust us with Every Facet of Your Life. Bangkok Fire and Rescue Department Annual Report 2011.
24. BMA. 2012b. Bangkok Fire and Rescue Department (BFRD): Measures and Preparedness for Public Disaster in Bangkok.
25. BMA. 2010. Bangkok public disaster prevention and mitigation plan 2010–2014 (in Thai).