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## Master Thesis 2018

Research Master Planning and Sustainability: Urban and Regional Planning

### **Analysis of the impacts of flood and affordable planning strategies for flood mitigation in Phnom Penh**



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# Analysis of the impacts of flood and affordable planning strategies for flood mitigation in Phnom Penh

## Abstract

Natural disasters are the scariest things the world are facing and it is becoming more frequent and would be more economically devastating, due largely to a sustained rise of floods and storms. Flooding is increasingly becoming a major issue for the citizens of Phnom Penh, the seriousness of a disaster is estimated in lives lost, financial loss, and the capacity of the populace to recover. Cambodia is a vulnerable country to natural disasters such as flood and tropical storm. According to, the In world risk index, Cambodia ranked the 9<sup>th</sup> among the most effected countries because of high disaster risks about 80 % of farmers are living along flood plains. There are two kind of floods in Cambodia; river flood and rainwater or flash flood. With fertilized land around, but also a chaotic mix residential, commercial and industry land use at the water front. During the dry season, water level drop and planted crops on the river banks. Phnom Penh is located in a very low part of the Mekong river delta. In addition, one out of five households live below poverty line due to the impact of disasters. Turning to, flood is a natural phenomenon, which have helped to shape natural landscapes, habitats and ecosystems in floodplains, wetlands and other lowlands. In any case flood can however, turn into disasters causing heavily damages, water borne diseases and casualties. When floods come in a city, it damages several objects like buildings, cars, housewares and even people, trees and many more heavy items. Flood happen at any time and fluctuate in size, span and the influenced zone. Note that water normally spills out of high territories to low lying zones. This implies low-lying regions may flood rapidly before it starts to get to higher ground. While flood can't be altogether forestalled, steps can be taken to maintain a strategic distance from or restrict harm and speed the recuperation procedure. Flooding is progressively turning into a noteworthy issue for the natives of Phnom Penh, causing issues in health, financial, business activities, transportation and pushing more people to be in poverty. In general, my thesis will focus on strategic planning to resilience and mitigate flood issue for Phnom Penh the capital city of Cambodia.

**Key word:** Inefficient drains, weakness and Non-Structural flood management planning



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## Research framework

**Introduction**

**Urban Planning policy**

**Historical flood and  
weaknesses**

**Case study**

**Planning Strategies**

**Conclusion**

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## List of Abbreviation:

- **MPWT** (Ministry of Public Work and Transport)
- **MLMUPC** (Ministry of Land Management Urban Planning and Construction)
- **MOWRAM** (Ministry of Water Resources and Meteorology)
- **PP** (Phnom Penh Capital Hall)
- **NIS** (National Institute of Statistics of Cambodia)
- **NCDM** (National Committee for Disaster Management)
- **NAPA** (National Adaption Programme of Action)
- **DSD** (Drainage and sewerage division)
- **CRBD** (Cambodian Rehabilitation and Development Board)
- **CUDSS** (Cambodian Urban Development Strategies Study)
- **CUEIP** (Cambodian Urban Environment Improvement Project)
- **Jica** (Japanese International Corporation Agency)
- **STT** (Sahmakum Teang Tnaut)
- **ADB** (Asia Development Bank)
- **WB** (World Bank)
- **UN** Habitat
- **PPP** (Phnom Penh Post)
- **LMB** (Lower Mekong Basin)
- **MRC** (Mekong River Commission)
- **WFP** (World Food Programme)
- **UNIDO** ()
- **CBDP** (Community based disaster preparedness programme)
- **CRC** (Cambodia red cross)
- **ADPC** (Asian disaster preparedness center)
- **AUDMP** (Asian urban disaster mitigation programme)
- **UNISDR** (The United nation office for disaster risk reduction)
- **NFC** (National flood forecasting center)
- **DHRW** (Cambodia Department of Hydrology and River Works)

## Acknowledgement

Since I take my journey in this Master. I cannot decide, which topic I shall discuss for my thesis. Whether Urban Heat solution or Flood mitigation planning. A couple of months after I got into deep during, Unit: 14 (Water and risks- an interdisciplinary approach) when I was guided in different aspects more importantly group work that we have to identify the impacts and find the solutions to solve the problem. Moreover, there were flash flood in Phnom Penh during December, these leaded me to come up with the idea to choose (Analysis of the impacts of flood and affordable planning strategies for flood mitigation in Phnom Penh) as my thesis.

Foremost, I would like to express my sincere gratitude to my advisor Prof. Vincent Rotge. For his valuable guides and his effort for my study and research, for his patience, motivation, enthusiasm, and immense knowledge. His advices helped me in all the time to enlarge idea to write this thesis. Each of the members of my Dissertation Committee has provided me extensive personal and professional guidance and taught me a great deal about both scientific research and life in general.

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Much regarding pleasure!

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## **1. Methodology**

My Research is designed to provide more information into the needs of mixed method approach through method triangulation of quantitative and qualitative method was chosen. For such a long period of time, Phnom Penh is regularly get flooded, this medium size city located by many rivers, with many bodies of water surrounding, which lead this city easily get flooded during rainy season. As far as I have researched there is no evident of any study on my project site, where situate in central region there are many commercial buildings, condominiums, markets etc. It leaded me to come across with this idea to do this site. Moreover, I privilege to study about flood as it is my concern. In order to tackle the issue firstly, data analysis play an important role to know what has happened before. It is a systematically process to illustrate statistical or logical techniques to describe the facts/ history and impacts. Also an essential component of ensuring data combination is the accurate and appropriate analysis of research. Secondly, focusing on planning policy here I will describe the development of general urban planning tools, services how does it work/ the way we do. The involvement, collaborative partnerships for the development I would like to mention the featuring intergovernmental and or public and Private Sectors Corporation should be identified in order to know who is taking part to plan the project. Later on, I will discuss the challenges, this play a significant role, undoubtedly one of the most common problems, sometimes we don't even know how to do it. Understanding these challenges is key to find accurate information and can provide useful overviews and other ideas of difficulties and will be vital to determine the most effective responses to tackle urban flood. Lastly, non- structural measure will be studied to find suitable solutions, I am considering to find the accessibility of open more space for the flow of water during rainy season. It is the most important part to address the issue.

## **2. Hypothesis**

- To begin with this first of all I will give the definition of flood, the reason why it is happen, later on throughout history, it is able to analyze the impacts, identify obstacles and what the city are facing.
- Evaluate, the reason why the drainage system are insufficient. Find solution structure and non-structure in order to deal with the problem.

## **3. Research questions:**

- How does flood has negative impacts in daily life and business activities in the city?
- Being a future urban planner, in what affordable strategies flood could be tackled?

## **4. Research objectives:**

- Identify the impacts of flood in the city and the effects to daily life
- Assessing the integration of political problems/ people behavior
- Formulating recommendations to find affordable ways to address the issue

## **5. Introduction**

### **a. Geography**

Phnom Penh is the capital and largest city of the Kingdom of Cambodia. It is located in the south-central region of the country, at the confluence of the Tonlé Sap, Bassac and upper/ lower Mekong rivers. It was founded in 1431 as the royal capital, Phnom Penh was a trade center for centuries after it was abandoned by the royal court. At the junction of the Tonle Sap, Bassac, and Mekong rivers, most important waterways. It is now a center of politics, economics, cultural heritage, security, etc. With a total area of 678 Km<sup>2</sup> it homes to 2 million people. Divided into 12 districts, which are under the governance of the Phnom

Penh Municipality. Each district also are further subdivided into 76 communes. The urban concentration in the most fertile river valleys and flood plains is an exceedingly unsurprising result of the changes from an agrarian to an urban industrial pattern of development, while more dykes and other flood management measures essential to adapt to regular setting of briefly overwhelmed marshes which is inappropriate for urban development.



Figure 1: Cambodia Map

This capital has a tropical wet and dry, the climate is hot year-round with only minor variations. Rainy season starts from May to October and dry season starts later on from November to April. The temperatures range from 18°C to 38 °C and weather is subject to the tropical monsoons.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	26.3	27.3	28.6	29.6	29.2	28.5	27.8	28	27.7	27.2	26.6	26
Min. Temperature (°C)	21.3	22.4	23.6	24.7	24.7	24.5	24.2	24.5	24.4	24.1	23.3	21.9
Max. Temperature (°C)	31.3	32.2	33.7	34.5	33.7	32.6	31.5	31.6	31	30.4	30	30.1
Avg. Temperature (°F)	79.3	81.1	83.5	85.3	84.6	83.3	82.0	82.4	81.9	81.0	79.9	78.8
Min. Temperature (°F)	70.3	72.3	74.5	76.5	76.5	76.1	75.6	76.1	75.9	75.4	73.9	71.4
Max. Temperature (°F)	88.3	90.0	92.7	94.1	92.7	90.7	88.7	88.9	87.8	86.7	86.0	86.2
Precipitation / Rainfall (mm)	6	8	32	70	151	150	155	158	228	261	121	31

Figure 2: Climate

## **b. Bodies of water**

Start from southern part of China, it turns down through the Himalayas into Southeast Asia and flows along the borders of Laos, Burma and Thailand, Cambodia and Vietnam. The Mekong is one of the longest river in the world and the 10th largest in terms of volume. Which is over 4,400 kilometers and provides food and water for millions people. This river flows 500 km to Cambodia and divided the country into half, it flows southward from the Cambodia-Laos border to a point below Kratie city, where it turns west for about 50 kilometers and then turns southwest to Phnom Penh. At Phnom Penh four major water courses meet at a point called the Chaktomok (Four faces). The Mekong, and Tonle Sap river (north of Phnom Penh in Cambodia) is the largest freshwater lake in Southeast Asia at the end of the wet season but is only a large lake in the dry season when it shrinks to a fraction of its wet season size stretching almost all the way from Phnom Penh to Siem Reap province, it provides water for agriculture, and fish resources to the people and also one of the country's most important transportation links. A number of the most sensitive and charismatic species, however, are critically endangered. In addition, the Mekong's flood pulse underpins the most productive and arguably most complex ecosystem services regime in the world, producing fish that sustains the majority of the protein and fatty oil needs of 60 million natural resource-dependent floodplain inhabitants in the Lower Mekong Basin of Laos, Thailand, Cambodia and Vietnam. Reservoir sedimentation reduces storage capacity, which can have an impact on hydropower production, irrigation, flood control, and other benefits of dams and reservoirs. Both climate change and land use change can affect the rate of reservoir sedimentation. Reservoir storage capacity loss due to sedimentation, however, can be diminished through coordinated catchment and river sediment management. Implementation of integrated sediment management plans for catchments with hydropower dams requires an understanding of uncertainty in future climate, land use, and sediment predictions. This river, however, is changing, and its floodplains is now facing several challenges: The construction of multiple dams in the upper part of the Mekong Basin may alter the natural hydrology in the Delta and also potentially result in sediment changes due to excess sediment trapping by upstream dams.

*Tonle Sap Lake* is a lake in central Cambodia, It is the biggest fresh water in South East Asia and well-known feature on the map as a huge dumbbell-shaped body of water extending over the north of the country. The shape changes depending on the flow of water in monsoon and dry season. In rainy season from earlier June to November, the lake is filled by water from the Mekong and also extends the size. While in dry season from the end of November to May its size 2,500 square kilometers with few meters deep and water flows out from the lake to the Mekong, in and out flowing is it natural occurrences. By the end of November, the weight is diminished and the lake inverts course and comes back to the bearing of stream expected of it. Be that as it may, the waters take a few more months previously they start to subside, and it isn't until February that the lake starts its arrival to typical size. The overflowed backwoods encompassing the edge of the lake is the best safe house and furthermore critical for a wide range of fishes reproducing babies. The Lake also plays an important role in providing more than half of the fish consumed in Cambodia. During rainy season, the Mekong switches its water into the lake making it extends to six times of it common size, it is known as the Mekong flood cycle. The Lake is additionally a critical business asset, giving the greater part of the fish expended in Cambodia.

*Kak Lake* was a slum area situated in the city center and considered the most important backpack area in Phnom Penh. It had been a prime draw for budget tourists from around the world gathered at this scenic

site to stay in guesthouses on the lakefront, drugging, share a few cold beers, attend concerts and picnics, meet fellow travelers, and watch beautiful sunsets over the lake. It is large body of water in the central area in Phnom Penh which is over 100 ha size. Estimates pegged the population around or close to the lake at around 4,200 families, or 20,000 people. In 2007 a private investment announced an agreement to transform the lake into a sprawling mixed-use development. The project is a joint venture between Phnom Penh capital hall 10% and a private developer 90%, based on a 99-year-leasing agreement, and it can be interpreted as a threat towards the livelihoods and economic existence of the people. They are going to be resettled a long way from the downtown area and there repaid underneath the market value of the land, if they will be compensated at all. In late 2008 a private company pumped sand into the lake, several of families were forced to abandon their homes, immediately, and the lake also the region were flooded. The reclamation of Phnom Penh's Kak lake extend the level and repeat of rainy season flood in regions in the city's north. The lake area drainage and flooding assessment report, prepared by an international team, found the filling of the lake for business and housing project would dispose of a noteworthy rain catchment region, prompting effects in regions and nearby the lake. While the lake is a shut framework with little catchment commitment past the lake itself, the proposed advancement area is adequately broad to make significant volumes of runoff. The anticipated increase in peak flood levels and flood frequency that would come about without alleviation is viewed as inadmissible. A coordinated weight driven exhibiting of the lake zone, assuming that the rain overflow from the proposed development would overwhelm the present poor waste foundation in Russey Keo region toward the north. The zones of most essential impact are expeditiously toward the north of the lake district on both the east and west sides of the railway track. The drainage assessment report guarantees the Environmental and Social Impact Assessment (ESIA) wrapped up by wander planner did not have every one of the reserves of being established on sound designing, and that it included just dubious plans for the development of a 20-square-meter waterway to diminish the extended flood. An admired khmer architect/ urban planner Vann Molyvann, predicted that filling in the lake could result in serious flooding and drainage issues for Phnom Penh during its rainy season. Moreover, Phnom Penh citizens, raising concerns about the impact on Phnom Penh's natural drainage systems and flood risk.

*Trabek lake* is a major lakes also in the city, although it is not filled however there are slums all over the lake. It could be said, slums on the lake are unauthorized residents. The governor claimed, over the past 10 years, newly comer residents had caused the lake to shrink from 60 hectares to 20 hectares, which lead the situation in this area is shrinking and shallower. At the edge, of the lake, wooden and informal houses mess the water's edge. The rubbish and open sewage is a place, where an extensive of bacteria, viruses and parasites live. People shouldn't be in a place where they always risk their lives and their well-being. Meanwhile, in case the pumping station is not worked correctly or breakdowns, they will be in danger of devastating floods. A couple of months ago, the government gave land titles (ownership) to the residents, which make them to live permanently and forever on this lake. This is an import lake since the water flow from significant regions in the city, for example royal palace, independence monument. Recently, the governor expanded the capacity of powerful pumping station in this lake to stay away from flood during rainy season. What's more, amid a canal-widening project and rumored new high-rises, the community faces a new threat eviction.

*Tumpun lake* is another one also about 2,572 hectares in total area, it is a major agriculture including morning glory and water mimosa, this is where many people make their living, it is now being filled. The effluvium then works its way through an extensive network of natural wetlands before entering the 3,400-hectare Cheung Ek a Phnom Penh's biggest lake and where it was a killing field site during Khmer rough regime. Right there, the water flow into the Bassac river, which end into the Sea in Vietnam. Additionally, 8,154 cubic meters of waste water and 2,335 cubic meters of urine and 234 tons of feces, are made come to here every single day. Right when joined with runoff, to consolidate one million cubic meters of waste water each day come into this lake. Around 80 % of this close by the treated and untreated misuse of some places around 3,000 industries enters the previously mentioned lakes and wetlands. A 2009 study coordinated by Thailand's Asian Institute of Technology concluded that "Cheung Ek lake is effectively reducing pollutant loads in Phnom Penh's wastewater before it reaches the Bassac River. Much like constructed wetlands found elsewhere, Phnom Penh's natural lakes have proven to be an effective (albeit unintentional) bio-filter. Grown on a network of ropes and floats, aquatic vegetables, which cover much of the city's peri-urban lakes and wetlands, greatly benefit from the nitrogen and nutrients contained in the city's waste water. These vegetables also inadvertently bolster the effectiveness of this waste water treatment system. Much of the treatment was being done in association with the dense morning glory fields within 350 m of the input to the wetland" (Otis.D 2013). The government shows that, this land reclamation project, which aims to have more than half the lake filled by 2020, leaving only 1,500 hectares to treat the city's waste water.

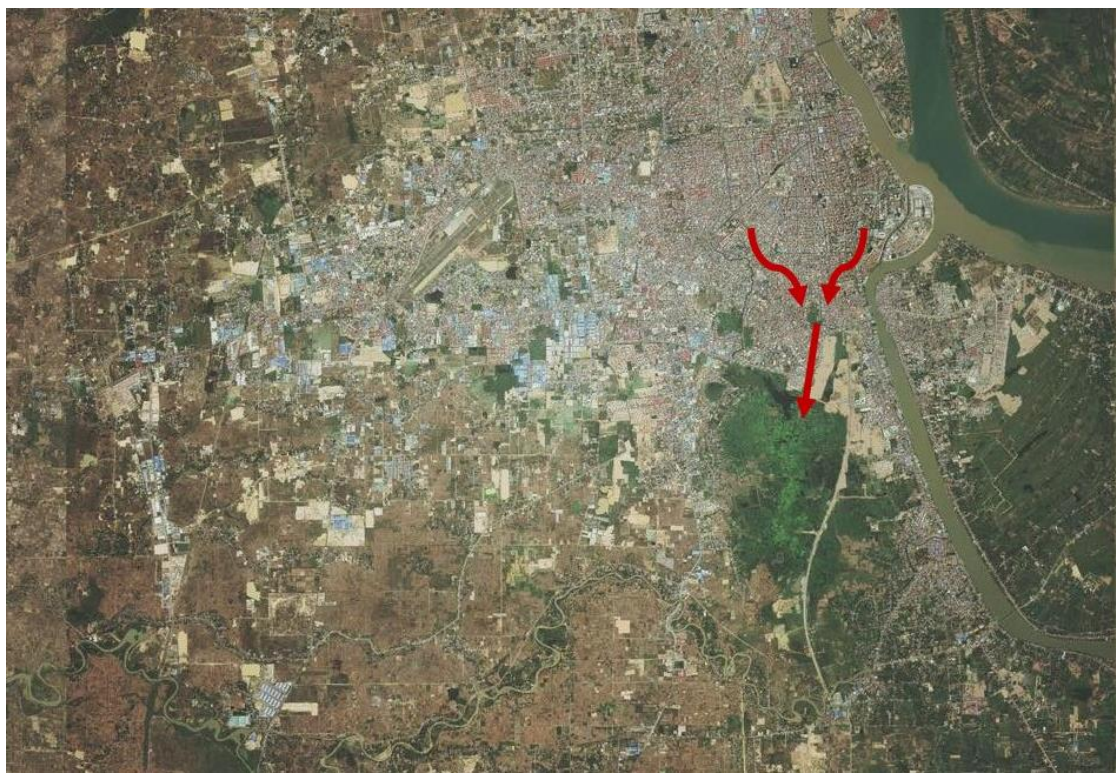


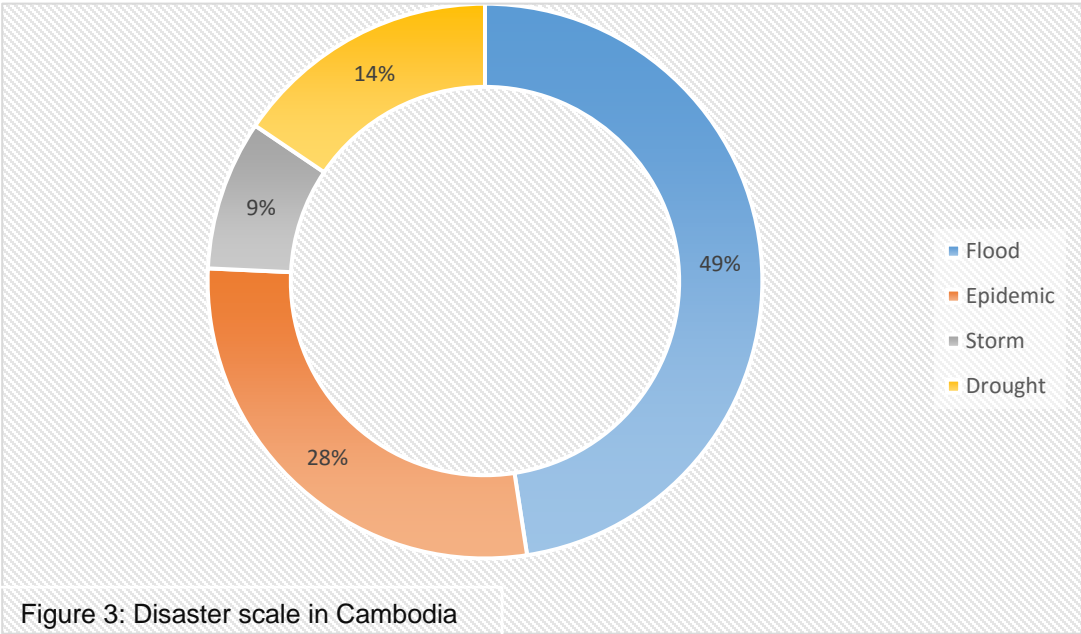
Figure 3: Flow of water further south

According to a study by a Czech NGO Sahmakum Teang Tnaut released in 2015, undertook a study of the current status of 25 lakes in Phnom Penh. This study found that "15 have been filled in, representing a loss of 60% of Phnom Penh's lake systems. The revitalization of the lakes which served as a flooding area and a drainage system for central Phnom Penh, but were obstructed with garbage and household waste,

is remarkable". The concern of flood risk expand has been elevated since the lakes were filled developments for real estate. Meanwhile, an ineffective drainage system that's usually clogged by the garbage or blocked by construction cannot get rid of the water quickly enough. It could be argued that, flood tend to concentrate in the outskirts districts of Phnom Penh. Over the past 15 years, more than 36,000 houses have been affected, 2,569 residences were heavily destroyed and killed 39 people by flooding. Overall, it can be assumed that, the demonstrates of Phnom Penh's urban development is having a significant impact on the water systems. Residents rated floods as the city's top disaster hazard, with fires and toxic waste placing second and third. For such a long period of time, Phnom Penh has been facing two events: flood and urban heat island, these phenomenon become worsening day by day. Meanwhile, the country is known to be vulnerable of climate change due to its low adaptation capacity. Water is very vulnerable in Phnom Penh, many canals and lakes are filled in with sand and garbage, ignoring the important hydraulic function of these basins for sheltering from heavy flooding. An illustrative example for the problematic and highly sensitive relation between lands, water, urban development.

**6. Flood analysis**  
**a. History**

Intend floods occurred in the past and will likely to continue due to uncontrolled development, water resource management facilities and environmental degradation. The rising frequency of disaster as a result worsening and more frequent damaging flood in the country for instance: those that contributed to flooding in 2001 and 2011. The urban landscape disrupted rainfall, leading to pockets and ribbons of rain that would intensify downpours in some parts of the city. Uncertainty in land use change will be evaluated using an ensemble forecasting (i.e using different initial conditions, boundary conditions, parameterizations, input data and models). To illustrate see disaster scale and the damages below.



Year	killed	victims	Homes damaged
1996	--	1.3 million	50,000

1999	37	527	491
2000	277	2.7 million	--
2001	62	2.1 million	429,698
2002	29	1.44 million	296,234
2006	18	700,000	800
2009	43		
2011	250	1 million	46,400
2013	168	--	418,770
2014	45	--	11,500
2016	3	--	9,546

Figure 4: Total damages

### b. Impacts

Monsoon season flooding is a problem, and the river sometimes overflows its banks. The cost of damage by mass floods in 2011 was \$624 million. More than half of that was to roads and bridges. Some 241,900 kilometres of national road were damaged in addition to about 142,900 kilometres of streets and pathways.

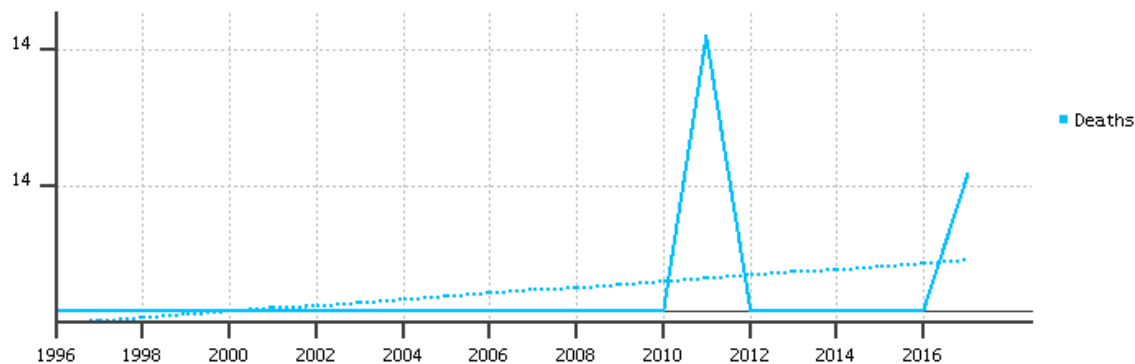


Figure 5: Deaths

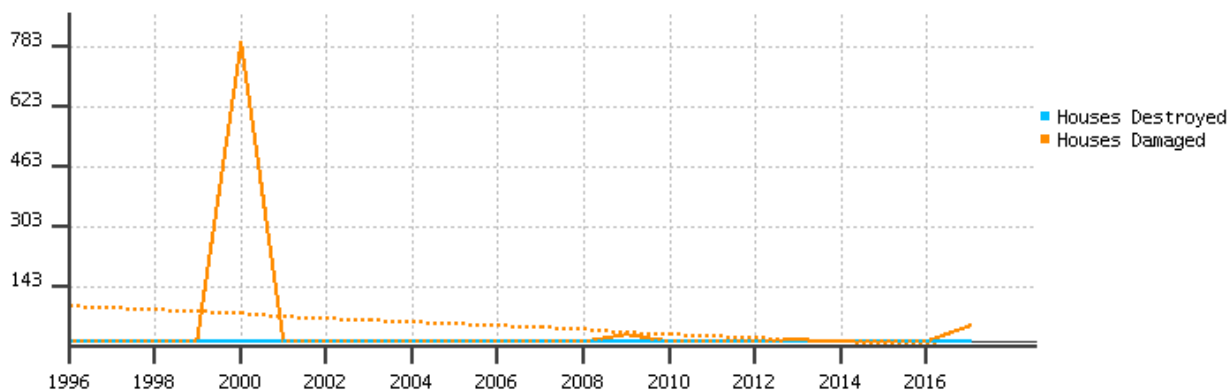


Figure 6: Damages

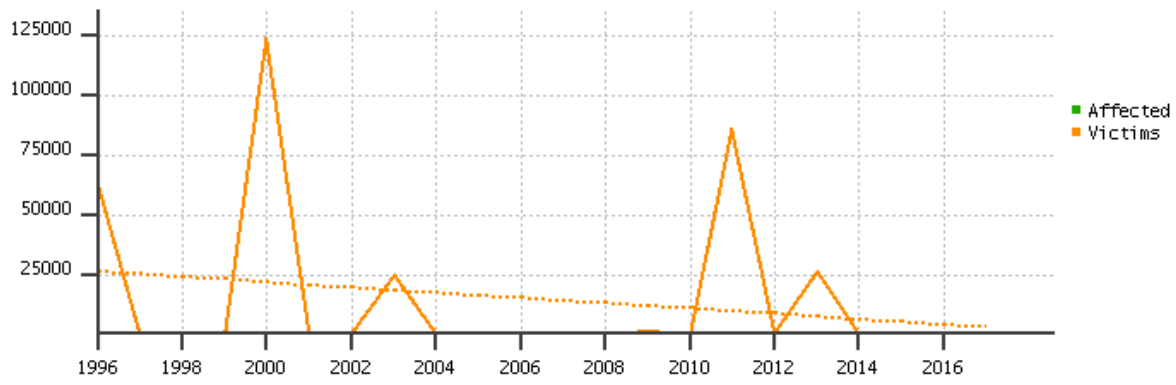


Figure 7: Victim

**Flood Risk regions in Phnom Penh**

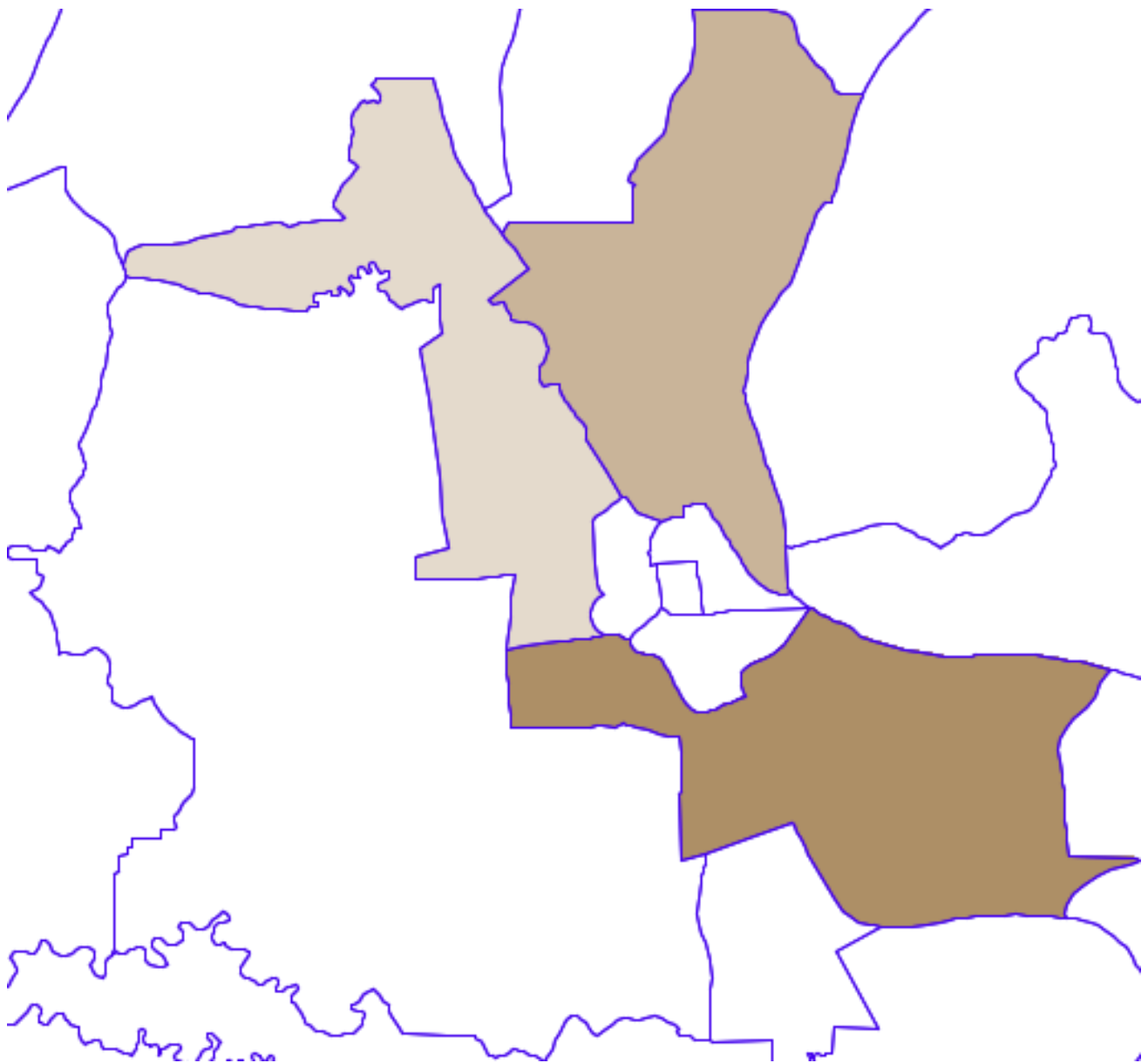


Figure 8: Most vulnerable region

### c. Climate

#### Rainfall

Phnom Penh has tropical monsoon climate, the annual average rainfall in 2004 to 2013 is 1,487.2 mm/year and large variation can be seen in annual rainfall from 1,170.9 mm/year (2006) to 1,938.7 mm/year (2008). Temperature and rainfall in Cambodia are governed by monsoons and characterized by two major rainy and dry seasons. The average annual rainfall is 4000 mm in certain coastal zones or in highland areas, while 1400 mm in the central low land regions only. The temperature is 29 °C, with an average maximum temperature of 39 °C in April and an average minimum temperature of 17 °C in January. The power of precipitation is a measure of rain that falls after some time. The power of rain is estimated in the stature of the water layer making the progress in a timeframe. It implies that if the rain stays where it falls, it would shape a layer of a specific tallness. As a rule a moderately low power is for example 2 millimeter of rain multi day and generally high might be 30 millimeter 60 minutes. High power of precipitation on soak inclines, may prompt flash flood. On flat areas it prompts ponding, or surges when the waste limit is deficient for the force of the falling precipitation.

Average monthly precipitation over the year (rainfall), monthly precipitation, rain. Show in inches »

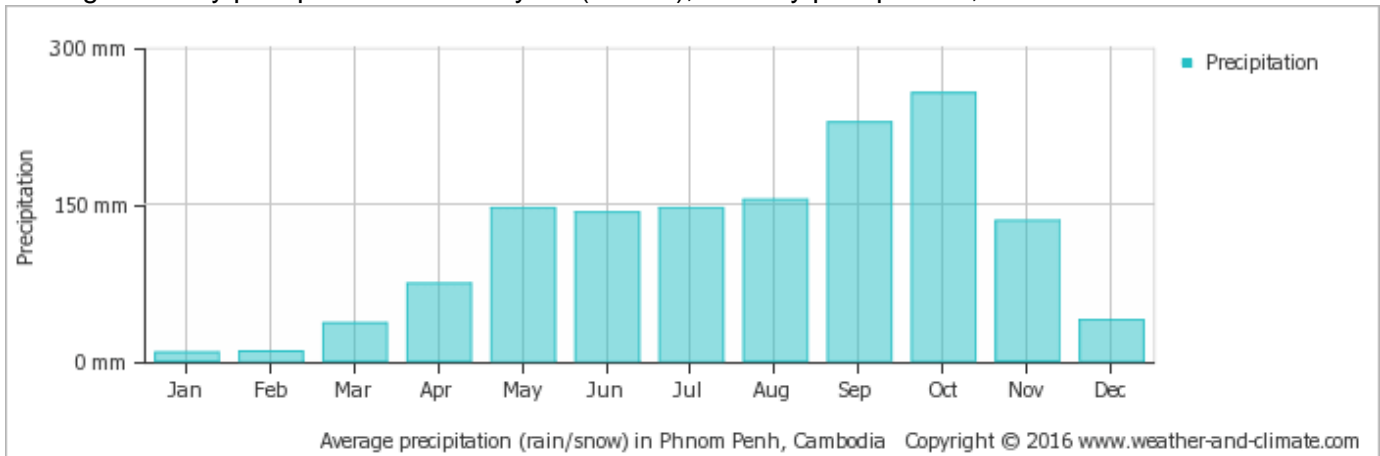


Figure: 9 Average precipitation

Average monthly rainy days over the year. This is the number of days each month with rain.

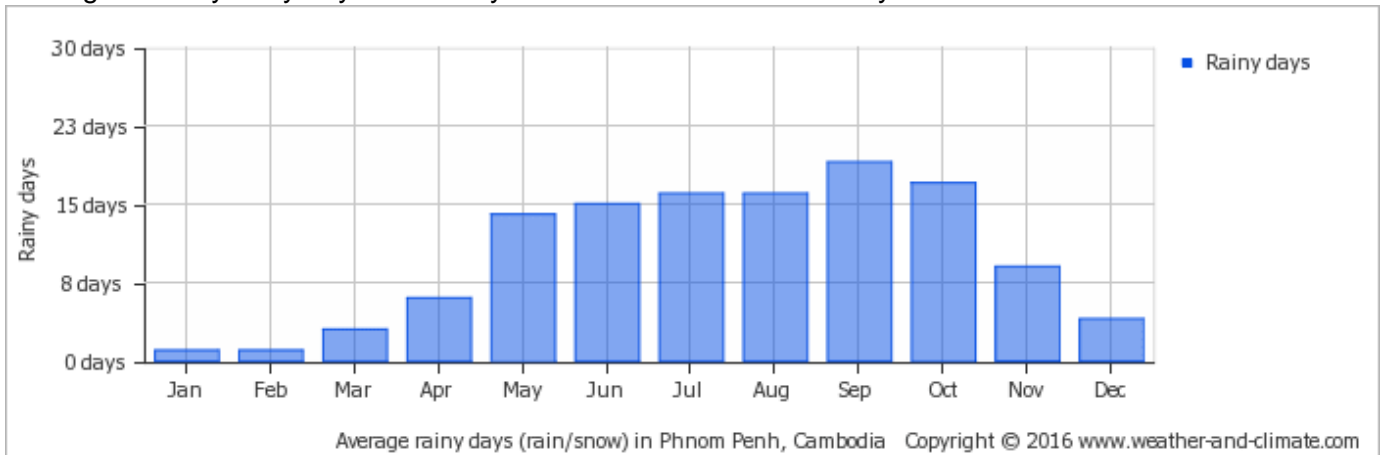


Figure: 10 Average monthly rainy days

*Meteorology*

According to the observed data from 1985 to 2013 at Pochentong Station, the averages of monthly maximum and minimum temperature are 35.3 and 21.8 degrees Celsius in Phnom Penh Capital City. The temperature is as a whole higher in March to May and the difference of maximum and minimum is about 20 degrees Celsius. The annual average of humidity is 77%, ranging from 70% to 80% and secular change is not observed.

Hourly Rainfall (Pochentong meteorological station) 2009		
Return Period (year)	Hourly Rainfall (mm/h)	Daily Rainfall (mm/day)
2	44.8	87.8
5	63.2	112.3
10	75.4	128.4

Table 1: Hourly rainfall

**d. River Water Level**

The highest water level of Bassac River and Sap River is generally recorded during August to October. The highest water level of Bassac River is 9.84 m (2011) and lowest level is 47 m (2010). On the other hand, water level during March to May is very low (1.2 m). The difference of water level between the dry season and the rainy season is about 8 m. According to the interview survey with MOWRAM (Ministry of Water Resources and Meteorology), water level is not observed during the dry season (December to April) because of backwater from the river mouth of Mekong River. The daily water level fluctuation is about 0.3 m to 0.5 m.

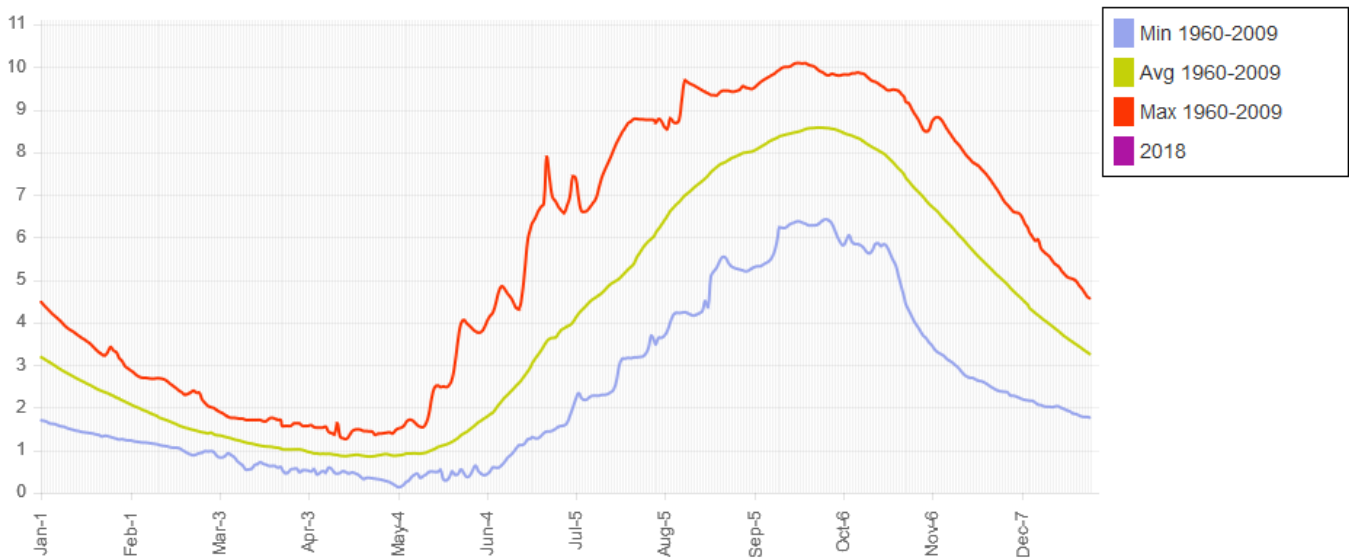


Figure: 11 Water level

*River Discharge*

According to the MOWRAM, “river discharge of the Upper Mekong River is 32,000 m<sup>3</sup>/s and maximum river discharges to Tonle Sap river and Bassac River are about 8,000 m<sup>3</sup>/s and 1,500 m<sup>3</sup>/s respectively. Peak discharge of Mekong River is recorded in June to October and the backflow from Mekong River to Sap River occur in this season”.

### *Inundation Area*

Inside of the inner ring dike, (the city centre) damage of inland flooding has been decreasing in many parts of the area with the upgrading of drainage pipe networks and canals, rehabilitation of existing pumping stations and construction of new pumping station. On the other hand, drainage improvement in the area on the northern side of Wat Phnom (eastern half of Sangkat Srah Chak) and most parts of Tuol Kok district have lagged behind other area. Inundation in these areas still occur several times a year in the rainy season, in southern and western part it is the newly urbanized area, especially in the Pochentong east area, not enough drainage facilities have been installed, and as a result, inland flooding damage frequently occurs even in short-time duration rainfall in the rainy season.

### *The rating system for flood-related damage*

Damage assessment methodologies usually focus on assessing future flood damage. But in this paper chose to focus on the assessment of post-flood damage for feedback purposes. Damage assessment almost always includes the assessment of direct and tangible damage because it is easier to identify and quantify. However, although there are numerous methods to assess the severity of this type of damage, they vary greatly in their content. Indeed, there is substantial heterogeneity among damage assessment methodologies depending on their purpose. Damage severity may be expressed in raw money values, percent loss estimates, an index value on a scale, a numerical standardised value on a scale from 0 to 1 or a range of indicators. In the literature, damage is often assessed with the replacement cost or the value of the impaired element. One major disadvantage of this kind of approach is that it weakens the possible comparison between two flood events. Indeed, depending on where and when a flood event occurs, there might be a considerable variation in costs. The objective of the damage assessment method presented in this paper was to easily gather and compare different types of damage regardless of the nature of the damaged element. The aim is not to obtain an economic evaluation but a functional assessment of damage. This approach also makes it possible to obtain objective information on damage severity. Different studies suggest that the analysis of damage severity over time and space is made difficult by the absence or low quality of available databases on flood damage and the lack of consensus upon flood data collection. With the DamaGIS database, this type of approach is made possible by using a simple rating scale operating on a range of damage indicators. This scale enables comparison over time and space as well as for a single flood severity category; the functional consequences of a flood on an element will stay the same. We use an ordinal scale, which means that the greater the damage is, the higher the value is on the scale. However, neither the value of the scale level nor the difference between two scale levels is meaningful separately. This scale is made up of four levels, shaped like a decision tree ranging from level one to level four. To illustrate this scale, the example of a road whose primary function is to provide land access.

- The first level of damage severity corresponds to the flooding of an element without the loss of its function. For example, a road is flooded but cars can still drive on it.
- The second level means that the flooding caused the loss of the element's function for fewer than 3 days. For example, a road is flooded and cars cannot drive on it for a day.
- The third level of severity indicates an interruption time of the flooded element function longer than 3 days. For example, a road is flooded and cars cannot drive on it for a week.
- Finally, the fourth severity level is based on the destruction of the element by the flood. For ex, a road is destroyed by a flood.

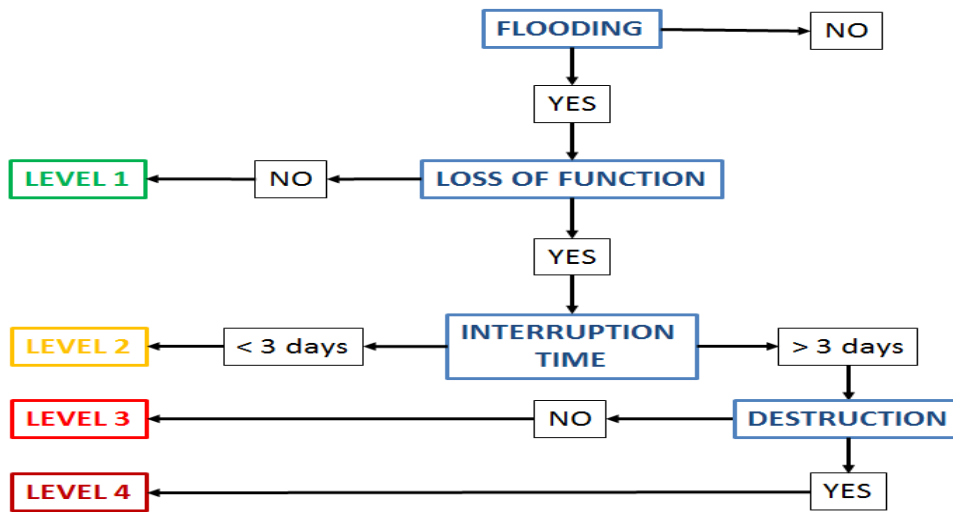


Figure: 13 Flood level  
(Martin. C.2018)

### Rainwater runoff

Runoff can prompt flooding and effects in urban territories by methods for two procedures, independently or in blend. Flooding of riverside zones: characteristic flooding that happens in the flood areas of streams inferable from worldly and spatial varieties in precipitation and spillover in the catchment zone. Flooding because of urbanization: flooding from the urban seepage framework because of the impact of soil impermeabilization, canalization or check of water stream.

### Flooding of riverside areas

Rivers generally have two beds: the minor bed, where the water runs most of the time. The minor bed is delimited by the risk of 1.5 to 2 years. Flooding happens when the water keeps running over the level of the minor informal lodging the significant bed. The levels of the significant bed decide the greatness and danger of the flooding. Flooding of a waterway's real bed is a characteristic procedure, as a result of the water cycle. "At the point When the population settles the major bed, which is a hazard region, impacts are visit. These conditions are caused by the accompanying activities.

- Cities' urban development master plans generally impose no restrictions regarding the settlement of areas at risk of flooding; the number of years without flooding is enough for entrepreneurs to divide up these areas for urban settlement;
- Invasion of government-owned areas near rivers,
- Settlement of medium-risk areas, less often flooded, but when they are they suffer significant damage.

The main impacts on the population are:

- Material damage and loss of life;
- Interruption of economic activity in the flooded areas;
- Infection by water-borne diseases such as leptospirosis, cholera, etc.;
- Water pollution by flooding of dumps of toxic materials, treatment plants, etc". (Tucci.C 2007).

Current administration offers no motivator to anticipate such issues, since when a flood happens the district announces an open crisis and gets assets that are not observed since there is no compelling reason to influence open solicitations to delicate to spend them. At the point when most sustainable solutions involve non-structural measures and restrictions on the populace, a major is probably not going to pick such an answer, as people in general by and large anticipates that some basic works will be done. To actualize non-structural measures, the government should meddle with the interests of the proprietors

of hazard areas, which is politically complexity at nearby level. To change this situation, there is a requirement for a program at common (departmental) level, including government funded instruction, in addition to activity with the banks financing works in hazard zones (Tucci.C 2007).

*Flooding due to urbanization*

“As the city is getting urbanized, the place where water could store, flow is filled for building purposes. Therefore it shortages the absorption of water and flood is becoming more frequent and severe owing to the impermeabilization of the soil and the construction of drain systems. Urban development blocks to runoff, for example, landfills, spans, insufficient drainage, hindrances of overflow and conductors, and clogging. This flooding is by and large viewed as nearby since it includes little watersheds (< 100 km2, and very often < 10 km2). As the city develops, the following impacts generally occur:

- Increase in peak flows and in frequency owing to the higher runoff capacity through conduits and canals, and impermeabilization of surfaces;
- Increased sediment production from unprotected surfaces and production of solid waste (refuse);
- Deterioration in quality of surface and ground water, owing to street cleaning, transport of solid material and clandestine sewage and storm water connections” (Tucci.C 2007);

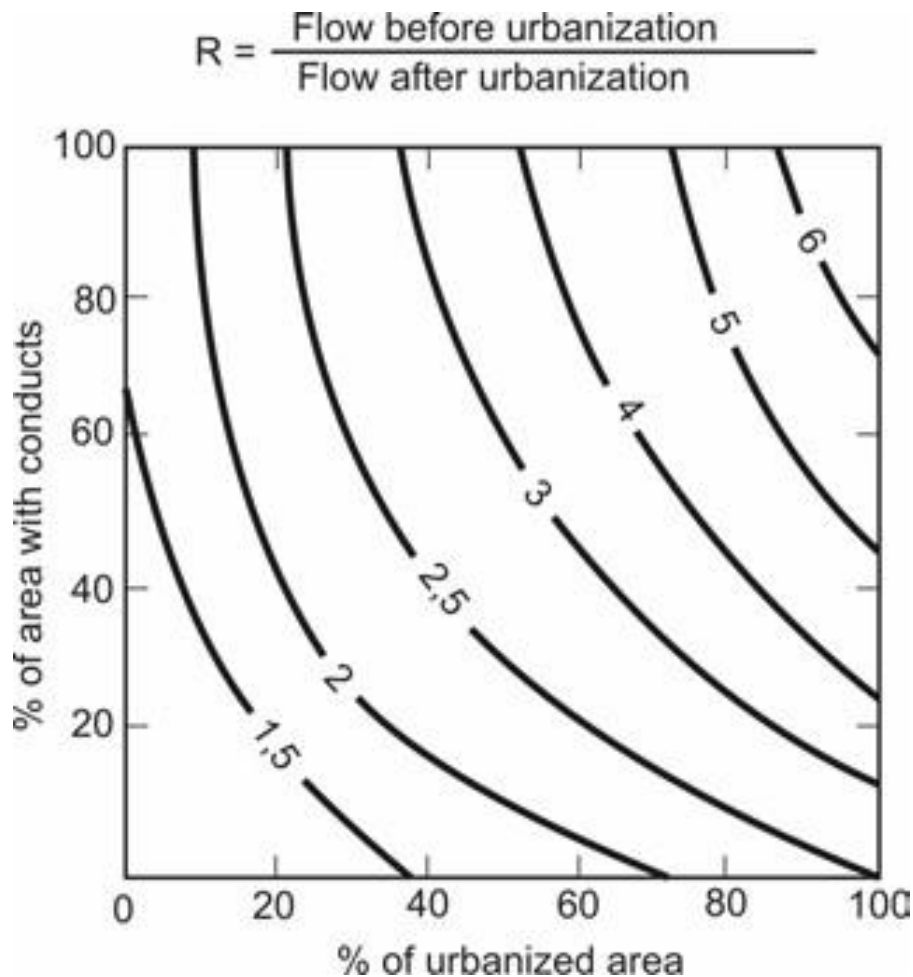


Figure 14. Curves for the value of R: increase in mean flood flow as a function of the impervious area and canalization of the drainage system  
Source: Leopold 1968,

“Disorganized implementation of urban infrastructure, such as: (a) bridges and street embankments obstructing runoff; (b) reduced canal section due to backfilling in bridges and building in general; (c)

deposition in and obstruction of rivers, canals and conduits by refuse and sediments; (d) inappropriate drainage projects and works, with reduced downstream diameters, drainage without runoff, etc” Tucci.C 2007.

Comparison between developed and developing countries

Urban infrastructure	Developed countries	Developing countries
Water supply	Solved, full coverage	Widespread coverage; tendency for reduced availability owing to pollution of sources; major leakage from the water mains
Sanitation	Widespread coverage of effluent collection and treatment	Lack of sewage system and treatment plants; those that exist fail to collect the planned amount of sewage
Urban drainage	Quantitative aspects are controlled; management of water quality	Unresolved quantitative impacts; unidentified impacts due to water quality
River flooding	Non-structural control measures such as flood insurance and zoning	Heavy losses owing to lack of control policy

Table 2: compares the state of urban water infrastructure in developed and developing countries

Source: Tucci.C 2007

Hydrograph

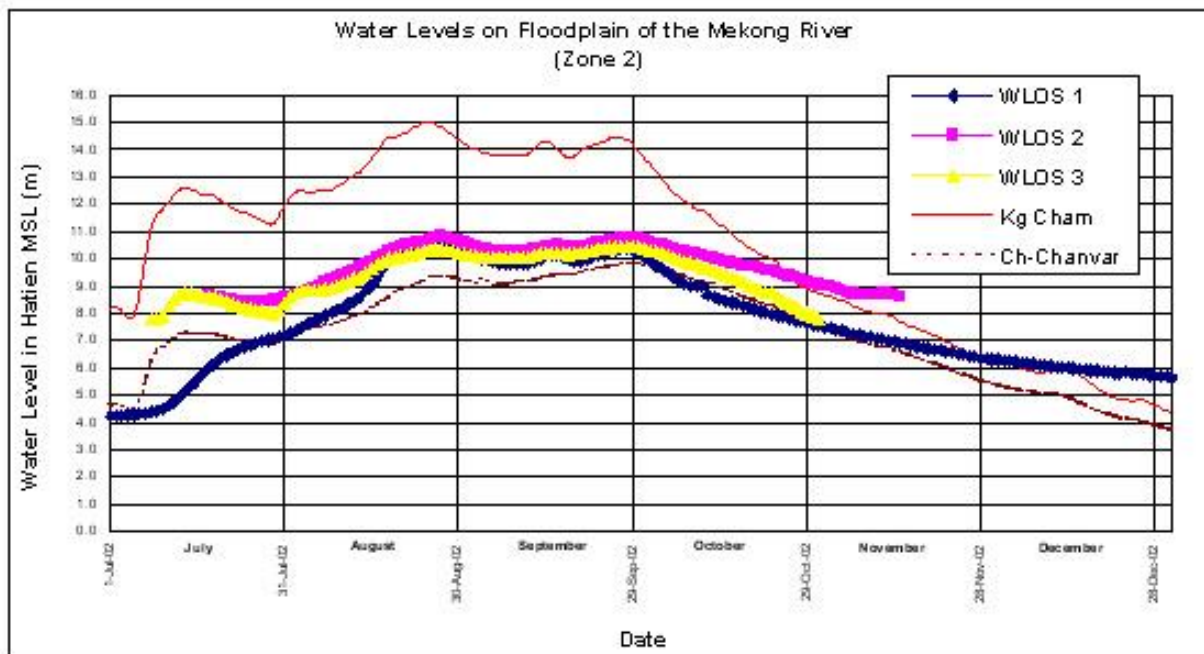


Figure 15. Hydrograph

People live along the river levees which are the highest ground dominating the flood plain. Often roads are built on those levees and they act also as flood protection dikes, directly behind the levees. In Cambodia, the traditional way of using floodwater for agriculture was the colmatage canal systems, which divert water from major streams across the levees into the flood plain, those canals are man-made or the improvement of the natural remnant of the river branches. Modern colmatage canal are gated up and downstream and designed in such a way to provide maximum spreading of silt into the area. The gates provide water control for flood protection (early flood to allow proper maturation and harvesting) and keep water from receding (when water in the mainstream starts to recede) for dry season cropping. Dike systems were used to protect cities, town, and agricultural land from flooding, sometimes to create shallow reservoirs for dry season cropping and access road. The Cambodian Lowland's population is around 5 million and this is the most agriculturally. Most Productive land in Cambodia.

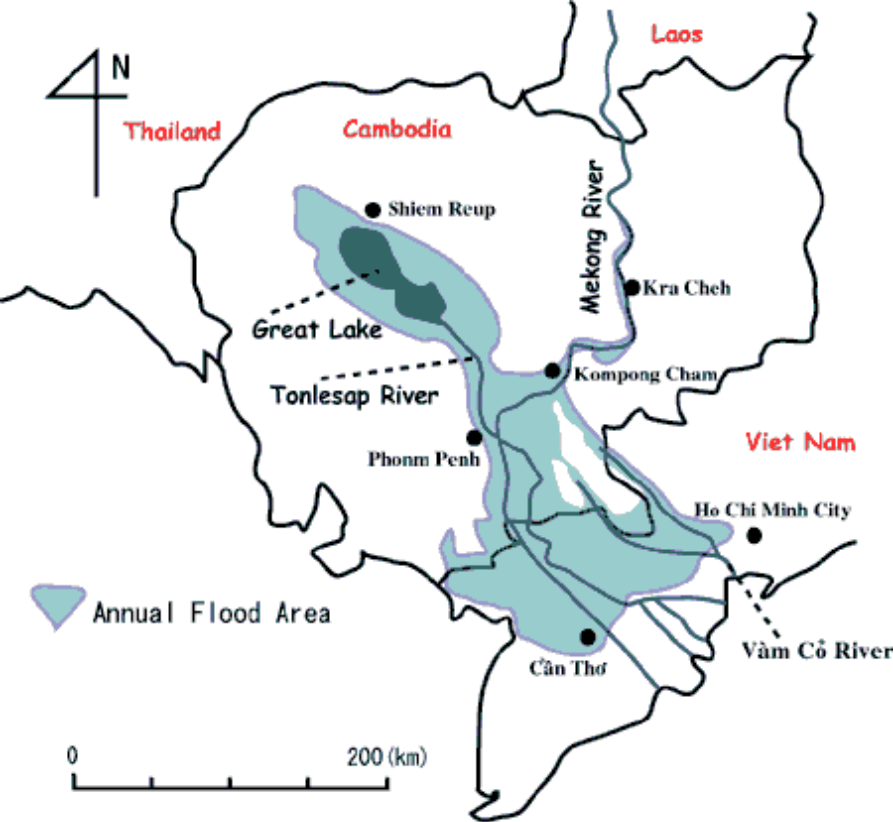


Figure 16. Flood prone are in Cambodia  
 Source: (Yamashita. A)

**e. Flood cause and types**

The flooding can be caused by natural as well as anthropogenic activities. The factors that causes flooding are mainly meteorological, hydrological and human factors and are shown below:

Meterological Factors	Hydrological Factors	Human factors
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-Rainfall -Cyclonic storms -Temperature -Snowfall/ Snowmelt	- Soil moisture level - Ground water level before storm -Natural surface infiltration - Presence of permeable cover - Canal cross section, slope - Presence or absence of over back flow network - High tide	- Land use change - Occupation of flood plain obstruction flows - Inefficient non maintenance of network - Climate change affects magnitude and frequency of precipitations and floods - Lack of flood control measures - Multiple authorities with non-responsibility
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Table 3: Flood cause type

Flood losses: can be categorized as:

1. Direct losses– Losses due to direct contact with flood water, to buildings and infrastructure, crops and animals.
2. Indirect losses-Losses resulting from the event but not from its direct impact, e.g. transport disruption, business losses that can't be made up, losses of family income, utility supplies and communication losses etc.
3. Tangible losses- Loss of things that have a monetary value, for e.g.buildings, livestock, infrastructure etc.
4. Intangible losses- Loss of things that cannot be bought and sold, for example, lives and injuries, heritage items, increase in ill health, homelessness, loss of livelihood.

Source: International Journal of innovative research in advance engineering IJIRAE (Ramkrishna. S, Pravin. S. Veermata Jijabai.2014)

Causes	Effects
Natural vegetation removal	Higher runoff volumes and peak flows; greater flow velocities; increased soil erosion and consequent sedimentation in channels and galleries.
Increasing of imperviousness rates	Higher runoff volumes and peak flows; less surface depressions detention and greater velocities of flow.
Construction of an artificial drainage net	Significant increasing of flow velocities reduction of time to peak.
River banks and flood plain occupation	Population directly exposed to periodic inundation at natural flooded areas; amplification of the extension of the inundated areas, as there is less space to over bank flows and storage.
Solid waste and wastewater disposal on drainage net	Water quality degradation; diseases; drainage net obstruction; channel sedimentation

Table 4. Urbanization impacts over floods

(Sen. D 2018)

The yearly flood in Cambodia have turned out to be more concentrated because of climate change and also more harmful. Regular flooding is a never-ending challenge for the general population in Phnom

Penh, a nation reliably positioned as a one most vulnerable to the effects of natural disasters. It is difficult to give a correct definition in Phnom Penh whether flood or River flood. Because of the area, some we can state since it keeps going under six hours, however a few areas it could be few weeks. Generally speaking we can divide flood into two types in Phnom Penh.

### *Flash Flood*

Heavy rainfall in a very short amount of time, flash floods describes as usually taking place after less than six hours of rain, and “are usually characterized by raging torrents, that rip through river beds, urban streets, or mountain canyons sweeping everything before them. Even without heavy rainfall, flash floods can come rushing in unannounced. These surprise visits can occur due to a dam failure, or after water is suddenly released, such as the breaking up of an ice jam. Check out the following video to see an example of a flash flood. Notice how fast the water moves, and the objects it carries with it. In the Southeast Asia region, flash floods account for a significant portion of the lives lost and property damages caused by flooding. Given that flash floods can occur at any time or place with disastrous results so that there is an urgent need to prioritize efforts that aim to improve early warnings capabilities of the National Meteorological and Hydrological Services. Upgrades assist society with coping with flash flood dangers by empowering the ordered national experts to attempt suitable measures, in this manner adding to shielding the population in danger from the deplorable impacts of flash flood.

### *River Flood*

“A river flood is one of the most common forms of natural disaster. It occurs when a river fills with water beyond its capacity. The surplus water overflows the banks and runs into adjoining low-lying lands. River floods are responsible for the loss of human life and the damage of property” (Sen. D 2018). Annually, the number of deaths from flooding of rivers is more than any other natural disaster. Several factors can cause a river flood. The most common reason of river flooding is heavy rainfall. In other case there are dams damaged, high tide, melting of snow also lead to flood risk. These occasions can push water up the rivers and bring to flood. Flash flood, which have a brief length, are exceptionally brutal in nature. They happen when substantial rain falls on soak land and keeps running off the land at a quick pace. What's more, flash flood additionally happen when the streams are excessively thin, making it impossible to hold additional water.

### *Flood Attenuation Mechanisms of the Cambodian*

“The team conducted longitudinal discharge measurements along the major river courses, Mekong, Tonle Sap and Bassac, every other week from July 2002 until January 2003. The results were combined with the discharge measurements and water level observations on the floodplains under the TSLVP. Utilizing and analyzing the data measured, the following facts were clarified in the hydrological functions of the Cambodian floodplains. In the stretch of Kompong Cham down to Neak Luong, 12 longitudinal discharge measurements were conducted in the 2002 wet season. The flood discharges of 45,100 m<sup>3</sup>/s on August 29 and 44,800 m<sup>3</sup>/s on September 26 are the observation data nearest to the peak of the 2002 flood at Kompong Cham. The large discharge of some 45,000 m<sup>3</sup>/s was regulated through overbanking flood and outflow into the flood paths of the floodplains. Some 25% of the discharge was reduced on the way down

to Chrouy Changvar. In addition flow divergence conditions down to the Mekong at Chak Tomuk junction dominantly depend on the absorbing capacity of the Great Lake. Depicts the relationship between discharges at Kompong Cham and Chroi Changvar. The flooding might start at Kompong Cham when discharge is about 25,000 m<sup>3</sup>/s (gauge height: 11 m in the rising stage). Beyond the discharge of 35,000 m<sup>3</sup>/s (gauge height: 13 m in the rising stage), extensive flooding might occur. In addition, the flood flow below 25,000 m<sup>3</sup>/s can be conveyed smoothly down to Chroy Changvar without flooding “(Kanehiro, Henrik, Takao 2004).

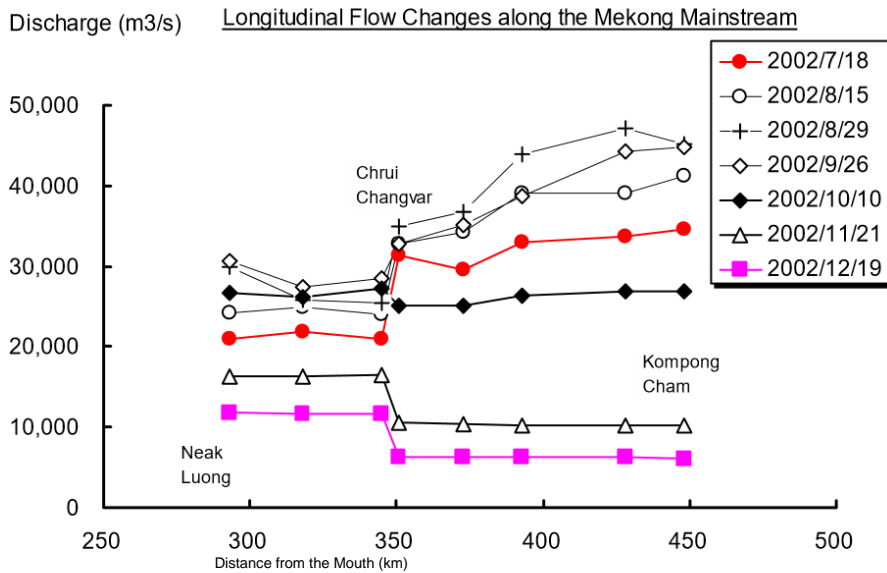


Figure 18. Longitudinal Flow Changes along the Mekong Mainstream

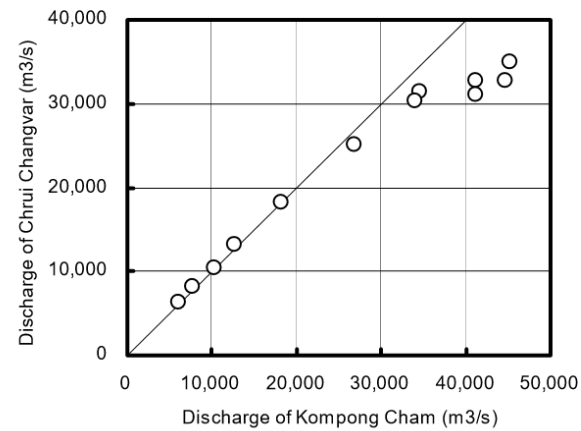


Figure 19. Relationship between Flood Discharges of Kompong Cham and Chroi Changvar

Source: MORISHITA. K, GARSDAL. H, Garsdal.H)

“Flood balance between Kompong Cham and Phnom Penh was computed utilizing a series of the work results, such as flood hydrographs at major stations, water balance in the floodplains, and hydro-hydraulic simulation outputs. From the figure the flood attenuation elements were estimated as follows: (1) flow conveyance; flood peak of 37,900 m<sup>3</sup>/s conveyed in the channel between Kompong Cham and Phnom Penh even though accompanying overbanking flooding, (2) flood divergence; flood flow of 11,900 m<sup>3</sup>/s (= 37,900 - 26,000) into two channels, Tonle Sap and Bassac, 31% of flow reduction at the Chak Tomuk junction, (3) overbanking flooding; flood flow reduction of 11,500 m<sup>3</sup>/s (= 49,400 – 37,900), equivalent to 23% reduction. Thus regarding flood attenuation functions, both of flood divergence at the Chak Tomuk junction and overbanking flooding between Kompong Cham and Phnom Penh can be almost equal from the 2002 flood events. Under the above hydrological mechanism, the area downstream of Kompong Cham, in particular, the Capital City of Phnom Penh, is protected by the natural flood attenuation functions; namely, the flood peak reduction by overbanking flooding in the floodplains and the flood risk dispersing through floodwater divergence into three channels. In addition, flood flow conveyance to the Great Lake is as well a crucial natural function in terms of conservation of the environment of the Great Lake. An almost equivalent volume of overbanking floodwater compared with the Tonle Sap reverse flow occurs in the same period. Therefore, these natural functions shall be conserved for the protection of

human lives and assets in the cities and towns against floods, as well as protection of the natural environment and resources of the Great Lake and floodplains against unregulated development. These functions are indispensable for the sustainable development in Cambodia” (JICA Study Team 2002).

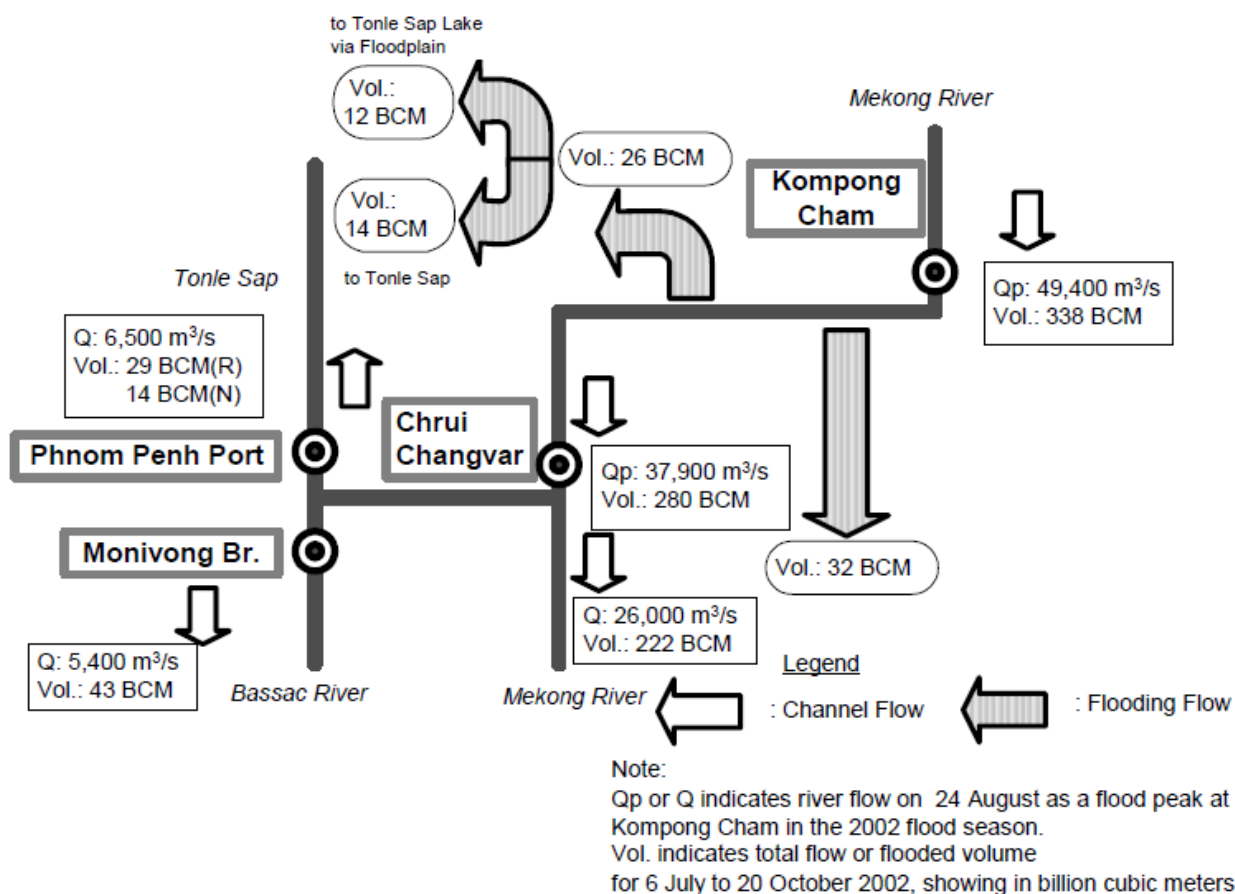


Figure: 20. Water Balance between Kompong Cham and Phnom Penh in the 2002 Wet Season  
 Source: JICA Study Team 2002, CTI Engineering International Co, Ltd., and DHI Water & Environment (Denmark)

### Flood Zones in Cambodia

Generally, there are 5 flood zones in the country, estimate the amount of flooded water by dividing the area as follows. Each zone should be divided more detail depend on the topography and water flow, dike roads, canals etc.

- Zone 1: Tonle Sap Lake and its flooded area
- Zone 2: Flooded area of the Mekong mainstream from Kampong Cham to Chaktomuk.
- Zone 3: Flooded area of the Bassac river from Chaktomuk to Chau Doc)
- Zone 4: Flooded area of the Mekong mainstream from Chaktomuk to Tan Chau
- Zone 5: Flooded Area of the left bank of Mekong mainstream from Kompong Cham to Neak Luong.

## 7. Planning regulation in Cambodia

According to *Cambodian Institute for Urban Studies* the country has divided planning regulation into these following descriptions:

- a. Local Government System

Cambodia is composed of its capital city Phnom Penh and 24 other provinces. Its basic framework for the establishment of administrative region was initiated and established during the era of French rule. Initially, there were not even councils established in the provinces and the local governments were appointed as local agencies of the central government (the Ministry of Interior). Therefore, the local administration body of the national government had a strong influence over local governance. However, in 2001, with an aim of bridging local authority closer to poor and marginalized people and having increased roles and responsibilities to address local development challenges in their jurisdictions, election law and organic law for administrative management of Commune/ Sangkat were adopted, allowed the Commune/ Sangkat councils directly elected for the first time in February 2002. In 2005, National Strategic Framework for De-concentration and Decentralization was adopted by the Council of Ministers, paving the ways for the Government to completely achieve the reform for unified administration at sub-national levels. Further, in 2008, organic law on administrative management of Capital, Province, and District/Khan/Municipality was adopted as a result of amendment of constitution. In this effort, Councils at Capital, Provincial, and District/Municipal/Khan levels were indirectly elected for the first time to oversee the accountability performance of Board of Governors for the delivery of services to citizens. Although the Sub-National Administrations are established, built, and promoted in Cambodia, however, these structures remain under a strong influence of the central government, it is gradually forming the two layered structures for administrative and planning system. The relations between government agencies at the central and provincial levels are characterized by a mix of centralized, deconcentrated and decentralized features. Both the province/municipality and district/khan are coordinated by the appointed representatives of the government called the governors. The relations between ministries and all institutions (departments) at national, provincial/municipal, and district/khan are unclear due to huge delay for the transfer of power and functions between key national ministries to sub-national level, particularly Districts and Municipalities. However, the foundation of 23 new municipalities in 2008/2009 (in addition to the pre-existing four old municipalities) added more clarity to the structure, creating a semi-autonomous level of municipal administration. The centralized system remains the backbone of the day-to-day management and administration. The election of commune/ sangkhat councils since 2002 changed the system from a completely centralized to more decentralized style, and that was reinforced by the district/municipality indirect elections since 2009. So key roles and duties are being gradually and systematically delegated to lower levels of government that are simultaneously being created. At the intermediate level of province and municipality, the management system is still fragmented in terms of planning, budgeting, and staff. Due to the overlapping roles and responsibilities and the absence of a “Unified Administration Code”, the management of provinces and municipalities still faces major obstacles. However, after the creation of new municipalities in 2009, the administrative complexity has improved. The lower level of district (called khan within urban areas) is directly responsible to the higher level of province or municipality, but the great differences in area and population size of districts make service delivery and planning difficult.

b. Planning System (Socio-economic and Physical Planning)

The two planning systems are adopted for the country, which is the “Socioeconomic Development Planning” which is owned by the Ministry of Planning (MoP), and “Spatial Planning” which Ministry of Land Management, Urban Planning and Construction (MLMUPC) is in charge of. The Rectangular Strategies of the national government is a top policy platform of the Ruling Party, the backbone agenda of socio-economic policy, the 5-years National Strategic Development Plan, sectorial strategies and plans including physical spatial planning. The Ministry of Planning appears to be following, rather than leading efforts

towards a stronger, consistent national planning framework that includes National Strategic Development Plan (NSDP); and as such the Ministry plays a rather passive role. Ministry of Planning in Cambodia is primarily dealing with socio-economic planning across the Government's ministries/institutions. So its role is quite different from the MLMUPC with its emphasis on land management and physical planning. While socio-economic development planning is structured at two levels, i.e., the national and sub-national level, and firmly rooted, the physical planning is still premature, and limited to capital, provinces and some cities. At sub-national level, Capital, Provincial, District/Municipal (DM) Development Plans (5 years) and Rolling Investment Plans (3years) are developed by the board of governor and adopted by its council for capital/provinces, and Districts/Municipalities. At commune/sangkat level, rolling investment plan (3 years) is prepared (based on a 5-year commune development plan) and integrated to district investment plan (through District Integration Workshop/DIW), and also link to the provincial investment plan due to some local development priorities and challenges beyond the capacity of the district and commune authorities. Currently, DM is a more focus in the local government reform agenda, therefore, the NCDD is scrutinizing planning system, resources allocation, power and functions (2016) to ensure stronger accountability mechanisms for the delivery of public services. DM fund and Commune/Sangkat (CS) fund including SNIF (Sub-National Investment Fund) are core elements to ensure integrated planning and clear division of responsibilities between both levels. In addition, the NCDD is implementing a plan (2015-2017) on social accountability framework (I-SAF), aiming to increase the accountability capacity of DM and CS councils and its administrations as well as to implement demand-side development approach by increasing satisfaction of citizens through citizen engagement, monitoring and empowerment. It means that participatory approach for local planning and budgeting including open local budget is crucial for the implementation of SAF 2015-2017. Therefore, planning and budgeting will certainly strengthen the accountability of board of governor to the council, and accountability of councils to citizens as well as accountability of all sub-national administrations to comply with national laws and standards (e.g. I-SAF). The Ministry of Planning is mandatory to coordinates the formulation of NSDP (the second top plan after RS) and oversees the progress of NSDP, and plans for the next mandate of the national government by incorporating needs and challenges of different sectors ministries. Various donors and national government agencies provided inputs to the NDSP by sector and by their expertise and areas of support. Physical/spatial planning appears to be lag behind, although basic laws/regulations were prepared for example land policy and land law 2001, owing to the limit of financial and capacity to plan particularly at sub-national level. Some urban development regulation, for instance sub-decree 86 on construction permits (1996) is out of date against an amended land law (2001). Political commitment both at national and sub-national level should have been playing important role to encourage technocrats to plan and to be endorsed by the government. But it has not been much of the case.

Types of Plan	Spatial Plan	Socioeconomic Development Plan
National level	National Policy On Spatial Planning	Rectangular Strategy (now phase-III, 2014-18) National Strategic development plan
Broader regional level	Regional Spatial planning	

	Circular on Cambodia Coastal Area Management (February, 2012)	
Capital/Provincial Level	Capital Land Use Planning and Master Plan (Phnom Penh Strategic Orientation 2035 has been approved in principle in December 2015-15 years vision) Provincial Spatial plan	5 years development plan, 3 years rolling plan, and 1 year development plan (project execution base on national budget)
Municipal/District/Khan	Provincial Spatial Plan District/Khan land use master plan	5 years development plan, 3 years rolling plan, and 1 year development plan (project execution base on national budget)
Commune/Sangkat level	District/Khan Land Use Master Plan	5 years development plan, 3 years rolling plan, and 1 year development plan (project execution base on national budget)-Commune/Sangkat plan is subject to be integrated into the District integration Workshop (DIW)

Table: 5 Planning Hierarchical Systems

### C. Spatial Planning and Development

At national level, the Ministry of Land Management, Urban Planning and Construction (MLMUPC) leads the spatial planning tasks as per role and function defined in the establishment of MLMUPC in 1999. The core ministries involved in spatial planning matters are, besides the MLMUPC, the Ministry of Interior, and the Ministry of Public Works and Transport, the Ministry of Economy and Finance, and the Ministry of Environment and others which formed the National Committee for Land Management, and Urban Planning (the committee is chaired by minister of MLMUPC). 22 national ministries are represented in the NCLMUP where all major decisions are vetted before they are taken by the cabinet. The key role is to advice on territorial planning including technical aspects, and decision prior the final endorsement to be made by the Council of Minister. At sub-national level, the sub-committee of LMUP (chaired by provincial governor) plays similar role with the technical supports from various line departments of the national ministries. All local plan will have to be aligned with national government's policies which the overarching decentralization and deconcentration (D&D) policies\* are very important, with a strong impact on any spatial and economic policies affecting all cities and towns. Right after the emergency relief phase of re-building Cambodia in the early 1990s, the D&D experiment phase were introduced with long-term support by UNDP and all other foreign aid agencies and D&D reform become official in 2002 after first election of CS councils. These overarching policies are still being expanded and filled in by means of the entire planning system on land management and local administration. The land management sector has been supported by international aid for nearly 20 years and will be likely further supported, along with international support to the urban planning and management functions at national and subnational levels.

#### D. Features of Socioeconomic Planning

In 2004, a document titled “Rectangular Strategy for Growth, Employment, Equity, and Efficiency” (hereinafter, the Rectangular Strategy) was issued, to present a comprehensive national development strategy of the new administration built in the previous year. The strategy extracted key elements from the “Cambodia Millennium Development Goals”, the “Socio- Economic Development Plan 2001-2005”, and the “National Poverty Reduction Strategy 2003-2005”, and inherited the traditional “Triangular Strategy” of the government. Followed by the issuance of the “Rectangular Strategy-Phase II” in 2008, the current “Rectangular Strategy –Phase III” (RS III) was issued in 2013. The government of Cambodia holds a vision of being ranked as mid/high-income country by 2030 and high-income country by 2050. The RS III plays a vital role as a base for realizing this vision, as it promotes national development and poverty reduction with a long-term sustainability through: Promotion of Agricultural Sector; The Development of Physical Infrastructure; Private Sector Development and Employment; and Capacity Building and Human Resource Development. The “National Strategic Development Plan (NSDP)” plays a role of 5 years action plan for making the policy guidance, the “Rectangular Strategy”, feasible. As for NSDP, its initial version was the NSDP 2006-2010 which was approved by the cabinet\* in 2006 as a 5-year plan combining the “Socio- Economic Development Plan –Phase II (2001-2005)” and the “National Poverty Reduction Strategy (2003-2005)” (Cambodian version of “Poverty Reduction Paper”, a collaborated request from the World Bank and the IMF to 72 developing countries). NSDP 2006-2010 was updated for the period of 2009-2012 rather than new formulation, allowing the next NSDP formulation to align with the cycle of RS-III 2014-2018 of the government of the fifth legislature of national assembly. The RS III serves as a policy framework, a roadmap of NSDP. The “Key Policy Priorities and Actions 2014-2018” of NSDP2014-2018 is consisted of 6 pillars: “Good Governance: The Core of the Rectangular Strategy”, “Overarching Environment for Implementing the Strategy”, “Promotion of Agricultural Sector”, “The Development of Physical Infrastructure”, “Private Sector Development and Employment”, and “Capacity Building and Human Resource Development”. Efforts and measures for spatial development are mentioned in each of the pillar individually. There are however questions on measurement indicators of the progress of NSDP and authority to do so. Ministry of Planning does not seem to have sufficient resources to assess the results, but national each ministry who often wanted to prioritize its territorial entity. To support the achievement of NSDP 2014-2018, the Government has assigned the Council for the Development of Cambodian to develop Development Cooperation and Partnerships Strategy (2014-18) aiming to improve the capacity of sector ministries (TWGs), oversee development assistance and partnership arrangements with traditional and new emerging donors to achieve development effectiveness rather than aid effectiveness.

#### e. Features of Physical (Spatial) Planning

The Royal Government's Rectangular Strategy for Growth, Employment, Equity and Efficiency, Phase III (RS-III) and the current National Strategic Development Plan 2014-2018 consolidates and outlines the Royal Government's goals, objectives, and actions to be achieved during the fifth mandate of the Royal Government and beyond. The RS-III identifies, “four priority areas” including ‘responding to urban development’ (section 14, para. 2). Which will contribute to “outcomes including: (i) lower transport costs; (ii) Improved reliability and effectiveness; (iii) Improvements in competitiveness; and (iv) increasing in investment in (economic and industrial development and) trade”. RS-III also highlights the need for “managing (the) environment and climate change (which) has become another challenge for the sustainability of Cambodia's economic growth and social development, due to pressures from population

growth and urbanization”. To achieve these prioritised objectives, the Royal Government will focus on (i) promoting the comprehensive land policy through the “White Paper on Land”, and (ii) the preparation of a Law on Land Management and Urban Planning”, to which the National Urban Development Strategy process will contribute. The NUDS will also assist in giving more attention to urban infrastructure and economic development needs through industrialisation and modernization as key factors in supporting economic growth and development, enhancing economic efficiency as well as strengthening competitiveness and promoting Cambodia's economic diversification, especially for poverty reduction. The Government has also prioritised its intentions to; “Enhance (the) welfare of people and ensure environmental sustainability through consistency with the framework of land management and urban planning (see RS-III section. 73), including the National Policy on Housing, and developing new laws related to land management, urbanization and construction, and a National Strategy on Development of Municipal and Urban Areas” (see RS-III section. 77, paragraph 6). “Preparing a Master Plan for Urban Infrastructure Development”, and ensure consistency with the evolving legislative framework on land management and urban planning, and prepare a National Strategy on Development of Municipal and Urban Areas, (paraphrased from NSDP, section. 4.103, paragraph. 6). “Develop a policy to manage the movement of people within the country in consonance with the implementation of strengthened land management and urban planning policies. Focusing on: (1) Development of Phnom Penh, and other key economic poles, satellite cities and urban areas of the country, while making efforts to create jobs in these communities; and (2) Linking satellite cities and urban areas with important economic poles and centres to form economic corridors” (see RS.III section. 133). The NSDP 2014-2018 also recognises the challenges for sustainability of Cambodia's economic growth and social development due to population growth, urbanization, climate change and disasters, and other factors, (see NSDP section 4.39). It states that during the five-year life of the NSDP, RGC “intends to intensify land reforms, focusing on strengthening the management, organisation, utilisation, and distribution of lands. That will contribute to reducing poverty, protecting the environment, and (promoting) socio-economic development, within a market framework” including “the preparation of Law on Land Management and Urban Planning” and other inputs (being drafted as of January 2016). The Ministry of Land Management Urbanisation and Construction (MLMUPC) is committed to undertaking a wide range of actions within its mandate including.

- Approving a Law on Land Management and Urban Planning, and related legal policy documents to implement this Law.

- Adopting and effectively using, the hierarchy set by the Policy on Land Management, and the Royal Decree and Sub-decree on the Establishment of Committees for Land Management and Urban Planning at all levels for land management plans in municipalities and provinces.

- Continue to adopt the National Housing Policy, in order to resolve housing problems for poor people so they can live in safety, welfare, and in dignity.

- Continue to provide technical support to the councils of all municipalities, districts, khans, communes, and sangkat in the preparation of master plans and land use plans.

- Strengthen the effectiveness of work on collection, compilation, and production, as well as the dissemination of data and statistics for land management and urban planning

Mutually these will guide and influence national and urban development in Cambodia for the coming period and will be crucial in giving and expressing overall direction and guidance for developing the National Urban Development Strategy (NUDS). They will also influence future national policies, strategies

and plans, which will require urban strategies to be adaptive and flexible to meet and address evolving and changing priorities. In the latter half of the 2000s, trial of Participatory Land Use Planning and Commune Land Use Planning at the rural community level kicked off in Cambodia. The effort of introducing spatial planning began in relation to delegation of land management authority to the local level. Further, it became to be perceived that spatial planning is indispensable for the sustainable development of Cambodia. However, system for the spatial planning is still under development. In the “National Spatial Planning Policy” approved by the council of ministers in April 2011 shows the hierarchy of spatial planning they are aiming. “National Spatial Planning Policy” states that spatial planning of each level of administration, Land Use Master Plan and Land Use Planning will be set force based on the principle of decentralization of power and various laws concerning the management of local administration. It classifies the planning of each level of administration broadly into the following:

- Regional/ global Supra national level: Economic Cooperation Development Plans (for example, within ASEAN and Greater Mekong Subregion)
- Planning in the national level (National Spatial Planning and Regional Spatial Planning targeting areas broader than a province); and
- Planning in the sub-national level (3 levels of planning such as Capital/Municipal: Capital, Municipal Land-Use Master Plans and (more detailed) Land-Use Plans, District/Khan level: District, Khan Land-Use Plans, and Commune/Sangkat level: Commune, Sangkat Land-Use Plan (CLUP), and local project development plan (example, community upgrading, land sharing, concrete road rehabilitation projects, etc.)

Although the legal basis is now (2015) much more complete than only a few years ago, the system remains to be one of policy declarations and regulations, without adequate implementation in practice. The system of plan making thus mainly consists of draft regulations as in the National Policy on Spatial Planning (2013). Here, an impressive hierarchy of cross-sector physical plans are proposed, from the communes up to the national programs. Cambodia has also begun to participate in interactive planning and policy making with the neighbouring countries, for example, in the Greater Mekong Sub-region (where the Asian Development Bank assists the six participating countries in their work). The Figure below illustrates the intended hierarchy of land use plans.

Description of Spatial Planning System from National to Local Level

<b>National/Regional Level planning</b>	Shall be developed by the National Committee on Land Management and Urban Planning, established by Royal Decree under the leadership of MLMUPC, and be adopted by Royal Decree. The plan shall have its vision for at least 20 years and shall be revised after 10 years through the request of Royal Government except there is a necessity then the revision could be made before this period.
<b>Capital/Provincial Level planning</b>	Shall be developed by the Capital/Provincial Committee on Land Management and Urban Planning, which is set up by sub-decree, with

	coordination from Capital/Provincial Council with approval from National Committee on Spatial and Urban Planning and adopted by sub-decree. The plan shall have their visions and last for at least 20 years and could be revised in every 5 years.
<b>Municipality/District/ Khan Level planning</b>	Shall be developed by the Municipal/ District/Khan Committee on Land Management and Urban Planning, which is set up by sub-decree, with approval from Capital/Provincial Council and adopted by the Chairman of the National Committee on Spatial/City Planning. The plan shall have their visions and last for at least 15 years and could be revised in every 5 years.
<b>Commune/Sangkat Level planning</b>	Shall be developed by Commune/Sangkat Council with coordination and technical support from Municipality/District /Khan Council on Land Management and Urban Planning. It shall be approved by Capital/Provincial Council through Capital/Provincial Committee on Spatial and Urban Planning. The plan shall have its vision and last for 10 -15 years, and can be modified in every 5 years, based on the need, situation of local development and especially commune/Sangkat investment program.

Table: 6. Description of Spatial Planning System from National to Local Level

The planning system is seemingly highly developed by now but in reality, not many plans for municipalities have been elaborated (all by national government, with some participation at the local level), but they have not been nor approved yet (by the national cabinet). With exception, The City of Battambang and its Land Use Plan has been approved early in December 2015 because of great advantage of more than ten years foreign technical aid, primarily from the German GIZ. Similarly, the Strategic orientation for Phnom Penh Capital with time horizon of 2005-2020 had been developed and discussed since 2002, and was only approved in principle in December 2015 (revised to as 2035 horizon).

f. Metropolitan and Other Regional Planning Systems

*The urban planning system and its instruments*

Several laws/regulation are being drafted to with respect to territorial management. This will require consideration and harmonisation with the National Policy on Spatial Planning and the Organic Law. The National Urban Development Strategy Framework (NUDSF) has been drafted (December 2015) providing guidance to a fully-fledged NUDS to be prepared in the future. The NUDSF stated that NUDS should contribute to and give guidance to existing and evolving system for master, land use, detailed plans and

other specific plans (as designated) as they are drafted and implemented at various levels of government. In the future, relevant sector based plans should incorporate and refer to the NUDS as a prevailing tool for coordinating national and local goals and objectives in urban areas. Jointly spatial and environmental frameworks and the administrative structure (the capital, provinces, municipalities, khan/district, and other sub-national administration areas such as communes/Sangkat) form the basis for the planning hierarchy, which may require further developments in planning legislation to enable and synthesis sector/area based plans, which may be developed. Clearly defined roles for local authorities exist; the Law on Administrative Management of the Capital, Provinces, Municipalities, Districts and Khans (the Organic Law#2-2008), Law on Commune/Sangkat Administrative Management (Organic Law#1:2001), the National Policy on Spatial Planning and the Sub-Decree on the Establishment of Committees for Land Management and Urban Planning (at different levels). There is also a need for capacity development and guidance for them as well as for clarifying the roles, responsibilities, and inputs to be provided by other national agencies and their subordinate entities. All development plans will have some resource requirements (natural, financial and human), and these need to be considered at an early stage to ensure that cost effective and implementable plans are developed and adopted. The NUDSF also emphasized on the needs for considering the Supra National, Regional Development Planning and Cooperation Requirements and Factors. (Including planning coordination between neighbouring regions/cities and distribution of employment and population). There is a need for a broad conceptual division of the national territory into a number of possible development areas (agricultural, tourism, industrial,-or where Special Economic Zones-SEZs exist, and urban settlements) and protected areas (national parks, nature reserves, other biodiversity conservation areas, as well as for heritage and cultural conservation). The coastal areas will require special attention to balance the competing interests from possible resource exploitation (oil and gas reserves), industrial, tourism and urban settlements (port cities and industrial complexes), as well as recreation and nature conservation areas and the increasing risks from climate change. Including consideration of new urban centres, that may be proposed and created as well as for population and employment distribution.

#### *Regionalization for analysis and policy purposes*

The present system of five or six statistical regions may need to be reformulated to a system of more appropriate planning regions. This will require consultation and consensus with other government institutions/ministries and stakeholders to ensure coordination and alignment between them. A possible proposal for adjusting the planning regions, would consider – Metropolitan Phnom Penh, border regions, other planning regions, based on geographic, economic, and administrative criteria. There will be a need to encourage and support sub-national regional planning with cooperation between cities, urban and rural areas along economic corridors for their mutual benefit. The macro-regional development framework of the Greater Mekong Sub-region (GMS) and ASEAN also needs to be considered especially for border provinces and urban areas. Where urban development across national boundaries is now to be handled by a special Urban Taskforce under the GMS ministerial conference. Further reference may be needed to integrate current and emerging policies from ASEAN and its ending ASEAN Economic Community (AEC).

#### f. Other Policies with significant territorial effects

During the recent decades, Cambodia has stepped ahead in establishing a fair amount of policies, strategies, laws and regulation pertaining to land management, and urban planning. Some important

policies are summarized below: The National Policy on Housing is likely to be one of the important components of the NUDS, as it is intended to regulate and facilitates processes for the provision of and or encouragement of cost effective and affordable housing for poor and vulnerable families. As well as addressing informal settlement issues.

#### h. Comprehensive Land Policy (Land White Paper)

Improving land tenure through property titling may need further refinement, as significant increases in values due to urban expansion are not being captured by the state. Potential “capital gains” through the increased opportunities for local taxation to contribute to revenues available to sub-national administration need to be considered, in which land conversions and changes of use significantly increase the values, some of which may need to be captured by local authorities for the operation budgets. Other aspects of the policy will need to be mainstreamed and incorporated into the NUDS. The Royal Government has adopted a cross cutting National Green Growth Policy and Strategy in 2013 and it has been mainstreamed into the National Strategic Development Plan 2014-2018 as an essential means to sustainable development and aspects of this policy need to be adapted and incorporated to NUDS as does the consideration of the “3E approach” (economy, environment and equity). The recently adopted Industrial Development Policy highlights the need to better consider the rapidly changing and diversifying economy that is transitioning Cambodia. It identifies possible thrusts for industrial development that will be linked to expanding the connectivity of growth centres and corridors and the future possible roles for urban expansion. As well as the proposed development of an industrial zoning and development master plan, aimed at “promoting competitive SMEs and industries in designated provinces”. The Government intends to provide essential support, including, “promoting spatial planning and urban development in designated industrial regions such as in Svay Rieng, Sihanoukville and Koh Kong provinces and Paoy Paet Municipality to coordinate industrial activities aimed at enhancing land use planning, environmental management, residential development and infrastructure development. Developing Phnom Penh capital into an industrial agglomeration through implementing a long-term urban development plan with clear designation of industrial, administrative and residential areas, aimed at transforming Phnom Penh into a dynamic centre of culture, knowledge and industry.

#### i. Integration of Transport and Land Use Planning

The majority of current transport routes connect and transit the main urban centres in the country and as these grow, transiting and locally generated traffic and the movement of goods and produce will take longer to get to their destinations. This will need to be monitored and alternative routes planned and developed. Additionally some urban centres are dispersed requiring motorised traffic to get around which is excessively wasteful of energy and resources, in this context how to reduce motorised dependencies through planning and development will be crucial. Compact cities and town concepts as well as ‘public transport policy and approaches for smaller towns need to be explored.

In “The Development of Physical Infrastructure”, policies for development of the national transportation network are stated. It states that master plan for improvement of transportation infrastructure across the national territory as well as those connecting with neighboring countries are to be developed and implemented with an aim of facilitating investment, trade, tourism and rural development. It also states that the focus should be placed on the restoration and maintenance of railway system (restoration of north line between Phnom Penh and Poipet to connect to Thailand), further maintenance of infrastructure of airport

and seaport, appraisal of investment possibility in the inland waterway transport and so on. In addition, it states that construction of high speed roads is to be encouraged, giving first priority to route between Phnom Penh and Sihanoukville. Moreover, it is projected that national, provincial and rural roads will be paved at the speed of 300 to 400 km per year.

j. Sewage and Sludge Management

No law relating to sewerage and drainage management currently exists. Therefore, a “Wastewater Management Law” is being formulated by MPWT as a new law concerning sewerage and drainage management. Formulation work has been ongoing as of February 2015. Although a draft has been written, the work is still in the stage of gathering ideas from neighbouring countries; therefore, completion of the final is still uncertain. This draft consists of 83 articles in 14 chapters. Currently, assistance from UN-HABITAT and UN-ESCAP is being sought. As stated above, no law has been enacted for wastewater management, except for those relevant to the Ministry of Environment. In order to proceed with the establishment of a sewer system, a law concerning the treatment of wastewater and disposal of sludge needs to be established. To address this issue, a sewerage law as the basic law concerning treatment of wastewater and disposal of sludge needs to be established and aligned with other relevant laws; while relevant local government ordinances and decrees need to be formulated. The sewerage law (or ordinance) to be proposed shall include, for example, definition of terms, business plan, structural standards, discharged water quality, installation of drainage utilities, announcement of commission, obligation of sewer connection, installation of specified facilities, monitoring of discharged water quality and effluent utilities, treatment and disposal of sludge, standards for operation and maintenance, setting sewerage fee and method to collect the charges, support scheme such as reduction or exemption of the charges, procedures for respective notifications, and penalty provisions.

k. Sewage and Sludge Management in Private Developments

The “Law on Land Management, Urban Planning and Construction (1994)” concerns private development, stipulating provisions related to processes of national or provincial level development planning and land use planning. Local authorities such as PPCC are mandated to formulate a Master Plan for development planning and a land use plan, which must receive national approval. Sub-Decree No. 86 “Anukret 86 on Construction Permit (ANK/BK)” concerning building permits was formulated on December 19, 1997. ANK/BK applies to all buildings in the absence of a land use plan or approved Master Plan. As the conditions for issuance of a building permit, there are provisions concerning sanitary facilities, connection of sewers and land reclamation (Article 2 of the mentioned law), and provisions concerning drinking water supply and connection of sewers and drains (Article 31 of the mentioned law). In the absence of a sewerage system, there are provisions for obligation to install wastewater treatment facilities such as septic tanks and its standards of facilities (Article 31-3 of the mentioned law). Building permits are issued by the RGC (Council of Ministers). In particular, the buildings in the following list require approval of the National Committee Chairman of the Ministry of Land Management, Urban Planning and Construction (Article 5 of the mentioned law). The member of the National Committee is stipulated in Article 6.2 of the mentioned law.

- Commercial or industrial building whose floor area exceeds 3,000 m<sup>2</sup>
- Commercial hotel 2-22
- Farmland development not less than 500 ha
- Airport, seaport, railway or carriage storage

- Public or private facility whose floor area exceeds 3,000 m2(including such a building whose floor area exceeds 3,000 m2 after extension)
- Construction in a protected area (environmental, scenic or historical cultural asset)
- Building classified as national heritage
- Building for defence of military facilities

Source: Tep. M, 2016

## **8. Drainage**

### **a. Partnership**

#### **Ministry of Public Works and Transport**

- Manage the Implementation of national strategy concerning every single public work by setting up the standards of law and coordinate with different stakeholders.
- Build, keep up and deal with all the transportation
- Establish the controls for the development of the streets, ports, railroads and conduits foundation.
- Establish the directions and control the vehicle by street, railroad and conduit.
- Participate and coordinate to build up laws, controls, and assorted benchmarks concerning the development of transport foundation.
- Realize alternate developments that the Royal Government depends to it.
- Cooperate with the Secretariat of Civil Aviation concerning all air terminal development works.

#### *-Department of Public Works and Transport*

Organizational Structure and Staff Assignment the Department of Public Works and Transport (DPWT/PPCC) is a branch under MPWT. Under the oversight of PPCC and MPWT, DPWT/PPCC for example, streets, ports, transport, urban development, sewerage and drainage, and different administrations. DPWT is one of the partner associations for the Study. What's more, when an undertaking is actualized through international collaboration, for example, this task, the deputy director responsible for International Relation Affairs and the Public Works Office are also involved. Among those divisions/workplaces, the drainage and Sewerage Division is unequivocally identified with the activity and support of sewerage and drainage system. It comprises of four areas and does errands for activity and management of drainage system in Phnom Penh. Around 30 workers allocate to the development of drainage system, and cleaning equipment. The Technical Section readies the change designs (budgetary requests) for drainage and sewage treatment system including such fills in as repairs of pipes, canals and equipment, task and operation of pumping stations, and reports to DPWT. Field works are actualized by contracted representatives in this system, (MPWT 2018)

#### **Ministry of Land Management, Urban Planning and Construction**

- Construction, building approval, technical and maintenance
- Engineering and evaluation construction site
- Foster Cambodian/ modern architecture and built environment
- Control building materials
- Land management/mapping/ survey policy
- Urban development, framework and regulation
- Control and standard the development

- Technical and solve land dispute

### **Ministry of Water Resources and Meteorology**

- To distinguish approach and technique improvement of water assets, to business advancement, keep up and conservation as per national and global as per arrangement setting of the Royal Government of Cambodia.
- To study and research on potential water assets incorporate on the ground water, underground water and the climate to affirm specialized science based which fit to national system.
- Improve Medium and long haul get ready for business advancement and safeguarding agreeing of water assets and meteorology to serve national financial for elective occupation of the urban and country individuals.
- To oversee and control all business making on water assets straightforwardly and by implication, and to limit the debacle.
- To create direction, enactment and different records to guarantee the administration and observing on the execution of water assets.
- To gather and reporting data on meteorology and hydrology, and make utilization of them to serve national and worldwide related division for national advantages.
- If fundamental, offer help and specialized counsel to partners, for example, private division, NGO, people group and individuals to suitably right/or better adjust on water assets business making.
- To broaden and present more model innovation keeping in mind the end goal to better prepare and engender generally.
- To take an interest in executing all works identified with Mekong waterway bowl as per obligations and duties
- Strengthen and advance national and universal participation on water assets and meteorology

### **JICA**

Is the greatest partner for Phnom Penh development. This Japanese agency provides technical, fund. Started its action during 1990s the first task was to provide clean water. Roads and bridges construction. Later on implemented (Master Plan for Flood Protection and Drainage Improvement) in Phnom Penh, followed by a series of (Project for Flood Protection and Drainage Improvement in Phnom Penh City).

### **ADB**

ADB has supported the government's objective of enhancing skill training. ADB help increase significantly to upgrade education quality task. This has incorporated the change of cross-border facilities to help transport and exchange as a component of the more prominent Mekong Sub-region Economic Cooperation Program. This program has put resources into streets and extensions, and also enhanced traditions border framework.

### **WorldBank**

WB is a principle donator to the development for the entire nation, it has been upgrading send out aggressiveness and financial broadening to maintain solid development and make employments. Building human resource for encourage monetary portability and shared thriving. Ensuring a more sustainable growth pattern by investing in natural capital, climate resilience, and sustainable urban development.

## **b. Drainages facilities**

### History

#### *The role of 'pioneer actors'*

“Shortly after the end of Khmer rouge regime, in the late 1980s, UN and NGOs were present in Phnom Penh and had created the International NGO Forum on Cambodia it is a network of civil society organizations which conducts policy analysis, monitoring, and advocacy on a variety of issues. A group of international specialists were called to fix the hydraulic system's sewerage network and dykes. Later on, François Legrand, who was Chief Engineer of Paris's Technical Services, and in charge of the sewers, volunteered to go on a first mission. He noted that: 'in some neighborhoods, particularly near the market, drains are totally clogged due to lack of maintenance and garbage thrown into the manholes, the lids of which have disappeared. Additionally, the Netherlands Organization for International Aid (NOVIB), focused on the city's drainage problems and tried to coordinate its action with the Sewers Subdivision. Considering the international embargo imposed on Cambodia and its population's rapid growth, the method recommended by these 'pioneer actors' was to restore the existing network through specific measures consisting mainly of leading canals and repairing the pumping stations. While the emergency assistance measures implemented during the 1980s prevented the situation from deteriorating by maintaining the sewerage system, they could not rebuild it completely. The international specialist's first task was at the heart of the project was to recover datasets and identify hazards. Since information on rainfall, evaporation and flooding was almost non-existent in Phnom Penh at that time, they often had to use sources from engineering offices that had worked in Cambodia before the war. The experts then reactivated the different measuring stations. Finally, they re-mapped the city centre's hydraulic network and various watersheds. As they gathered new information, the international engineers needed to ensure that it was transferred to the new staff members of Phnom Penh's Department of Municipal Works, and the Sewers Subdivision. However, since almost all the people who worked in these offices had been annihilated, the city's new employees often needed preliminary vocational training, which took place in countries that provided bilateral assistance to Cambodia, such as the former USSR, Eastern European countries and Vietnam. Nonetheless, Legrand was able to establish a physical description of this network, which included precise information about its type, its length and the diameter of its pipes. Thanks to the study of specific areas, recurring problems such as the lack of sewer maintenance were identified, and a general methodology was developed that could be applied to the entire city. In a time of relentless international embargo, these 'pioneer actors' successfully identified hazards and prevented outbreaks and health crises through timely interventions that focused primarily on the sewerage network, but very little on the dykes. This preceded a much greater influx of international expertise during the 1990s. Gradually, the city-system would again be conceived as a whole, and finally its sewerage networks would be restructured” (Celine.P).

#### *'A kernel and margins': a structured city-system*

“The expansive Lon Nol dykes worked toward the north and south of the capital in the mid-1970s incorporated new spaces into the hydraulic system. These spaces contrast from the downtown and the neighborhoods regarding space homogeneity, as indicated by whether they have watersheds, backfills, and a drainage system. Hence, the hydraulic system is made up of a 'kernel' the part encompassed by the intra-dyke built in the 1950s and 'margins' where new dykes were built in the 1970s. The system is planned to cover, and consequently to bind together the whole urbanized area. In other words, it promotes

and gives coherence to the multiplying interactions among spatial structures as well as between actors and spatial structures. The different watersheds that make up the intra-dyke built in the 1950s were well covered by a sewerage system. In 1979, as people began to repopulate the city, the first areas they settled were the neighborhoods closest to the river that were well covered by the sewerage network, even though it was in poor condition. There is clearly a difference in space occupancy between the city centre and its periphery. Most importantly, these areas were the most poorly serviced by the city's roads, electricity, water supply and drainage networks. Within a city-system, characteristics such as these (lack of networks, low population density, development on lands prone to flooding) are indicative of belonging to the 'margins'. This spatial organization lasted until the late 2000s. Although parts of the city centre's network lost their optimal structure, they still remained better organized than in the periphery, even before the reconstruction of the hydraulic infrastructure began. The work of the 'pioneer actors', assisted by much wider international expertise in the early 1990s, led to specific actions that contributed to maintaining interactions and consistency within the city core, differentiating it from the city's margins. For the first time since early 1970s, backfilling tidelands began again in late 1991. The kernel of the city-system was extended to include new spaces, though it nevertheless remained highly vulnerable. Then, in order to create new constructible space from the alluvium which had accumulated since the 1970s, a new north-south dyke was built by a local entrepreneur 150 metres east of the embankment. Using a polderization method, the land was surrounded by a dyke, then drained and finally backfilled with sediments collected from the river with a dredge. The new buildable lots located in central Phnom Penh near the rivers' convergence point were intended to accommodate luxury hotels. However, some of these new lots were reserved by the city to provide gardens, recreational areas and leisure. As the system's input element, output product and integral component, water defines this open space system as a hydraulic system. However, as a result of population growth, system failures worsened in the 1990s. On the one hand, the network as a whole had not been reconstructed. On the other hand, the city's new inhabitants, who often came from rural environments, used the sewerage networks inappropriately. For example, those who had parcels of land located along the riverbanks would backfill drainage channels, or families would settle in areas where storm waters overflowed around pumping stations. Compounding the damage done between 1975 and 1979, inappropriate practices were detrimental to the interactions between various structures of the city-system that had been renewed in the early 1990s. The drainage network was gradually fragmented, reducing its ability to cope with disturbances. According to experts, flooding then started to occur more frequently in Phnom Penh, and more intensely than before" (Celine.P).

### *Spatial resilience factors*

"Later on, the city's health situation worsened because of population growth and a lack of regular waste collection, combined with drainage problems. The network's components, or microstructure, no longer absorbed flows and floods extended into the city centre. These disruptions at the microstructural level generated a systemic instability that was partly absorbed at the mesostructural level by the scale's watersheds. Moreover, because the citysystem's 'kernel' was extended in the 1990s, the area located at the entrance of the Bassac River near the confluence became a privileged location for buildings and luxurious hotels in the capital symbols of the country's economic revival and proof of the adaptability of the system. Moreover, despite the successive floods that assailed the large dykes built under Lon Nol, or the macrostructure, and despite their lack of maintenance, they did not break. Only the flood of 1996 appeared likely to endanger the city-system's sustainability, but no structural changes were made. For

example, in Phnom Penh, only pieces of the network were changed when they became too damaged, outdated or unusable” (Celine.P).

### *A resilient urban system*

“After the great flood of 1996, when the large Lon Nol dykes did not break, JICA performed a sectoral study of Phnom Penh in order to reconstruct the city’s entire hydraulic infrastructure. It first sought to strengthen the system’s core by rebuilding the inner-city networks, beginning in the oldest neighbourhoods located near the river, and working its way from one watershed to another until it reached the city centre’s newest areas. The pipes were changed, the channels cleaned out and the old pumping stations were replaced by new ones. Although some flooding persisted in the city centre, particularly near the royal palace, the network reconstruction was almost completed by late 2008. Simultaneously, the large Lon Nol dykes were rebuilt and strengthened, making the whole city-system safe from flooding, although the ‘margins’ remained without a proper sewerage network until 2010. However, new towns located north of the city centre, such as Camko City, which were financed by private investors beginning in 2008, had sewerage networks built as the tidelands were backfilled for construction. Their wastewater is sent into septic tanks, and storm water is partly stored for watering lawns and plantations, leaving the excess water to flow into lake. Worsening floods in the city centre, but also building permits granted by the city, are finally acting as incentives for investors to participate financially in building the periphery’s hydraulic infrastructure. A large canal running from south to north now removes a part of the lakes waters and the run-off from new towns, and two pumping stations are being built on the great Kop Srov dyke. On one hand, technical innovations are spreading gradually from the ‘kernel’ to the ‘margins’. On the other hand, the National Committee for Disasters Management (NCDM), created by the Royal government in 1995, plays a major role in the building of hydraulic infrastructure to reduce Phnom Penh’s vulnerability to flooding. Finally, this is indicative of both horizontal and vertical interactions having recovered within the city-system, to the point that they are now multiplying” (Celine.P).

Source: Compiègne university of technology (Author: Dr. Celine Pierdet)

### **c. Drainage development**

In Cambodia, the sewerage coverage ratio is 11% and the total length is 150km. In Phnom Penh the sewerage coverage ratio is 20%, with the coverage ratio decreasing considerably in the area outside it 10 km radius. The sewerage system has a close connect with the rain water waste framework, in Phnom Penh, immersion harm is frequent. This is on account of the maintain work was not directed on rain water waste facilities amid the war from 1970-1980, causing and the framework ability to be diminished. Cambodia's rain season continues going from May to the end of November. Over the overwhelming rain, the capital city of Phnom Penh battle with an over-farthest point of its drainage system caused by a vast flood of individuals that swelled the quantity of residents in the city. The greater part of the canals and seepage frameworks in Phnom Penh were developed directly after the finish of civil wars. Consistently, the drainage system ended up being extremely disintegrated, consequently, around 250 to 300 countless tenants are by and by impacted by floods amid down-pouring seasons. Right now, there are various sort of drainage system in the city, sewerage, canals, pumping stations, dams keeping in mind the end goal to deplete the city amid blustery season. Thanks to JICA, who takes a serious concern on water issue in Phnom Penh, currently it has implemented pumping stations, sewerage system enforcement, and access to clean water for instance. It has partnered with the government since 1999 to improve clean water and

expand the city's drainage afterward. Phnom Penh capital hall and JICA cooperate together to combat flood in Phnom Penh, flood protection and drainage improvement. “Earlier this year, the authority announced, a disaster response plan, which promises to better prepare the capital for emergencies, especially floods and fires has created. The 73-page Emergency Response Preparedness Plan (EPRP) will be distributed to officials down to the commune level and designates responsibilities for preparing for and responding to emergency situations. It includes disaster risk maps, detailed population counts for each neighborhood, and a breakdown of procurement options for necessary supplies should a disaster strike. The purpose behind existing isn't just to scatter the data to general society yet additionally for the nearby authorities to know how to adapt to those disasters. It incorporates particular guidelines for how the region should function with neighborhood cooperative and locale experts in case of floods and fires, indicating duties and levels of leadership. Among the strategies, for instance, are flood warning system once water levels measure by gauges in Phnom Penh and in Kandal province pass certain limits. It delegates duties regarding what segment of government needs to do and how the district will react to a disaster (Suntharoth 2018). The management additionally lays out duties regarding managing the disaster of a debacle, for example, planning for provisions for homeless by a flood or fire, with requested records for basic necessity. The EPRP falls under the area of the 2015 Law on Disaster Management, which requires each province, municipality, district and commune to do such plans and requires the National Committee for Disaster Management to ink a countrywide emergency. While most regions have made such plans, a substantial extent of regions and collectives are falling behind. The National Committee for Disaster Management needs to formalize their alternate plan of action and subsequently all these (response plan) need to feed into NCDM's general emergency plan of action for the whole nation seeing that the work is an initial phase in a general emergency plan for Phnom Penh. There isn't much power behind NCDM to push diverse ministries to execute the law without getting tied up together, it will be hard to have a 100 % facilitated emergency. Phnom Penh central districts are secured by inner dikes, which was worked in mid 1950s and sub-partitioned into 7 hydraulic units which go about as little watersheds. Every watershed is secured by an essential sewerage organize that gathers and transports sewerage and waste water. The sewerage flows downstream from every collection zone through the system to lakes.

**Condition of Existing Drainage Facilities**

Drainage facilities are constructed by DPWT and local authorities, such as Khan and Sangkat. After construction, the drainage facilities are operated and maintained by DPWT. DPWT records the total length of drainage pipes by diameter and number of manholes by size since 1994. Cumulative length of drainage pipe and number of manholes constructed in 2006-2013 are shown below.

**Total Length of Drainage Pipes and Number of Manholes**

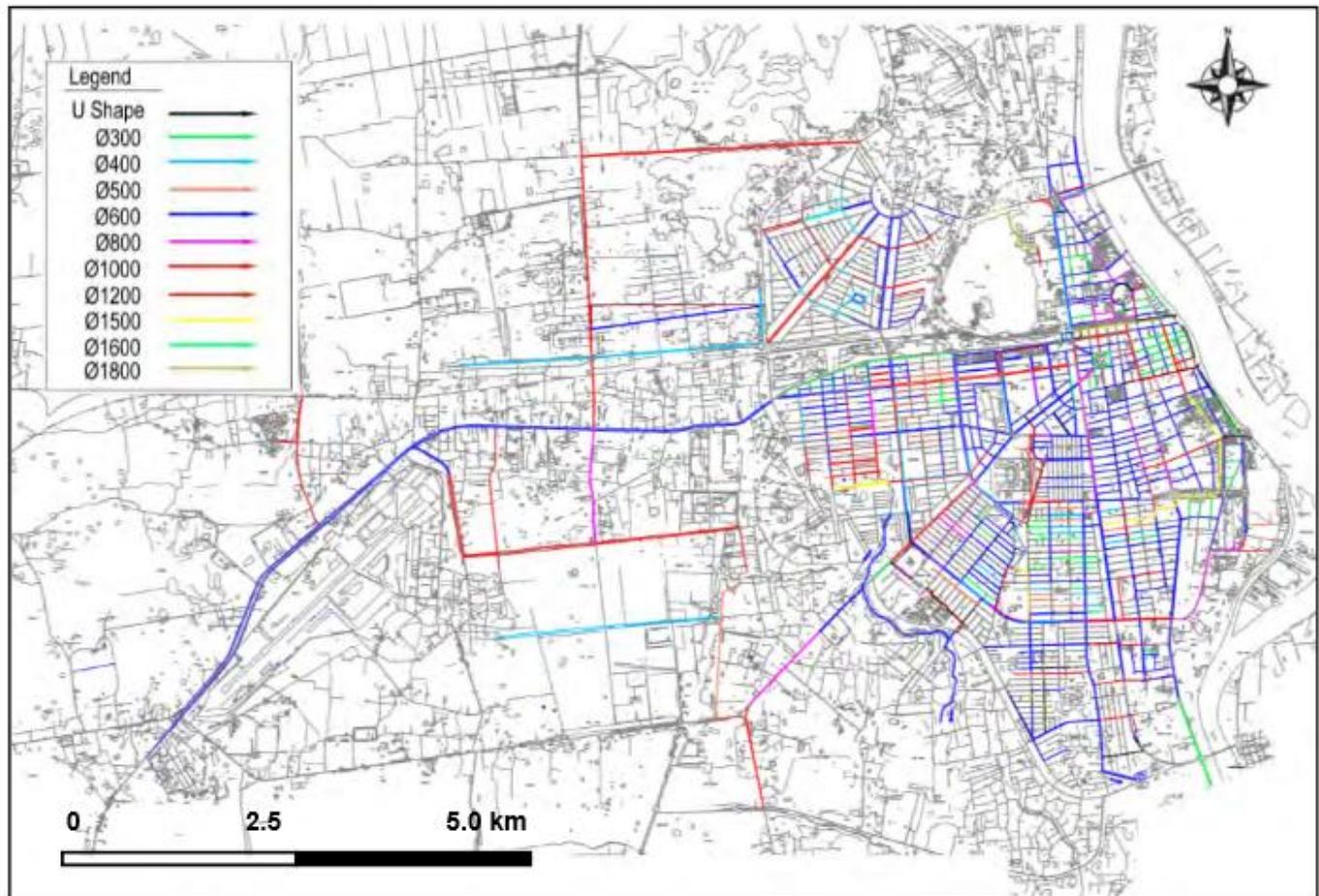
Drainage Pipes (m)								
Pipe size	2006	2007	2008	2009	2010	2011	2012	2013
Ø200cm								
Ø180cm					301	301	301	301
Ø160cm	85	85	85	85	85	85	85	85
Ø150cm	8,331	9,631	10,847	13,918	17,966	17,966	18,752	19,782
Ø120cm	775	17,820	17,820	17,820	18,187	18,187	18,187	18,187
Ø100cm	42,837	57,962	65,620	81,250	82,110	82,417	84,325	87,876
Ø80cm	26,675	41,712	46,317	50,601	50,939	51,452	51,452	52,125
Ø60cm	124,106	142,125	147,297	157,628	158,068	160,173	160,545	162,049
Ø50cm	51,753	59,873	64,488	64,488	66,237	66,237	66,237	66,237

Ø40cm	13,815	18,942	22,049	22,049	22,105	22,105	22,105	22,105
Ø30cm	33,883	42,902	46,115	46,755	46,755	47,173	47,536	48,412
U-drain					320	320	320	320
Total (m)	302,260	391,052	420,638	454,594	463,073	466,416	469,845	477,479
Manholes								
Size	2006	2007	2008	2009	2010	2011	2012	2013
Rg200x130					45	45	61	127
Rg130x130	1,993	3,420	3,701	4,510	4,530	4,558	4,617	4,785
Rg110x110	1,395	1,669	1,823	2,025	2,025	2,025	2,025	2,052
Rg90x90	5,171	8,080	8,545	9,120	9,142	9,233	9,266	9,354
Rg70x70	6,629	9,103	9,334	16,662	16,682	16,822	16,895	17,104
Total	15,188	22,272	23,403	32,317	32,424	32,683	32,864	33,422

Table: 6 Length of drainage pipe

Source: DPWT/PPCC

DPWT is in the process of establishing the database of drainage pipes at present. The location map derived from the database. However, there are still many drainage pipes in the capital city that have not been recorded in this database yet. Further survey about drainage pipe network is necessary.



Source: DPWT/PPCC

Figure: 21 Drainage Pipe Location Map from Database

Details of open channels and pumping stations managed by DPWT as of September 2014. Total length of channel is about 55 kilometres and number of pumping stations is 12.

Total Length of Open Channels Managed by DPWT

No.	Name	Total length (m)	Improved Length (m)	Canal Type
1	Boeng Trabek Upper Canal	2,410	2,410	Reinforced Concrete Canal
2	Boeng Trabek Downstream Canal	850	0	Earth Canal
3	Boeng Tumpun Canal	3,710	3,710	Improved Earth Canal
4	Stoeng Mean Chey Canal	1,900	0	Earth Canal
5	East & West Tuol Sen Canals	1,118	1,118	Improved to Reinforced Concrete Canal
6	Boeng Salang canal	1,260	887	Improved Earth Canal (887m)
7	Canal Baraing (France)	3,700		Earth Canal
8	Canal Lou Pram	1,700		Earth Canal
9	Tuol Poug Ror Canal (South Prey Pring)	7,500		Earth Canal
10	Prey Spoeu Canal	7,000		Earth Canal
11	O Akuch Canal	4,200		Earth Canal
12	598 Canal	1,850		Earth Canal
13	Tuol Sampoeuv Canal (Philippines Canal)	5,000		Earth Canal
14	Kop Srov Canal	4,700		Earth Canal
15	Bak Touk Canal	3,800		Earth Canal
16	O Veng Canal	4,150		Earth Canal
Total		<b>54,848</b>	<b>8,125</b>	
Improved to Reinforced Concrete Canal		<b>3,528</b>		
Improved in Earth Canal		<b>4,597</b>		
Normal Earth Canal		<b>46,723</b>		

Table: 6 Length of Open Channels  
Source: DPWT/PPCC

#### List of Pumping Stations Managed by DPWT

Station Name		Electrical Engine Driven				Diesel Engine Driven				Total Discharge Capacity [m <sup>3</sup> /sec.]	Observation (Date of Equipment)
		Nos	Pump type	Power /Unit [kW]	Capacity /Unit [m <sup>3</sup> /sec.]	Nos	Pump type	Power /Unit [HP]	Capacity /Unit [m <sup>3</sup> /sec.]		
1	Boeng Trabek	8	Horizontal	132	1.0	1 unit of Backup Generator, 1000 KVA				8.0	Operation since 2003 (ADB Loan)
2	Boeng Tumpun	5	Submergible Pump	280	3.0	2 units of Backup Generator, 700 KVA each				15.0	Operation since 2004 (Japan's Grant Aid)
3	Tuol Kork I	2	Vertical shaft	45	0.47	2	Vertical shaft	145	0.69	2.32	Constructed in 1970's
4	Tuol Kork II	1	Vertical shaft	45	0.47	2	Vertical shaft	145	0.69	1.85	Constructed in 1970's
5	Chak Tomuk	2	Pump Gate	45	0.7	1 unit of Backup Generator, 200 KVA				1.4	Operation since 2010 (Japan Grant Aid)

6	Preah Kumlung 1	1	Pump Gate		0.2		-		0.2	Operation since 2004 (Joint Research with Kubota)	
7	Preah Kumlung 2	2	Pump Gate	22	0.35		-		0.7	Operation since 2010 (Japan's Grant Aid)	
8	Phsar Kandal	2	Pump Gate	45	0.7	1 unit of Backup Generator, 200 KVA			1.4	Operation Since 2010 (Japan's Grant Aid)	
9	Phsar Chaas	2	Pump Gate	45	0.7	1 unit of Backup Generator, 200 KVA			1.4	Operation since 2010 (Japan's Grant Aid)	
10	Svay Pak Km No.9	4	Submergible Pump	75	0.13	3	Vertical shaft	190	0.38	1.66	Operation since 2006
11	Kop Srov	5	Vertical shaft	400	2.8				-	14.0	Operation since 2010
12	Tuol Sampeo	3	Submergible Pump		0.66				-	1.98	Operation since 2014

Table: 7 List of Pumping Stations Managed by DPWT

Source: DPWT/PPCC

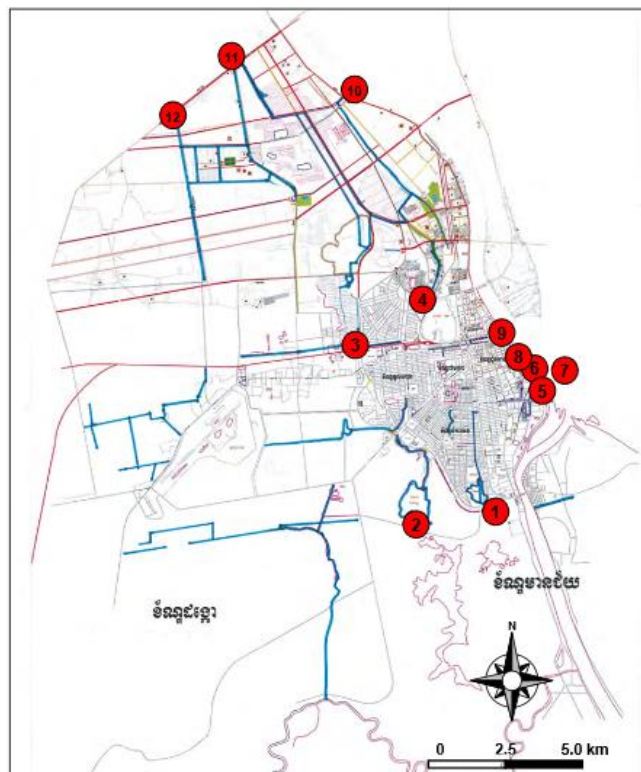


Fig. 21 shows location of open channels and pumping stations managed by DPWT

Source: (Jica 2016)

To address flood, the government has promoted the knowledge about policies, strategies and implementations, which coordinated by NCDM, ADPC, ADB, MRC. These joint ventures provided operations, budget, and assistants, through the previous flood experiences. The combination and coordination, of different flood mitigation have raised the viability, of methodologies to lessen the effects through the cycle of deliberate activities.

#### d. Jica Project

##### -Flood Protection & Drainage Improvement in Phnom Penh: Phase 1 & 2

In 1999, JICA implemented (Master Plan for Flood Protection and Drainage Improvement) in Phnom Penh, followed by a series of (Project for Flood Protection and Drainage Improvement in Phnom Penh City). The Phase 1 of the project targeted at South-Western part of the city to improve drainage sluiceway/channels, construct drainage sluiceways and pumping station, and to reinforce dikes. Phase 2 aimed at improving the drainage systems in North-Eastern area, including construction of an underground reservoirs, pumping stations, riverbank revetment, and interceptor pipe along Tonle Sap River Park. Phase 1 and 2 succeeded in lessening the damage of floods in the targeted areas.



Figure. 22 Phase 2 Target area

Source: Jica 2016

##### - Phase 3: Construction of Drainage Systems & Sediment Chamber and Maintenance of Drainage Systems

In 2012, JICA, in cooperation with Department of Public Works and Transport Phnom Penh Capital City (DPWT), started to implement the Phase 3 which targets the drainage networks in South-Eastern part of Phnom Penh. In addition to the construction projects, including the reconstruction of more than 50-year-old Sediment Chamber, the project also focuses on strengthening city's capacity to maintain drainage pipes/channels. To this end, JICA procured two sets of Sludge Suckers and two sets of High Water-Jet Machine for the cleaning of drainage pipes. It is a common practice in Cambodia to have drainage-cleaning staff crawl into 60cm drainage pipes to clean-up the inside. With the introduction of High Water-Jet Machines, however, cleaning staff may no longer have to endanger their lives to conduct the clean-up of unsanitary drainage pipes (Jica 2016).

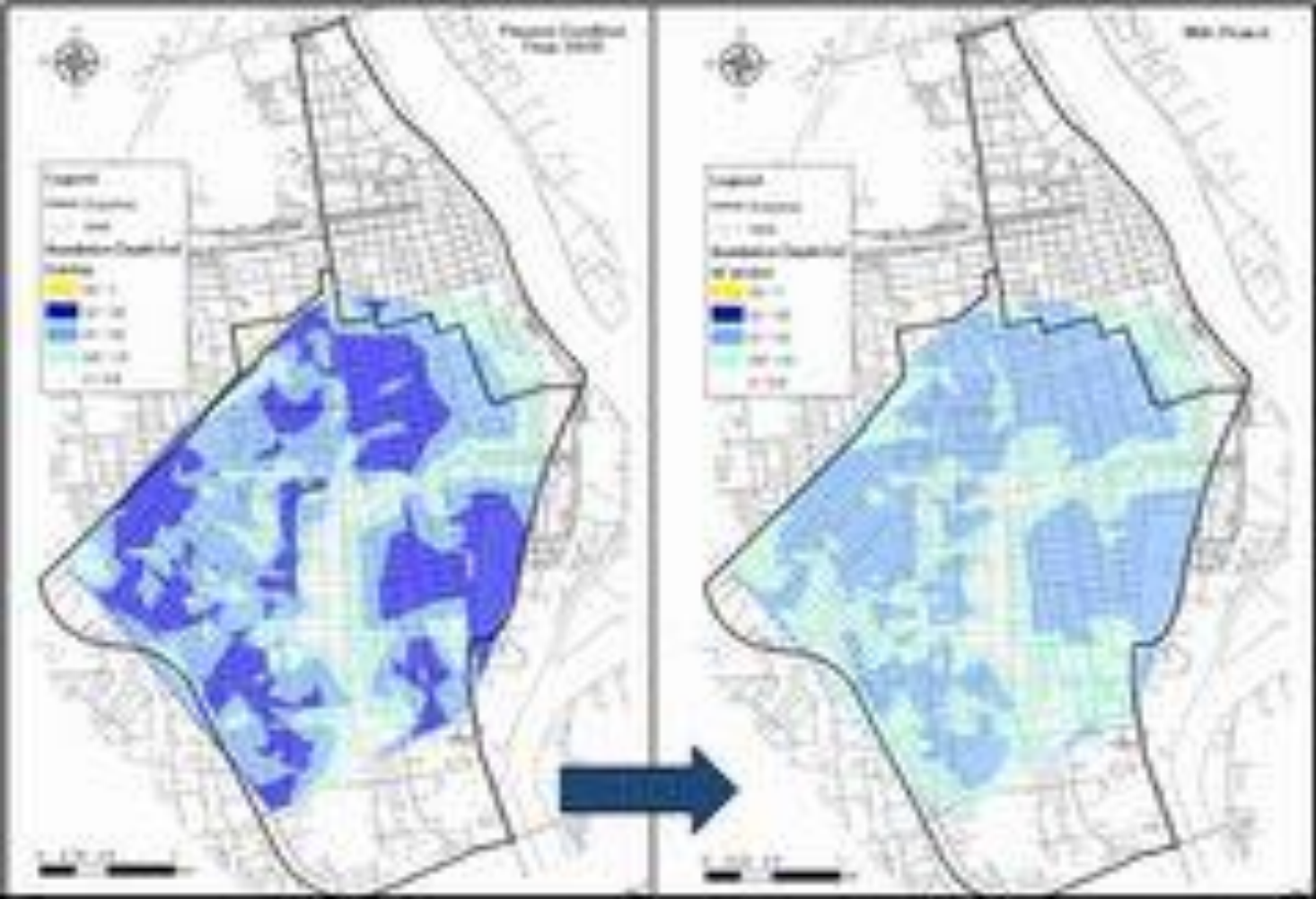
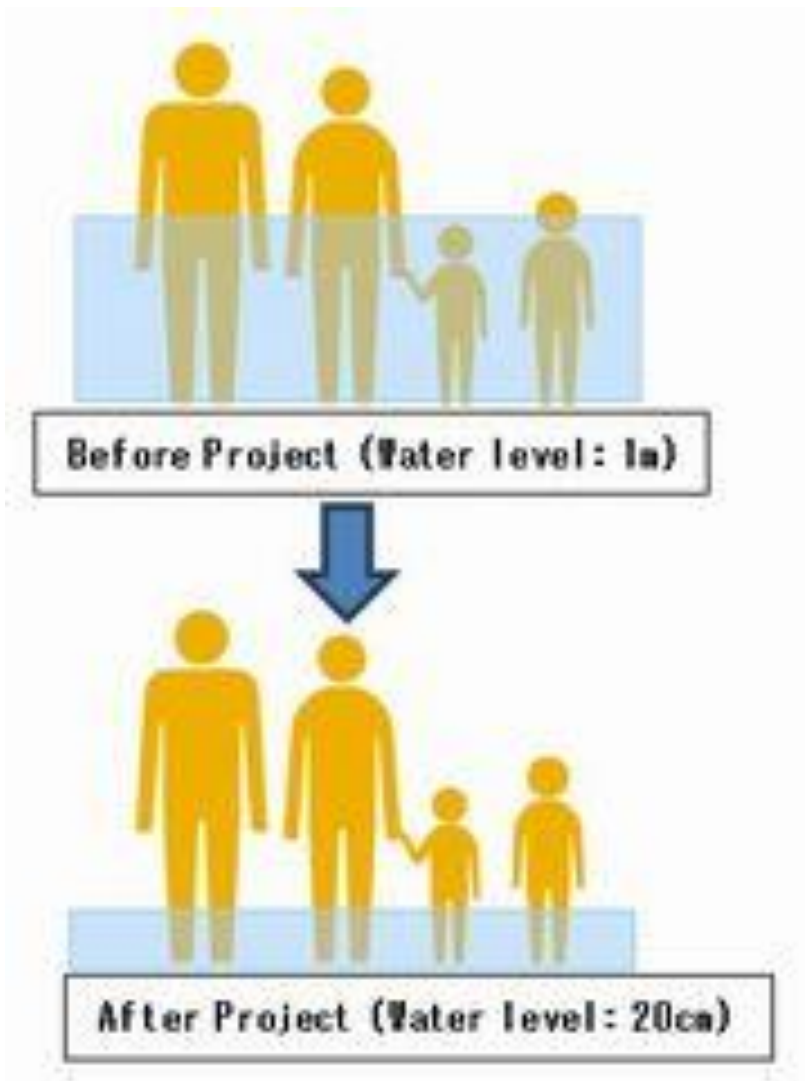


Figure. 23 Phase 3 Target area  
Source: Jica 2016

Upon the completion of Phase 3 (Expected in October, 2015), about 230 thousands residents, about 2,600 stores/markets, and 60 public centers in the targeted area would be protected from the devastating consequences of flood (Jica 2016).



Before project, about 1m-high water level lasted for about 7h. After the completion of this project, however, the water level is expected to go down to 20cm high and would last 2h (Estimation based on Two-year probability rainfall) (Jica 2016).

Figure. 24 Project water level

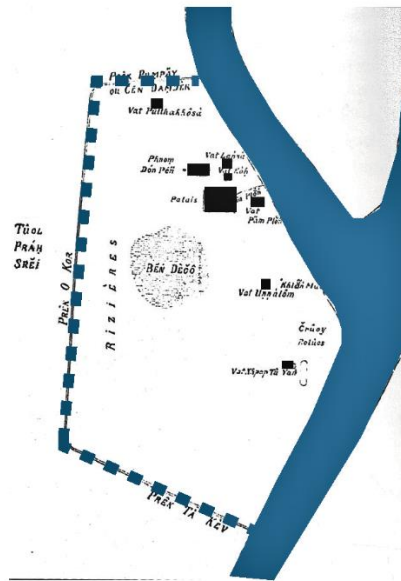
Source: (Jica 2016)

### *Urban Dwellers in Action: Clean-Up Campaign*

Past endeavors to inspire subjects to clean up together have to a great extent fizzled, implying that regardless of the continuous development of a \$350-million-dollar drainage system by JICA, flooding has not been mitigated. People still litter in the city, along the canal, little and little it blocks the flow of water. What the authority stated, support of drainage system requires collaboration and comprehension from people. Realizing that JICA or neighborhood government alone can't keep everything cleaned, the governor of Phnom Penh propelled a Clean-Up Campaign. This campaign aims at raising awareness on hazardous consequences of littering, which is considered as one of the elements to cause stopping up in drainage system. This eager crusade likewise goes for cleaning every one of the drains by using sludge suckers and high water-jet machines donated by JICA. (Jica 2016)

**d. Urban transformation**

**1866**



**1432-1866 (firstly found until early colonization)**

- Establish along the Mekong in an area call Wat Phnom
- Canals, reservoirs were made due to flood

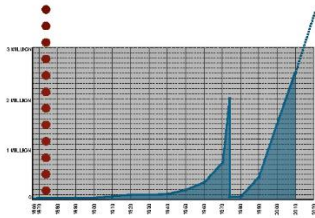


Figure. 25 PP in 1866  
Source: Doyle. S, 2012.

**1863-1953 (French colonization)**

The creation of cultural centre ( cinemas, museum,)  
Lakes filled, Strategic planning based on public space

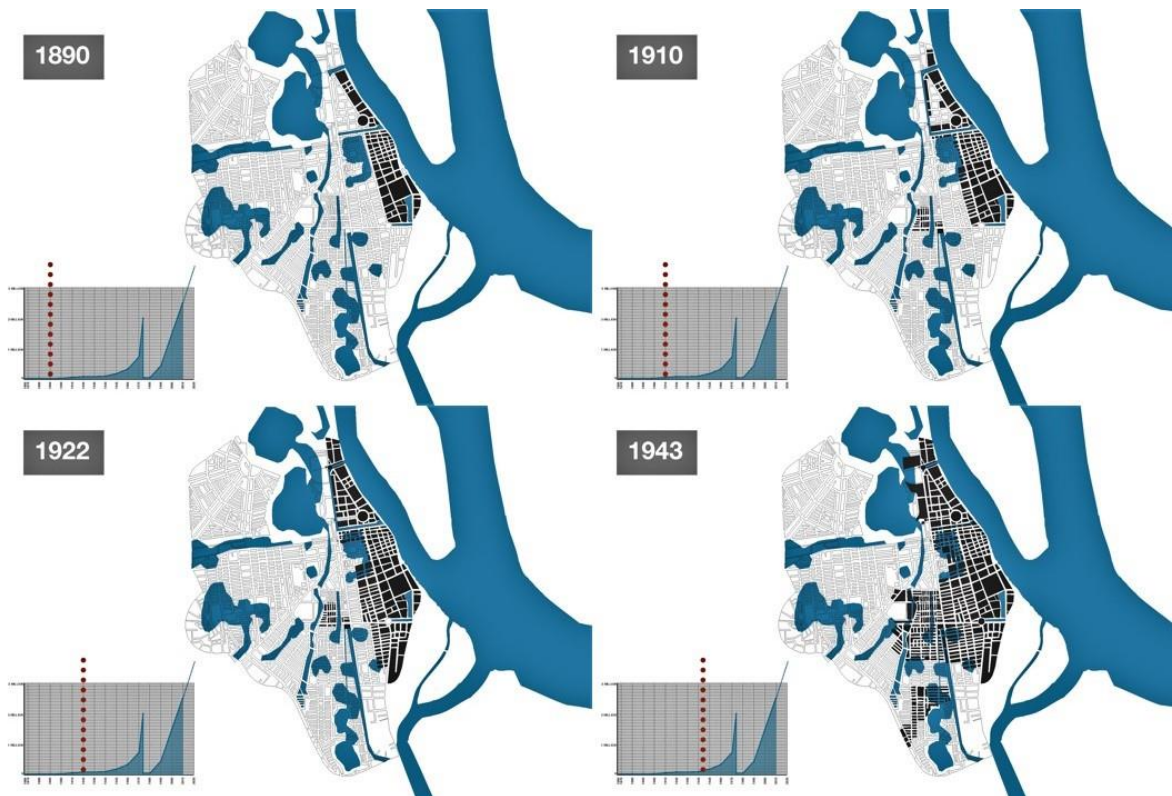


Figure. 26 PP in 1890-1943  
Source: Doyle. S, 2012.

### 1953-1975 (Independent-Pre Khmer Rouge)

Planning of land use based on flats

Airport, Olympic stadium

First urban planning was created

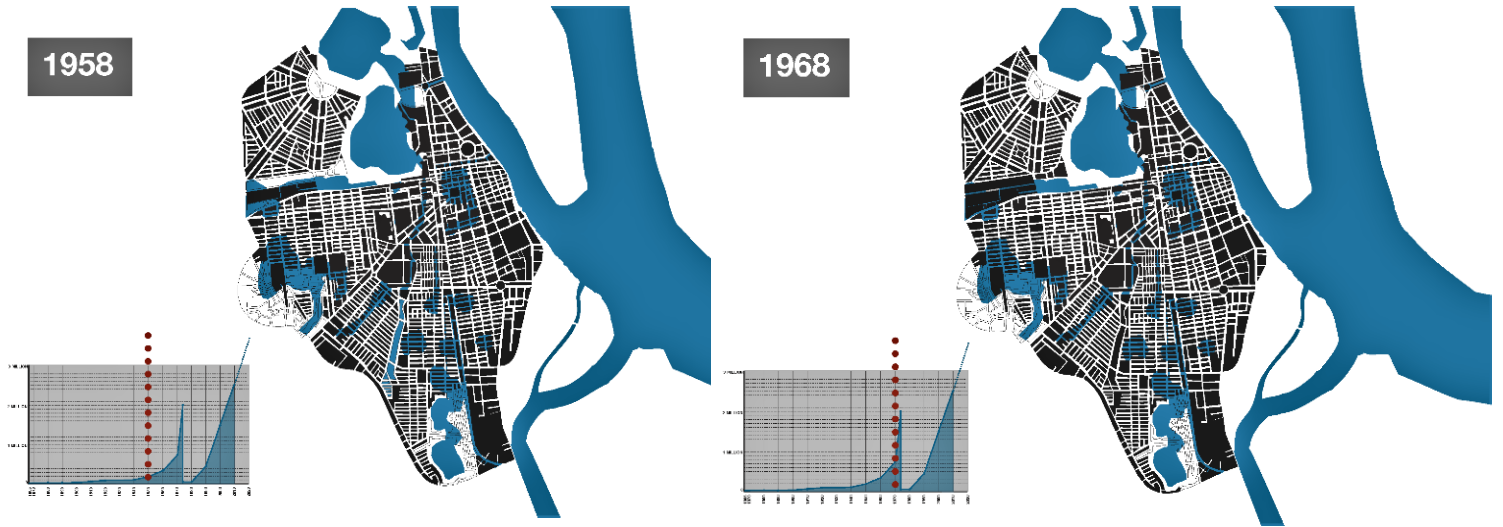


Figure. 27 PP in 1958-1968

Source: Doyle. S, 2012.

### 1975-1979 (Khmer Rouge)

Everyone were forced to leave their homes, the city was abandoned.

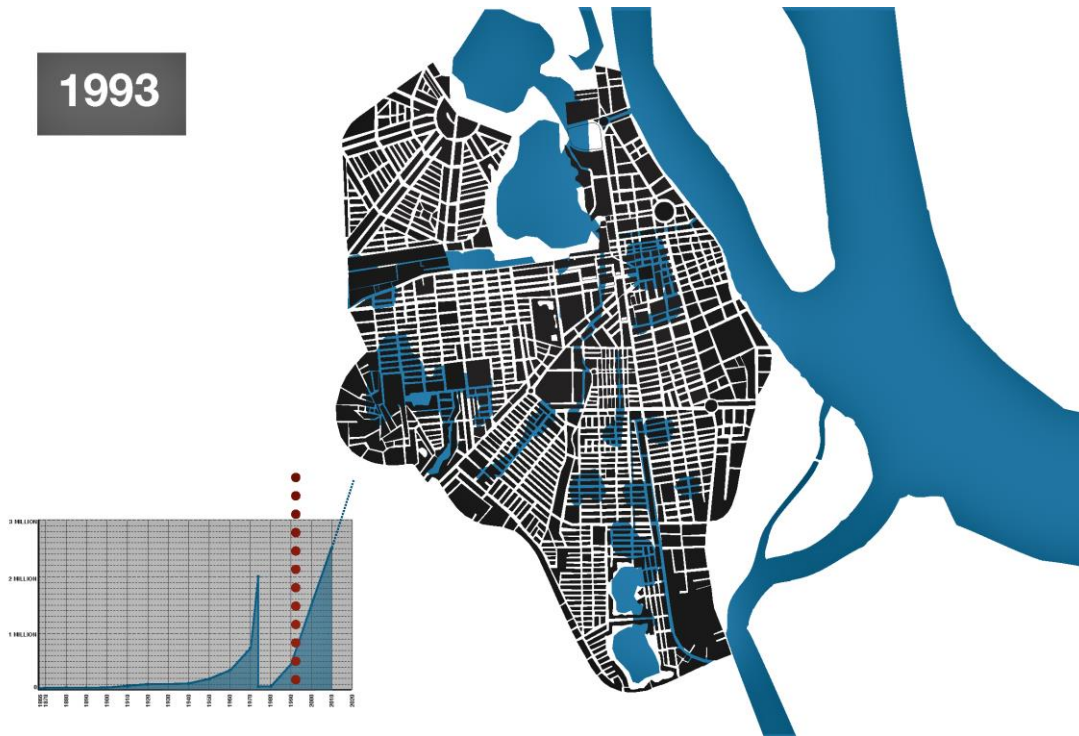


Figure. 28 PP in 1993

Source: Doyle. S, 2012.

## After Khmer rouge – Paris Peace Accords- 1990s

People returned to city shortly after the fall of Khmer rouge, Cambodia still involved in civil wars until Paris Peace Accords was introduced, the sign of peaceful appeared and in 1993 the country first election was prepared. Villas, Ministries, offices, markets, hotels were opened. Warehouses along the Mekong bank were replaced as gardens. With the international donations and investments, there were several projects. Firstly was the land reclamation from lakes, parks, and the rebuilt of boulevards/ roads. At the same time clean water, electricity, and the redevelopment of dikes outside of the city.

## 2003 – Present

Until 2003 the arrival of foreign investors have announced, satellite cities, high rise buildings, offices in general real estate was rapidly developed and land price was also increased. However most of the projects were attracted among foreigners only, because the majority were poor. Additionally, these rapidly development has considered as unclear urban planning and the impacts went to outskirts of the city, agriculture lands, lakes, canals were filled. The drainage system was destroyed, during rainy season the rainwater lead to flood. The municipality of Phnom Penh has implemented a master plan with roads zoning/ drainage system and open spaces. The municipality of Phnom Penh raised, as a city in flood prone area, urban planning with drainage system is prioritized. Nowadays, the city extended outside of the dikes therefore, pumping station and reservoirs are needed. The Urban Planning division has divided drainage system into these categories:

Rivers/ Reservoirs/ Swamp	Natural reservoirs and river play the most role in draining the city. There are pumping stations in some parts that could drain rainwater to the Mekong river. More importantly, plants in natural reservoirs improve the quality of water. Currently, Phnom Penh has no wastewater treatment plant yet. However, a comprehensive one is being built earlier this year.
Canals	Include, canal and stream, a major canal size 1.200.000 m <sup>3</sup> with a sufficient pumping station that could pump 20m <sup>3</sup> /se. It is necessary to keep lakes/ streams, land fill is not allow. Despite, lakes also an attractive place to build park and garden.
Drainage system	Wide range of sewer networks are built with large pipe. Until now there is 900 km.
Secondary network	Medium pipe are installed along several allies that flow into sewerage network.
Private network	It is probably sewer pipe, which built inside the owner property, the water flow from this to secondary network or primary canal in some areas.

Table: 8 Present drainage

## 9. Case studies

Singapore situated to tropical climate, similar to Cambodia. The average annual rainfall in Singapore is about 2,400 mm. There are no distinct wet or dry seasons as rain falls every month of the year. The two main seasons, the North-east monsoon season (from late November to March) and the South-west monsoon season (from late May to September) refer to the prevailing winds dominant at the time of the year. The transitional months (or Inter-monsoon period) separating the two monsoons are April to early

May, and October to early November. The topography of the main island of Singapore is undulating with its highest point, the Bukit Timah Peak at only 163 m above mean sea level. Much of Singapore lies within 15 m of mean sea level and the ground levels of some 30% of Singapore are less than 5 m above mean sea level. At a population density of 7,540 people per square kilometer, the country is considered 100% urbanized with 80% of Singaporeans living in high rise apartments. Singapore's average rainfall of 2,400mm per annum, whereas previously most of it would have soaked into the soil. The majority of the rain falls during the two monsoon seasons, November to March and May to September. Floods come by a combination of large rainfall, high tides and inefficient drainage, especially in low-lying areas. Usually the country faces flash floods that subside in few hours. Mostly floods impacts only minor inconveniences, Singapore has also experienced several major floods that have resulted in widespread devastation, as well as destruction to life and property. Many years ago, many areas in Singapore were easily flooded whenever it rains. Over the years, the former Public Works Department (PWD) or Ministry of Environment and relevant government agencies have upgraded and improved the drainage systems and the Singapore River tributaries to curb flooding problems during the monsoon seasons. In 1954, 50,000/ 1969 3,000/ 1978 1,000 people were affected by flood. Moreover, tide exacerbate up to 3m, in low lying areas were seriously impact. From 1960s in response, the government has implemented several flood alleviation schemes. PUB is a statutory board under the Ministry of the Environment and Water Resources. It is an agency that dealing with water supply, water catchment and utilized water in an incorporated way. PUB works with different organizations to enhance the drainage framework or raise street levels to lessen the danger of flood repeating. PUB connects with private owner on fitting flood security measures to shield their property from surges. It does repairs of canals, waterways and conduits, where fundamental, to guarantee that they keep on functioning viably. Singapore have been taking seriously on water issue, the catchment water involves collecting rainwater on a large scale. It stores rainfall into a reservoir, through a network of drains, canals, rivers and rain water collection ponds and sanitize for tap water, this tiny country have built 8,000km of sewage system. Overall, Water demand in Singapore is a hot issue, they take it seriously use it carefully, all water catchments also collect rain water, flood management then clean it to use. PUB announced at a groundbreaking ceremony to commemorate the beginning of construction for deep tunnel sewage system, which aims to create a network of 40km of deep tunnels and 60km of link sewers. Singapore is exploring the feasibility of constructing an underground drainage and water reservoir system which could mitigate the impact of climate change, flood prevention and act as a buffer against droughts. "During a storm, for example, tunnels could transport excess rain water from drains, drop the water down deep vertical shafts and store it in underground caverns" (Kotwani. M 2015). A pumped storage hydropower system would harvest the energy of the rain water in the tunnels as it makes the drop into the cavern. That stored energy can be reused when the water needs to be pumped out. Canals, drainage cleansing are normally tasks to do and conduits to coordinate the cleaning elements of open zones and to guarantee that the canals perform to their composed limits and stay free-flowing. It is finding a better ways to detect floods this monsoon season. A trial project in collaboration with A\*STAR's Institute for Infocomm Research, the flood detection system utilises image analytics technology to scan real-time PUB CCTV footage and detect images with flood waters. This will complement PUB's flood monitoring of about 170 CCTVs and 200 water level sensors, along with weather information, in the 24/7 PUB operations centre. "The automated detection of floods through the CCTV image analytics technology will aid in speedier alerts and quick response amidst increasing volume of data that comes in. Currently, PUB installed 208 water level sensors around the country for monitoring of the drainage system, key canals,

and water levels. These water level sensors provide data on water levels in the drains and canals, enhancing the monitoring of real-time site conditions during heavy storms and response time. Once the water level warning, an SMS alert system on the rising water level is now open to the public for subscription. This will facilitate more timely updates to the public on potential flash floods” (Pub 2018).

**PUB manages flood risks in three ways:**

**I Provide adequate drainage ahead of new developments**

- Plan and implement drainage systems and set aside drainage reserves based on current and projected land uses
- Implement flood alleviation projects to tackle and reduce the size of flood prone areas

**II Adopting flood protection measures**

- Stipulate the platform and crest levels required for new buildings and infrastructural facilities for flood protection purposes
- Raise low lying grounds / roads that were flood prone (in conjunction with redevelopment proposals)
- Advice on appropriate protection measures for older buildings

**III Making continual drainage improvement**

- Continually reviewing and improving drainage in flood prone areas
- Keeping the drains and waterways free flowing and to operate drainage facilities
  - Regular desalting of canals and rivers
  - Cleansing of open road side drains
  - Trapping and removing flotsam and debris
  - Pumping stations and tidal gates

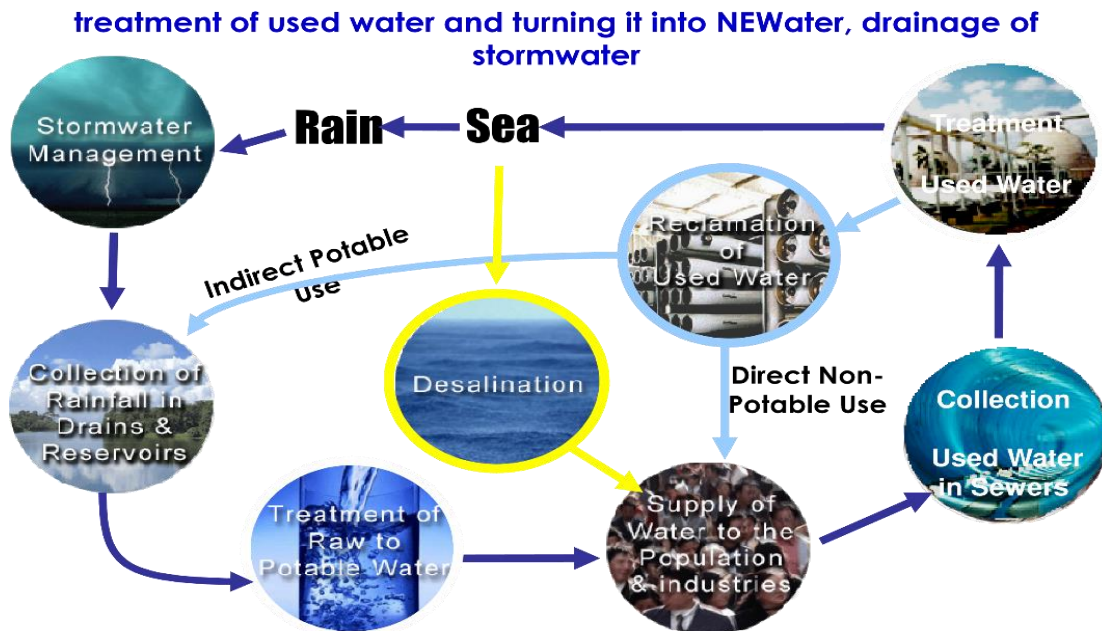


Figure. 29 Water treatment in Singapore

Source: Hua. D, Wen. L 2011

## 10. Project

### a. Site

Characteristic of choosing this district as a research study, because it is a flourishing new commercial areas, where, markets, malls, condominiums, offices, schools are located. Among the 12 districts in Phnom Penh, the 11-square-kilometre Chamkarmon has a population more than 200,000 people. Located in the city centre and is competing and rating with neighboring areas for both foreign and local residents as a premium zone. It is not a central business district, however it is the costliest area in Phnom Penh and also in Cambodia due to its central location and a favorite place for foreigners. There are few canals situate in this district, the first one is Lu teak syoy about 2.7 km long and 8 m wide, some part is covered with concrete due to its smell, so that it became an underground sewer system. According to the Paris Urbanism Agency, "it was likely built sometime between 1943 and 1958, during an era of urbanization efforts in Phnom Penh which included the rapid expansion of a system of dikes, landfills and other canals". This infrastructure was at first worked to elevate the city, enhance its living conditions. However the Canal, and in certainty the entire framework, has neglected to suit Phnom Penh's unchecked development over time. It was purposed to higher the city level from flooding, although rapid population growth gradually did away with the capital's ethnic zones for the locals. A Master plan of Phnom Penh divided zones as more barriers and canals were collected, depleting water into two critical lakes south of the city whose wetlands gave a characteristic filtration framework. Building a city of waterway and canals maybe good during 19th, anyway it set Phnom Penh up for the sorts long haul issues to deal with. Taking thoughts of the illumination and urban planning and forcing those thoughts upon a natural condition where they didn't look good has incited a huge amount of current day issues. In the 21st century, issues that began in the colonial era have have expanded exponentially as the city is filled in with concrete and covered with new materials like plastic bags, which which can easily block drains. A large amount of money spent, meanwhile, have been spent keeping up the Canal and its system of pipes and pumping stations. Patched up in 2002 to diminish flooding in Phnom Penh's swamp, the waterway has been utilized all through the most recent two years to pipe both water and sewage from enormous swaths of the city toward the southern edges, for unavoidable treatment at a future sewage plant. In the meantime, the Asian Development Bank invested \$4.7 million reestablishing it and its sister Toul Sen Canal as a major aspect of a gigantic task to refresh Phnom Penh's sewage system, which fell into decay under the Khmer Rouge. JICA has burned through \$75 million to improve Phnom Penh's sewage system. A critical piece of the financing spent on the Canal has gone to system to avoid flooding and keep up the flow of the canal to Phnom Penh's lakes, whose aquatic plants and morning glory farms have made a successful natural filter for the city's semi-treated sewage for as long as century and a half. Second is Steng Meanchey channel, there are open waterways that discharge water from Phnom Penh International Airport, Boeng Trabek and parts of Sen Sok district to it. At present, the canal begins from Boeng Salang waterway and keeps running from Stung Meanchey to Prek Hor Bridge, Kandal province. It is more polluted than the first canal, in light of the fact that there are industries nearby and usually filled to the overflow with rubbish and mud, stopping up the whole waterway and leaving fetid pools of sewage in different places in the city. The pollution influences the kids the most because they remain play around. People experience the effects of lung diseases, skin, eye infection, sometimes their eyes are so swollen they can't see. However, they believe, it is in the city easier to make their living and also cheap in comparison to other neighborhoods. Costing as little as €30 per month for a little space over the canal. Additionally, the nearby police here, working usually with the authorities, are presently beginning to clean-up this area, to unblock the drains

and to enhance the entire zone for the most part. Experts claimed, huge relocation from rural areas to the capital means progressively sewage is coursing through its canals and waterways. The canal is possessed more than 500 families, in excess of 400 Phnom Penh families living along the waterway will be granted land titles after development to the area's defunct drainage system takes place. It gets ready for another sewage system and canals all through Phnom Penh were reported by the Phnom Penh Capital Hall as a major aspect of the capital's 2035 Master Plan. The governor expects to form this canal into a concrete canal, and in addition different canals will work in a perfect manner that will be anything but difficult to manage. Moreover the authority enhances drainage to anticipate flooding that has influenced the areas for a considerable length of time. The system will be cleaner and will help the city arrange waste disposal. In rainy season rain water flow out of sewerage into then it flows further to Boeng Trabek. Therefore these two canals, play major role in draining the city, this area should not be a place where flood happen.

### **b. Weaknesses**

"It can be seen that in developed countries many of the problems of water supply, sewage treatment and control of the quantity of runoff in urban drainage have been solved. In the latter case, priority has been given to control by means of non-structural measures that oblige the population to control the impacts of urbanization at source. The main problem in developed countries is control of diffuse pollution carried by rain water. Whereas in developing countries the problem is still at the stage of sewage treatment. In some countries, such as Brazil, the problem of the water supply, which could be solved, owing to the wide coverage of the supply, reappears owing to major contamination of sources. This problem is caused by poor coverage of sewage collected and treated. There are actually many treatment systems and plants, but the proportion of untreated sewage is still very high. Owing to the contamination cycle, caused by an increasing volume of untreated sewage for a constant dilution capacity, the objectives also concern public health, since the population becomes contaminated by all the sewage produced by the city, that we term the urban pollution cycle. An example of this scenario is the city of São Paulo, Brazil, which is in the catchment area of the river Tietê and has a total water demand of some 64 m<sup>3</sup>/s. Half of the water (33m<sup>3</sup>/s) is imported from the Piracicaba river basin (headwaters in the Cantareira mountains). This is done because some of the sources near the city are contaminated by untreated sewage. The quality of the Billings and Guarapiranga springs is compromised. The quantitative control of urban drainage water is still limited in developing countries. The stage of controlling the quality of drainage water is still further off in those countries. In South America, as in most developing countries, the aim is to bring the quantitative impact of storm water drainage under control. For example, the detention systems built in the Brazilian cities focus only on controlling the impact of flooding, without tackling water quality control" (Tucci. M 2007).

Cambodia has abundant of water resources during rainy season and a water scarcity in some areas during dry season. The close proximity to the sources of water is both a blessing and a curse to the people. The water provide food and income for millions of fishers. Be the way, it additionally has a negative impact, when the water level ascents in the rainy season and prompts floods and pulverization in the encompassing. The frequency and seriousness of flood has expanded over the most recent two decades and has started to influence regions where flooding was once uncommon. Flood risk is similarly high in urban centers, and the fast development of urban areas, particularly those situated along the rivers, coastline, expands the presentation of people and advantages for flooding. The occurrence of

flood happen especially in low-lying regions when urban growth missed the extended the drainage and capacity of drains cannot cope with large amount of rain water, roads are covered by concrete also impermeable surface, and lessens the invasion limit of soils the subsequent increasing speed of runoff challenges the limit of urban areas to oversee drainage infrastructure. Insufficiently planned and manage urban areas also make new risks which threaten to erode current development. The absence of sufficient drainag and risky housing, inadequate and poor health services can turn natural hazard into a disaster. For example, poor waste management can make blockage water and sewage that can prompt waterlogging and flooding. The rapidly creating urban areas with a nonappearance of urban development, the rot and nonattendance of utmost of urban drainage and an extended rate of development on floodplains. In addition, the extending densities of population, close by the poor level of management and the limited effort of partners towards flood reduction are critical issues undermining possible efforts towards addressing the hazard. High density places are imperative impasse in Phnom Penh, subjecting the zone to lack of room for the heap of human exercises, which frequently shows itself in obfuscated human settlements, stuffing, slums and natural issue. Since urban development affects the environment, which in this way strengthens risks and vulnerability, strategies for building resilience include interest in waste and water management and the shirking of advancement in low-lying zones. Guaranteeing these strategies are actualized thusly depends on good urban and local governance. Although greater progress has been made in adjusting urban areas to climate change than reducing disaster risk, these endeavors have offered ascend to inventive urban practices with hazard decrease benefits. The continued advance of urbanization serves as a threat to the preservation of ecosystems through the fragmentation of the environments. This has resulted in the development of isolated green spaces in urban areas which segregates populations of different species. Therefore, the development of ecological corridors has become commonplace within policy environments. According to the Paris Urbanism Agency (APUR), "Ideal for trade, the site of Phnom Penh was less ideal for human settlement. Situated on a flood prone area, the landscape surrounded with rivers, lakes, and marsh. A town built up of raised wooden houses built on the water's edge or floating upon it to accommodate flooding and a royal decree that only the King could build on the land" (Hale.E 2017). Flooding is a common occurrence during the rainy season, not surprising, situating in several bodies of water, insufficient drainage system, garbage, and various physical factors; such as open spaces, built density and land use. Land use change could be leaded to flood consequently include a plenty of nearly interlaced process progression that make their analysis and the desire for any impacts at the catchment to scale significantly troublesome. Yet, with gaps in city planning, authority and regulation, the influx of development has carried with it real difficulties, including insufficient flood and waste management with the poor routinely bearing the effects. As mentioned above, Trabek lake was reliably redeveloped, and the rest of in threat of being filled. This would push wastewater further south, where another lake Tompun is being reclaimed to make a satellite city. Not surprising many regions in Phnom Penh were lakes and this capital has filled many lakes to meet the demand. Additionally, natural reservoirs, which traditionally absorbed the effect of floods are being filled to make sellable land. Often vegetation patches are placed under selective pressure through the development of man-made infrastructure. This process raises controversial human rights and environmental concerns of blocking waterways. The lack of comprehensive, strategic planning is a very big issue. Flooding is a main factor of poor urban planning and there is no reasonable advancement of flood risk mapping/planning. These hazards that occur are most times unavoidable but their impact could be reduced if the necessary circumstances are put in place. Social awareness, in Phnom Penh most enterprises considered that,

damage caused by floods is not a consideration for their business and the economy, even though minor flooding on roads is a frequent occurrence due to undeveloped drainage facilities in the city. In addition, because of lack of experience with natural disasters, their awareness of disaster risk is undeveloped. A comprehensive planning system in particular for land, soil, and water is missing in Cambodia at present as well as a land policy that brings the private rights and the state rights for these resources into equilibrium. The Land Law of Cambodia from 2001 was expected to be implemented to ensure an equitable, proper and efficient system of land management, land distribution, land tenure security, eradication of illegal settlements and land grabbing, and the control of ownership concentration for speculative purposes. To illustrate these are common factors which lead Phnom Penh to flood.

Financial problem	Cambodian is a developing country, no doubt the government has very limited budget, and mostly the government invest in building roads, bridges, and parks maintenance. "During the last decade, total development assistance to Cambodia amounted to about US\$5.5 billion. Cambodia obtained, on average, development assistance of around US\$600 million a year during the last five years, of which about 10 % is provided by non-governmental organizations or loaned from partner countries such as Japan, China, South Korea, and many international agencies ADB, WB, EU" (Ek & Sok 2008).
Weak government	The present city administration is now facing some constraints on urban planning. Phnom Penh divided into 12 districts each has to be responsible, and follow the same rules. However, the procedures are complicated and inefficient to regulate of certain aspects. Moreover, Cambodia is a corrupted country, everything is possible. There is a weak or non-existent anti-corruption policies. Many businesses gave benefit to the government for proceeding the documents or for properties, etc.
Land-use problem	It is not a very long time ago that the city has understood that the root of all issues, because the lack of the systematic city planning and city development. Since there is no powerful control on land use, the development and urbanization of Phnom Penh have brought about a haphazard, free-for-all pattern of land use. Houses, slums along rivers are mixed with commercial buildings and factories. A comprehensive city structure, zoning, building control, public utility layouts, and so on, cannot be drawn up. Horizontally, the city is spreading along the new streets that are opened up to suit the bigger urban population and business, industrial, and community demand - typical "ribbon development (Sebego.R2013).
Political problem	The economic has seemingly been the fastest among post-conflict nations, driven by the tenable reclamation of peace and security, vast public and private inflows, financial receptiveness, sensibly judicious macroeconomic administration, and a dynamic, coordinating neighborhood. An inheritance of history and little size is that the government has restricted policy space, despite the fact that this has not really hindered financial. Last election the government lost to the opposition party. In order to get the attention back

	and trust they tend to spend money for schools, roads, gardens (flood management is not prioritized). So that the voters may think the government developed a lot for the city. Moreover, huge migration from countryside to the city and settle illegally on the bank of the rivers/ canals/ swamps. The upcoming election will be in July this year, so the government gave land titles to these illegally settlers for having back votes.
Lack of cooperation	It was found that the failure of the implementation of development was partly due to the lack of people's participation such as; city level, district level and community level. The residents got a very little information about any development and they had no opportunity to tell their needs, give their ideas and show their interests. The authorities lost their trust among the most people due to corruption, weak governors and land disputes. In Phnom Penh, there are several state/ private investments for large scale properties, or infrastructures. Sometimes it is projected on the owner properties, so they are force to leave there homes, with small compensation. People always say development with tear. Therefore they aren't willing to change.
Lack of expertise	Specifically, in Cambodia there is no high education in Urban Planning. There is an Urbanization division in Phnom Penh Capital Hall, however, only few are specialized in this field. In spite of the fact that planning is multi-disciplinary undertaking, education by instruction is as yet required for a large portion of the staffs. Tragically, many staffs originated from various foundation with a little got degree in planning. Not surprising, there are foreigner expertise mostly French and Japanese come to plan and leave after they finish the project.
Waste management	Waste management is a big deal in Phnom Penh, nowadays the city made almost 2,000 ton/day. Nearly half or 40% of the households have no access to garbage collection, people believe, the city is struggling to deal with waste management as the city grow every day. For the poorest household's outskirts of the city, the figures are twice as high. An inefficient waste management, can be seen everywhere and led to illegal buried at informal dumpsites, on-site burning, and the accumulation of household waste in waterways, drainage systems, and community streets. The collected waste water sources, discharges toxic amid copying, harms people wellness, and diminishes the general livability of the society.

Table: 9 Cause of flood in Phnom Penh

**Legislative Systems for development including Land-use, rivers and building code.**

	<b>Laws/Regulations</b>	<b>Supervisory Authority</b>	<b>Matter</b>
Law	Law on land 2001	Under survey	Land use
Law	Law on Forestry 2002	Under survey	Forest
Degree	Sub-degree on community forestry management	Under survey	Forest
Degree	Sub-degree on river basin management (draft)	Under survey	Forest

Table: 10 Legislative Systems

Legal provisions pertaining to land use and forests are stipulated in the law on land and the law on forestry. Regulation for the development and use of river basins are to be enacted by government sub-degree. A draft of the document has already been published.

### **c. Evacuation**

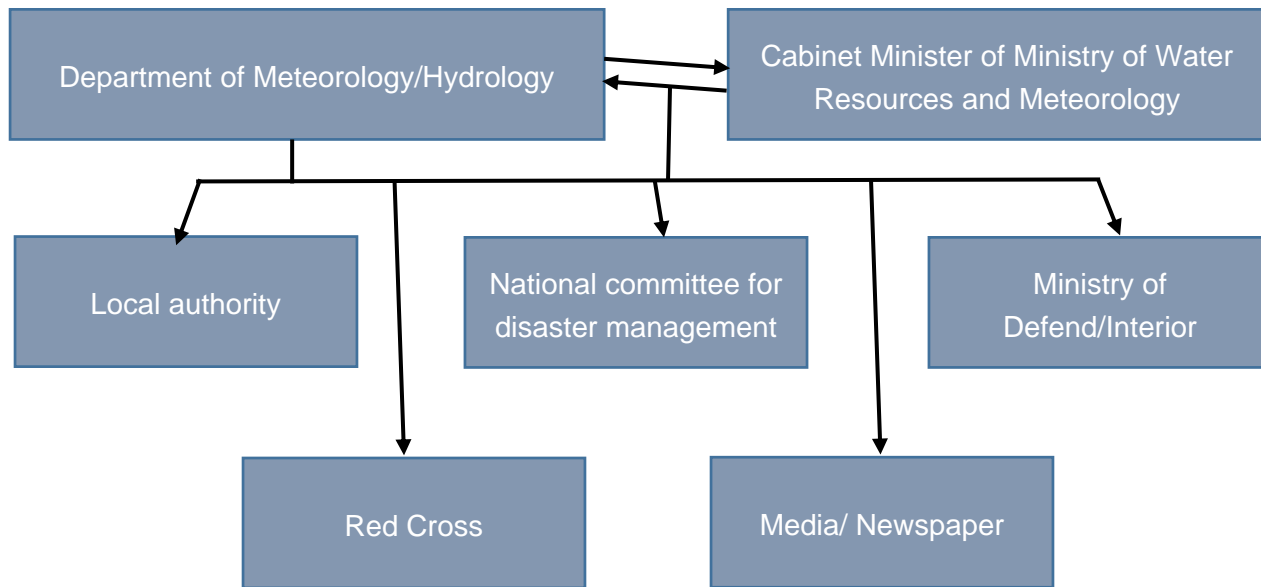
#### Preparedness

The successful preparedness response is to fortify strategies, specialized and institutional limits in national and local level. Also, the information innovation gives training course to enhance human resource and enhance technology. Related departments in ministry of water resource and meteorology give early warning information and weather forecasting. Government fund to get ready and audit the most recent data of disaster preparedness exercises, emergency courses of action at all levels, for example, evacuation training, access to vital food, non-food relief supplies in suitable way to affected people's needs. In ten years structure activity plan from 2005-2010 form the resilience of nation and communities, encourage the launch emergency funds to maintain response, recovery and preparedness measures. Particular systems are created to include the lively investment and significant partner exercises including networks, local people and country.

#### Warning system

The early warning message dissemination dashboard has been developed by People in Need for the National Committee for Disaster Management. "The system gives NCDM the capacity to send voice based alerts in case of a disaster in Cambodia. As indicated by a 2011 Ministry of Environment "following flood in 2010, 36% of people did not get any flood related information about the disaster and 72% percent of those who did receive alerts, got it amid or after the occasion had happened. In 2013, in excess of 1.8 million were influenced by rain crosswise over 20 provinces. Families were unprepared for the intensity of the storms, nor were they mindful how seriously the flooding would influence their families and their employments; bringing about a more noteworthy loss of lives and and more significant economic losses. "It was assessed that the total damage and loss caused by the 2013 floods to be over \$356 million USD, of which \$153 million spoke to the demolition of physical assets in the influenced zones, and \$203 million in estimated losses in production and economic flows. Thanks to financing from ECHO in 2013, People in Need with Open Institute, InSTEDD and Provincial Committee for Disaster Management (PCDM) guided the primary voice based, mobile phone early warning spread in 3 flood prone areas. Since that time the EWS 1294 System has kept on continued to expand into further areas of Cambodia. It is now completely dynamic in 6 disaster provinces with more than 50,000 users. Every Provincial Department of Disaster Management (PCDM) approaches this dashboard, which features potential disaster and enables to record and send messages straightforwardly to those people and families. The system has been formally recognized by NCDM and the Ministry of Posts and Telecommunications as a front line emergency phone service and the broadcast communications suppliers (Cellcard, Metfone and Smart) have all made the service freely accessible to everyone. NCDM and PIN intend to additionally grow the system all through Cambodia, with plans to reveal nationwide before the end of 2018" (MOWRAM 2018). To illustrate:

## Weather/Flood Information and Early warning processing



Source: NCDM

### d. Rehabilitation and Recovery

Rehabilitation and recovery framework is to apply the needs of affected communities for long term during 1-5 years. Small project promotes government and public transportation offer accentuation to projects of household asset. The recovery has been regrouped according to the duration of needs in the short term (0-6 months), medium term (1-2 years), and long term (1-5 years) (ADB 2010). The fundamental activity of government is to persuade farmer like planting the agriculture on time. There are numerous priorities, for example, transportation, horticulture, training, housing, water management. Recovery in farming is imperative frame to give seed, fertilizer, and equipment, in particularly with the potential risk on food security in the most effected regions. Reconstruction and rehabilitation of streets in national, provincial and local regions that were harmed by the flood have been developed of particular standard for street development and maintenance. Recovery education focuses on the school materials that were impacted, recording the quantity of impacts classrooms to decide short, medium, and long haul. "Housing, repairing and rebuild management of house destroyed and damaged in the short term and hazard-resilient construction in the medium and long term impact. To wrap things up, procedures that expansion the environmental resilience recovery included: building up the utilization of characteristic developing the use of natural resource management techniques to improve soil fertility and reduce soil erosion; cultivation of more land, and more efficient use of existing land; and increasing productivity of vegetable farming activities; rainwater harvesting or small water impounding system" (Mary. C 2016).

### e. The Humanitarian response

Both the government and the Humanitarian Development Partners reacted rapidly to the need of the affected families. The Royal Government of Cambodia got generous help with terms of either food and non-food stuffs or budget, from other countries and partners. "PCDM's system and Cambodia Red Cross

distributed the aid received in food and non-food items at local level. Flood risk management measure is to upgrade the resilience level of nearby neighborhood through a cycle of efficient activities: preparedness, emergency response and rehabilitation and recovery in policy strategies. In the strategic National Action Plan for Disaster Risk Reduction 2008-2013, developed in 2009, activities for disaster management have been distinguished and include: protecting areas from the dangers of flood and drought, empowering for disaster preparedness and risk reduction, and lessening the vulnerability of the poor to external factors including natural hazard. Starting at 2012 be that as it may, the activity design has not yet been actualized. The NCDM build up the Institutional Development Strategy, which stipulates the establishment of an effective inter-ministerial system of dealing with disaster preparedness, response, and rehabilitation for 5 years from 2001. The record in regards to the National Policy on Emergency Management and the National Contingency Policy for flood have not been discovered, accordingly insights about the strategies are unclear (HRF, CHF 2017).

## **11. Planning strategies**

Urban flooding has been and will continue being an enormous issue for the city. Noteworthy to the enhancement of the effects of these flood is the need to detail management strategies, which is driven by learning of the frequently and size of impacts. Inside the region of flood look into, tries are being enhanced to get a cognizance of the causes, impacts, and case of urban flooding. Yet moreover from rapidly sprawling, and spontaneous urban development that is outpacing the change of drainage system. Poor drainage are exacerbated by poor waste management, as uncollected waste regularly enters canals and sewers, causing blockages and limit the flow. For the most developing countries, flooding is more likely to occur if waste accumulates in drains, and blocked drains create insect breeding sites. Structural elements such as the incorporation of waste traps are an important design aspect of drainage systems. Innovation could decrease the development in flood zones; decrease runoff through change controls for flood mitigation; appoint courses and open spaces for better reaction and recuperation adaption, reduce impacts from unavoidable flood and suit urban development and expansion in flood safe areas including through resettlement and redoing. As land in city is highly demand, it is difficult to assign land purely for flood management purposes, it along these lines needs an elective use to guarantee that casual settlements don't show up. Most urban centers all around the globe are 60% to 90% impermeable, this is similar to Phnom Penh. Because of the absorption of rainwater have reduced gradually due to the expansion of urbanization (buildings, impermeable roads and lack of vegetation) therefore, small scale of drains cannot cope with and certainly there is no way to stop the rains or stop flowing surface water from bursting its banks. Urban flood management is a complicated system to do, it is required numerous partners; the government, private sector, NGOs and people. Among public awareness often discuss about the caused and blame the government by the filling in many lakes, on the other hand, it is just a factor. Compounding the issues of flooding is the lack of park or open spaces to absorb the waters. The inner districts are home to a series of formal parks and gardens but they are often hardscape, formally planted and home to decorative, rather than functional water features. Climate change is truly an unforgettable challenge, this is why flood is a cycle in which is needed to change condition, widen the project and planning horizons. Flood damage, unlike other natural disasters, can be reduced and mitigated to a certain degree by structural measures. Flood planning is a commitment and a challenge for the most urban areas. It could be argued that, flood is more likely to occur in delta regions, low lying areas. To mitigate the city beside structural measures, attention should also consider on surrounded areas like; wetland, reservoirs. Structural measures are not intended to give add up to security. This would require protection against the

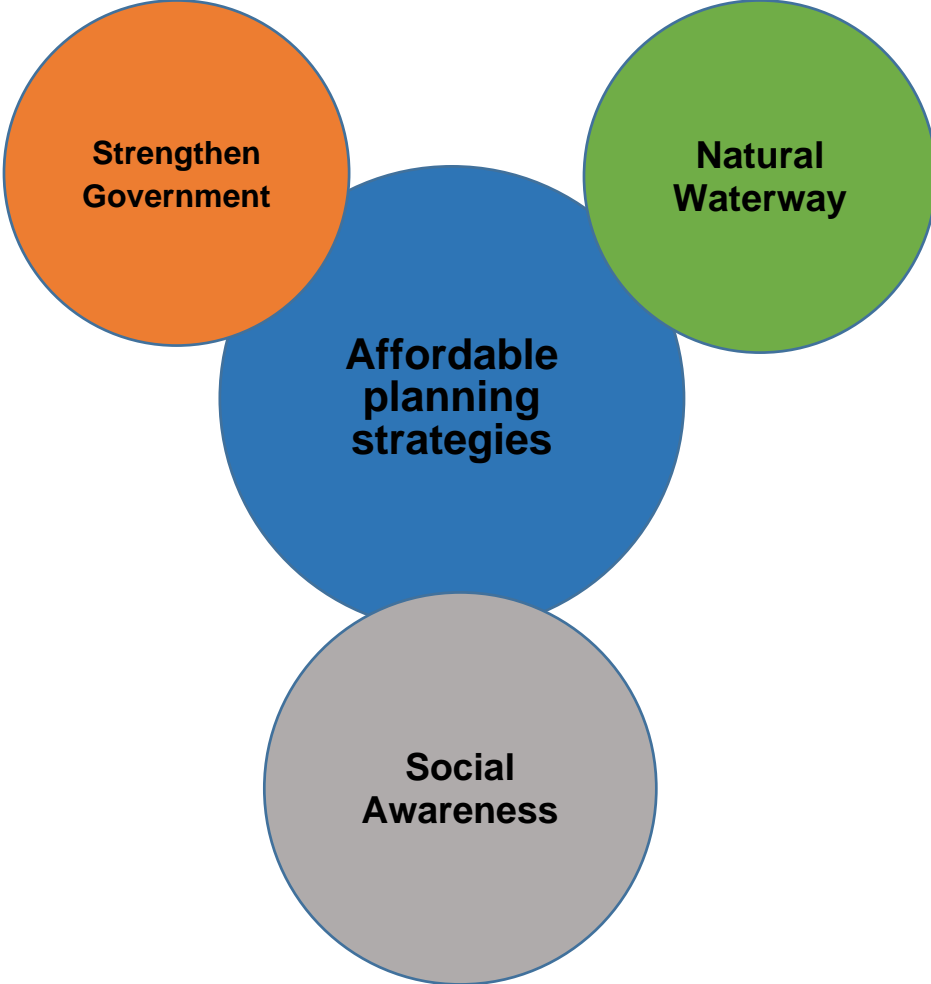
most astounding conceivable flood level. Such protection is physically and financially enviable much of the time. Non-structural measures, with or without structural ones, can essentially limit misfortunes at bring down cost. The cost of securing an area liable to flooding with structural measures is by and large higher than for non-structural measures. The cost of protection one fourth of the area was identical to the cost of implementing non-structural measures to ensure the other 75 % of the area liable to flooding. It measures are especially related to urban and architectural planning. For the non-structural measures to be effective, however, there must be a given effort and cooperation from people, as well as related government authorities. The measures have the aim of reducing vulnerabilities and developing the capacities of ecological systems to cope with floods through multi- disciplinary approaches. It includes flood risk mapping, land use zoning and planning, flood vulnerability assessment, flood proofing, flood modelling, institutionalization of policies, flood awareness campaign, flood forecasting, relocation of properties, resettlement of human population, and green infrastructure planning. Inside a satisfactory level of flood risk, land use measures must seek to minimize loss of life and property while maximizing net benefits from waterfront economic and recreational activities and ecosystem services; this adjust guarantees that communities not only survive, but also adapt and grow despite disruptions from flood disasters. Non-structural flood management strategies for relief focus upon safeguard action and depend overwhelmingly on conduct changes with a particular true objective to be practical. These are particularly pertinent in in low-income communities, where flooding is inescapable and assets for strategies are rare, reasoned that an all around facilitated and adjusted blend of both structural and non-structural measures is required as part of the long-term flood mitigation strategies. To control the zone, type, density, and timing of development through regulation, public infrastructure investments, market incentives, and conservation of natural resources such that development is safe from flood and in harmony with an economical urban water cycle. Another potential solution is to build streets with permeable surfaces that enable water to seep in and even grass to grow through them, accordingly streets would absorb less heat, although a few specialists have forewarned against measures that may expand the city's humidity excessively and thus worsen the risk of heat stress. Well prepared in such a complex setting requires the government, specialists and the resident, to ensure a completely successful project without tears. Measures, for example, waterway reclamation and tree planting intend to reestablish forms that have been influenced by human activities like cultivating, land management and house-building. "Natural flood management is an area of increasing interest for policy makers, but its implementation can present a complex balancing act between the needs of different groups, including the public, farmers and land owners" (Dadson. Dr 2017). A publication in 2003 by Dr. Jonathan Parkinson, "A key element for the successful implementation of non-structural rainwater management programmes is an inclusive approach, which promotes participation of stakeholders in the development and implementation of urban drainage plans. In this section, the importance of participation in non-structural rainwater management programmes is stressed, and these programmes are discussed in relation to the partnerships and institutional arrangements for management and implementation. Public participation is an opportunity for urban authorities to assess the social feasibility of rainwater management systems and flood response strategies. Experiences from high-income countries, such as the United States, demonstrate that urban runoff control programmes need public backing and involvement to succeed; a strong motivation to act is essential to the success of rainwater management projects. Urban drainage can't be created in isolation from the communities that they serve. Slum misuses also the linkage between the natural drainage paths that influence the urban infrastructure and environment of the city. "Depending on size and species, a single tree may store 100

gallons or more at least until it reaches saturation after about one or two inches of rainfall” (James. R. 2010). “When multiplied by the number of tree in a community, this interception and redistribution can be significant. When trees are combined with other natural landscaping, as much as 65% to 100% of runoff can be reduced in residential area” (Navar. J 1990). In this context, institutions should be viewed not just in terms of structures and systems but also in terms of the way they routinely think and respond to problems and issues. A research by (Commission for Architecture and the Built Environment Uk Based):

- Increasing the green space cover in urban areas by 10 % reduces surface run-off by almost 5 %
- Increasing tree cover in urban areas by 10 % reduces surface water run-off by almost 6 %
- Adding green roofs to all the buildings in town centres can reduce surface water run-off by almost 20 %.

**a. Potential solutions**

It is useful to have urban landscape it is a permeable surface with vegetation areas such as parks, gardens, remnant natural corridors. With Cambodia’s specific flood situation in mind, and the country’s existing capacity, it would be achieved through pursuing the following strategies:



Good governance	For the Royal Government, good governance is the most important pre-condition to achieve sustainable economic development with equity and social justice. Accomplishing good governance will require the dynamic participation and duty of all portions of the general public, improved sharing, responsibility, equity, comprehensiveness, the rule of law and anti-corruption is the most important in Cambodia. In order to gain trust among the people, anti-corruption is highly recommended so that people will respect the rule of law. Weak institutional capacity can multiply the negative impact.
People Participation	people's cooperation characterize as the taking part in an action, people with the authorities and private sectors in choosing projects and activities, setting needs and doing the undertakings as accomplices. It turns into a need to guarantee that cooperation by the commitment of their thoughts, premiums, work and time. Cooperation can be supported by the accompanying means; meeting, studies, the network of associations.
Land use	To lessen the underlying causes of flooding and guarantee proceeding with development, cities must organize risk based land planning. A risk based approach to land use planning is essential to urban areas in both developed and developing countries. "Land use planning to manage flood risks must adjust contending needs: it should try to maximize net advantages from waterfront economic and recreational activities and ecosystem, while guaranteeing least death toll and property through safe area, safe development, and safe activities. By supporting the spatial integration of "gray" (conventional) hard-engineered infrastructures with "green" infrastructure to manage water resources and protect against flooding, land use planning can help to create a balanced urban water ecosystem" (WB 2017).
Legislation and enforcement	<ul style="list-style-type: none"> <li>-Prior review, designation of flood risk districts, evacuation of disaster affect. Etc.</li> <li>-Requirement of integrated regulations and institution.</li> <li>-Develop categorical manuals or guidelines like the flood prevention standards for each district or building code.</li> </ul>
Phytorestore (Filtering garden/ Urban greenery)	This process was introduced in 2004 by a French man: Thierry Jacquet It is designed to create a set of playful garden, waste/rain water storage and filter. It reduces sludge production and limit CO2. In many urban areas, population growth and development are projected to continue. This will put greater demands on existing or shrinking, green space over the coming decades. Urban green spaces like parks, urban forests, rain garden and greenways are often not equally available to everyone. Many researchers have found the advantages of urban green space on natural conditions like lessen air pollution, reduce heat, more critically, urban greenery make better water management system that requires

	utilizing green foundation components in urban planning and reestablishing a portion of the rain-retention limit that urban areas have lost to urbanization.
Open space	It gives noteworthy advantages to the societies. These advantages incorporate ensuring biodiversity, improving psychological health, social interaction and cohesion. The significance and value of open space is likely to increase over time as a result of emerging pressures of population growth, demographic change, urbanisation and climate change. The cooperation between authority and community should be consider to fit the local needs. Open space could be playground/ public exercise space, square.
Preservation of water bodies	The water bodies such as rivers, lakes, ponds, sea coast in an area are important aspects as they have multifarious functions. It Controls urban flooding, preserving bio-diversity, recharging aquifers and adapting to climatic changes are the major ecological functions of water bodies. The degradation of water bodies can have multiple impacts on the local land and water ecosystem. The most pronounced is the urban flooding. Absorbing large quantities of storm water runoff reduces the incidence of flooding of nearby areas. This is done by the significant amount of small and large community ponds and private ponds. It plays a significant role for the water to flow, it was formed by the flow of water during flooding, it should keep as usual. The development projects very often ignore the conservation of water bodies and transform them into other developments. This is harmful for the nature and the flow of water.
Wetlands and reservoirs	The creation of more wetlands which can act as sponges, and provide a temporary storage for floodwaters. Soaking up moisture and wooded areas can slow down waters when rivers overflow. Ending deforestation and wetland, reforesting upstream zones and reestablishing harmed wetlands could essentially diminish the effect of flooding.
Vegetation roof	“Once established a green roof can significantly reduce both peak flow rates and total runoff volume of rainwater from the roof compared to a conventional roof. Green roofs store rainwater in the plants and substrate and release water back into the atmosphere through evapotranspiration. The amount of water that is stored on a green roof, and then evapotranspired into the atmosphere, is dependent on the depth and type of growing medium, type of drainage layer, vegetation used and regional weather. Green roof are increasingly used as an innovative means of rainwater management. It will intercept between 15 and 90% of rooftop runoff. Absorption of runoff into a green roof system will vary between 50-80% and is related to the type of growing medium and plant cover variability”. Besides, it is popular to improve urban environment and heat. (the green roof centre 2004).

Education	In Cambodia, drainage systems are choked with garbage and people have little knowledge of the effects that can have during a rain. Whenever the rain comes, waterways and culverts are trapped by garbage and debris, and water finds its way into the streets and into people's homes. Hence, education is important, to let people know how serious of flood is, and the cause by trapping the waterway.
Early warning/ announcement	As of late, the weather is ending up more flighty and less predictable, numerous zones are experiencing flooding. The early warning system framework will inform owners, businessman, and local authorities more time before a flood arrive so that they could response to it. An early warning system could give you sufficient time to set up measures to secure the property and belonging.
Permeable surface	“Traditional road construction, made with asphalt, gravel and sand, is a very compacted structure that leaves little space between the particulates, and thus no room for the rainwater to seep through” ( Apte. P 2017). Permeable surface works by having a permeable layer of concrete on top that allows water to drain through a matrix of relatively large pebbles into a loose base of rubble beneath. “Permeable concrete allows surface water to freely drain through the wearing surface to the underlying ground with the ability to act as a reservoir during periods of high downfall. It could not only help to tackle flash flooding in urban areas but may also help to reduce the heating of tarmac in hot weather. There are a variety of permeable surface, but Porous Asphalt is the cheapest one generally 15% to 20% higher and it is useable for bike land also. For highly traffic roads, pervious concrete would be an ideal” (McFadden 2017).
Elevate buildings	It is very common in rural areas in Cambodia, however, it is rare in the city. Elevating the structure over the base flood level implies the least living floor space is over the anticipated water. Elevate the ground floor past the floor line. Introduce pilotis or dock and enhance the internal floor or building by filling land. These are extremely basic way.
Rainwater harvesting	Managing, controlling and making use of rainwater within the vicinity of rainfall is known as rainwater harvesting. “Rainwater harvesting decreases peak flows as well as reduces flooding and the damages resulting from flooding” (Aballah.S, Ruzouq.R 2018). Every house in rural area, people harvest rainwater and use it as normal. It is different to the city because tap water is accessible 24/7 and rainwater is not recommend for human consumption, however it could be used gardening or washing.

Table: 11 Planning strategies

**b. Proposal**



Figure:30 Existing map ( blue line identified canals, rivers and lakes)

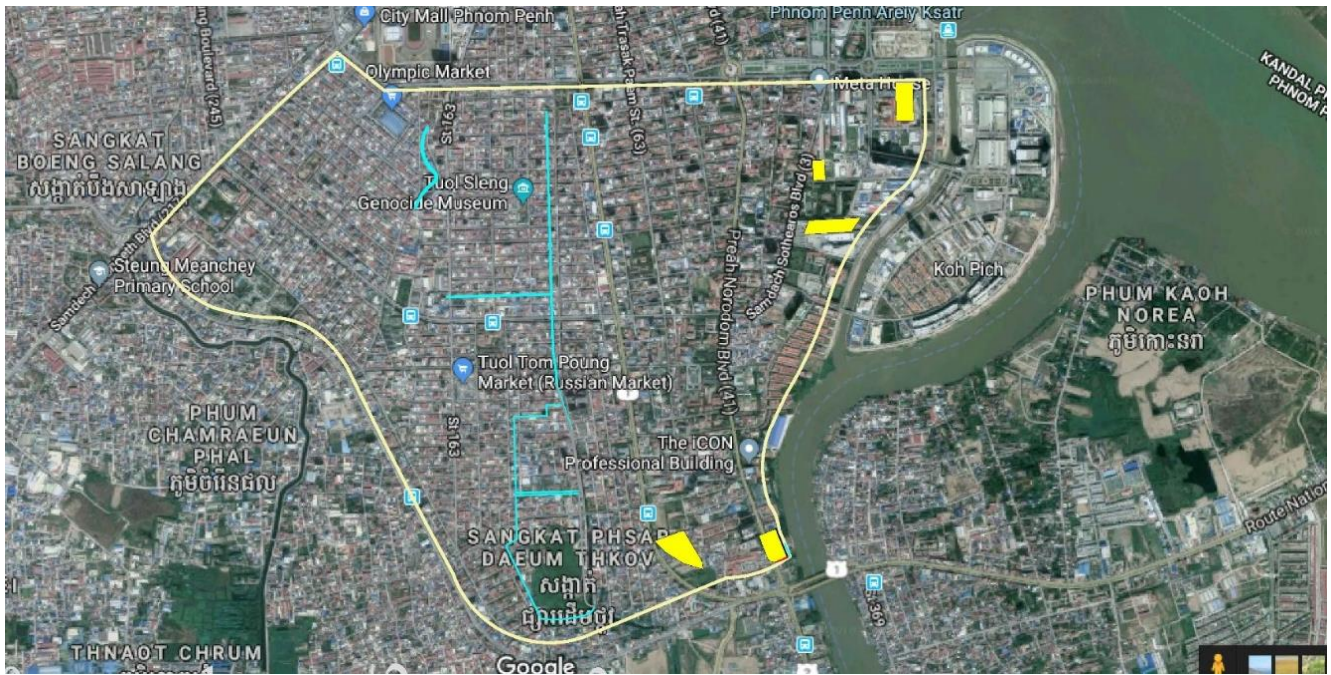


Figure: 31 Built up area  
Yellow parts are unbuilt zones, this total area is about 97% built

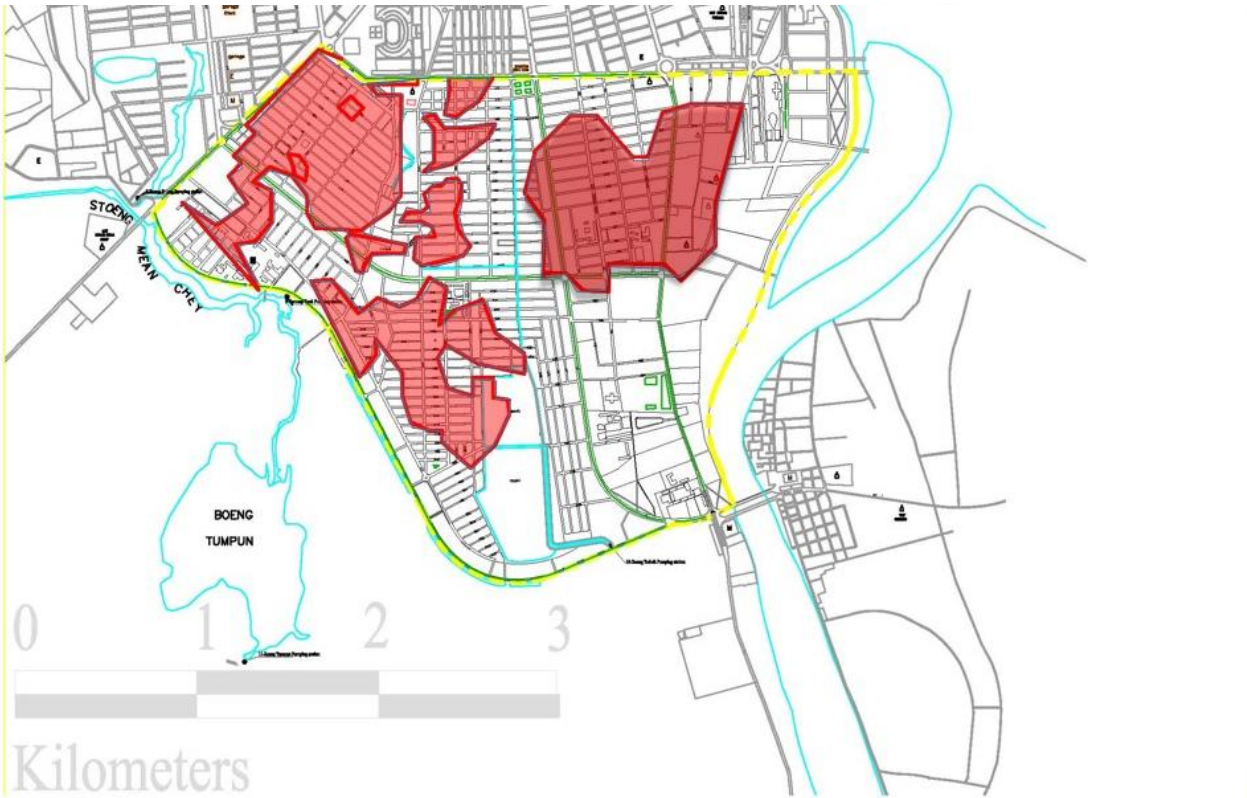


Figure:32 Flood zones shown in red about 40% of the total area are usually flooded



Figure:33 Propose green space (An increase of 0.5km<sup>2</sup> of green spaces) it is equivalent to the whole city parks and garden combine.

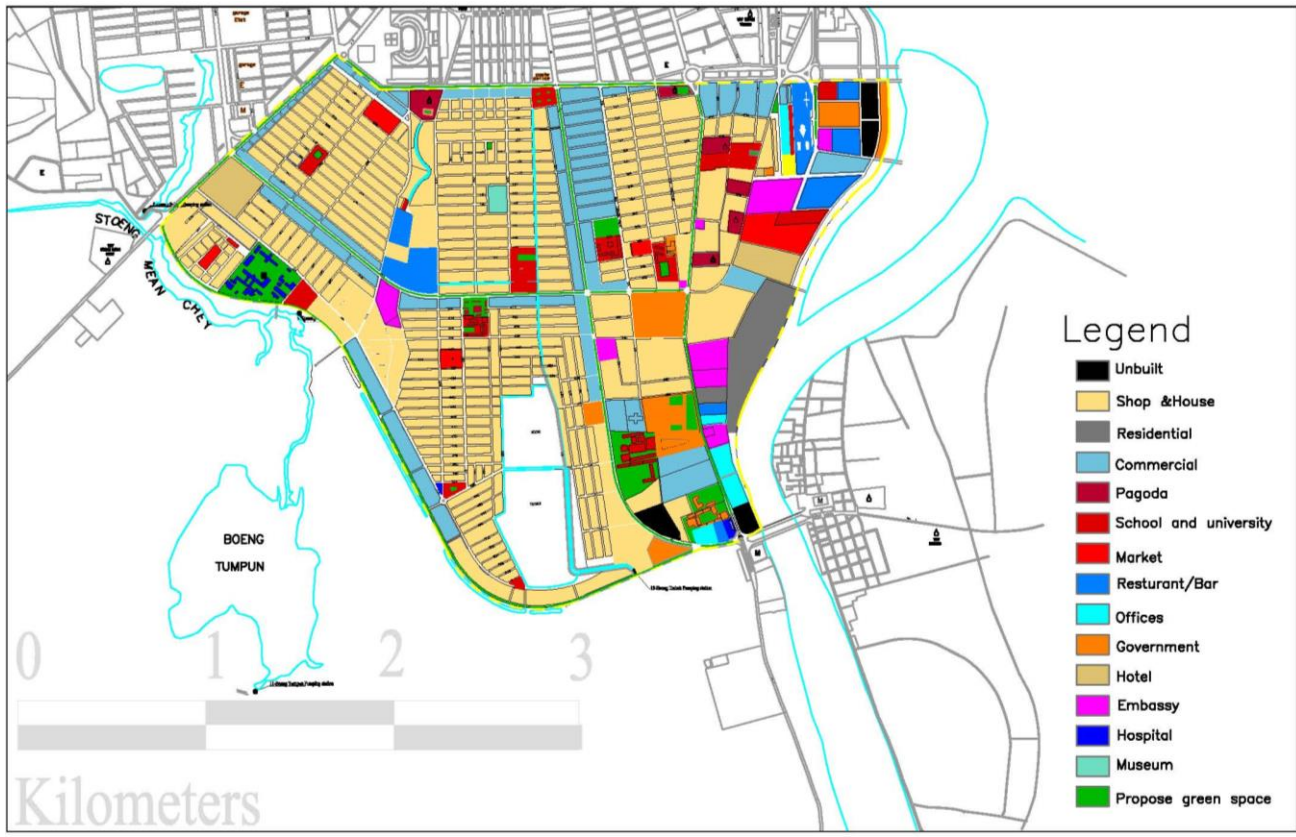


Figure:34 Propose map



Figure:35 Wetland (lake restoration)

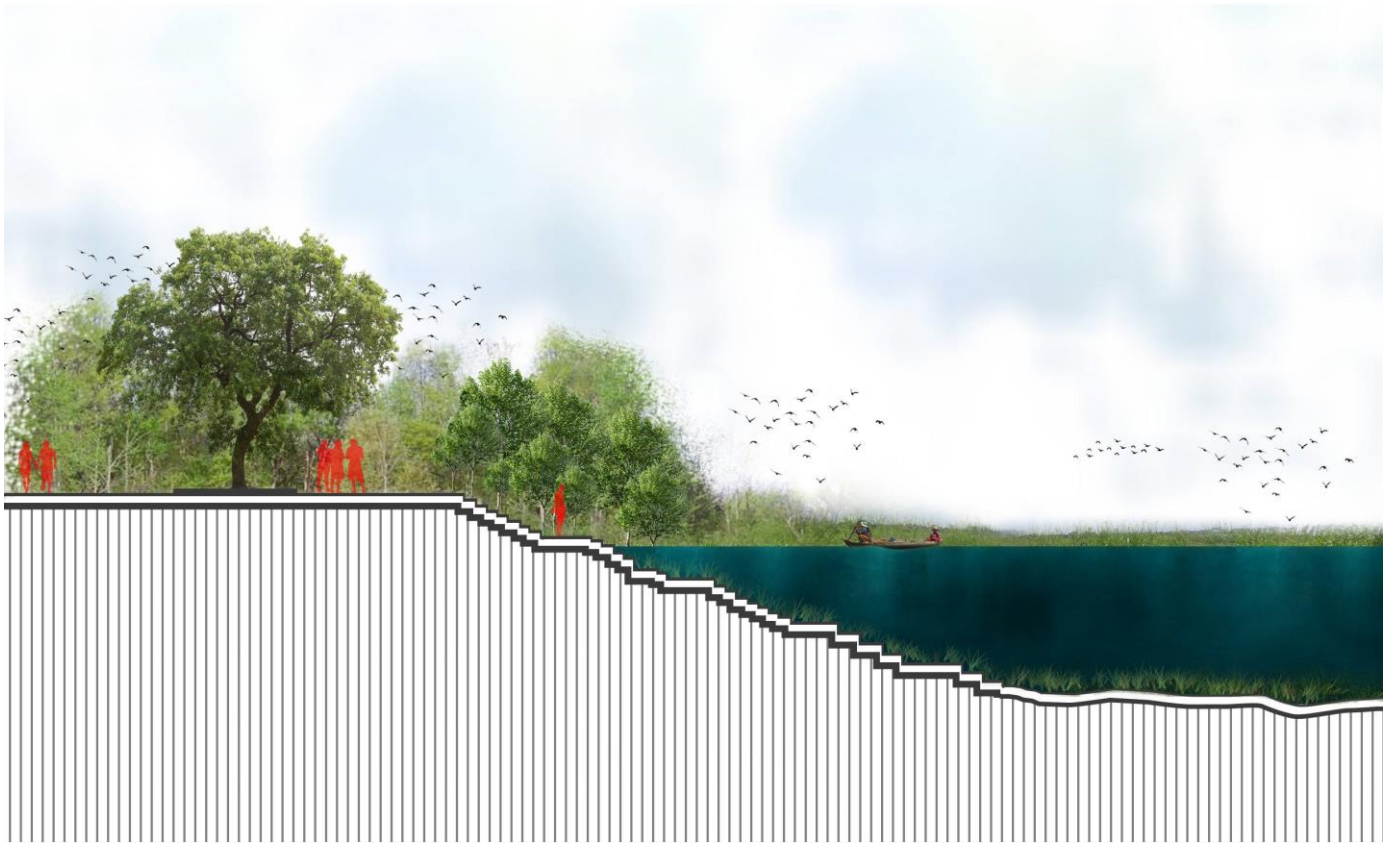


Figure:36 Wetland (lake restoration)



Figure:37 Mid-street green space

## 12. Conclusion

Cambodia has abundant of water resources during rainy season and a water scarcity in some areas during dry season. The close proximity to the sources of water is both a blessing and a curse to the people. It is a vulnerable country to natural disasters such as flood and tropical storm due to its low adaptation capacity. Moreover why Phnom Penh is at a high risk of flood is based on its geography, situated by many rivers, it is a flat also with many lakes surrounding. According to the Paris Urbanism Agency (APUR), "ideal for trade, the site of Phnom Penh was less ideal for human settlement. Located on a natural floodplain, the landscape was dotted with rivers, lakes, and marsh. Still, a town sprang up of raised wooden houses built on the water's edge or floating upon it to accommodate flooding and a royal decree that only the King could build on the land" (Hale.H 2017). It can be assumed that, the demonstrates of Phnom Penh's urban development is having a significant impact on the water systems in this region by filling lakes. Despite the fact that the city is 11.89 m over the river bank, monsoon season flooding is an issue, and the waterway in some cases floods its banks. It is progressively turning into a noteworthy issue for the nationals of Phnom Penh and has dependably been a piece of life in Cambodia. It is beneficial for agriculture, about 80 % of farmers or five million people are living along flood prone areas in Cambodia. "Over the past 15 years, more than 36,000 households have been affected, 2,569 residences damaged or destroyed and 39 people killed by flooding in Phnom Penh" (Sengkong.B 2016). In addition, one out of five households live below poverty line due to the impact of disasters. Some of the causes could be ascribed to unusual hydro-meteorological condition, but man-made factors such as changes in land use, the impact assessments or consultations of the people on this land leasing deal have never been implemented adequately. The development of the lake, filled in with dredged silt deposits, and are then rented or sold for urban and industrial purposes. Additionally, 15 out of 25 lakes in Phnom Penh have filled in, representing a loss of 60% of Phnom Penh's lake systems, this would push wastewater further south, where another lake Tompun is being reclaimed to make a satellite city. Experts said that flood risk has been elevated since they pumped the lakes for real estate developments. The revitalization of the lakes which served as a flooding area and a drainage system for central Phnom Penh, but were obstructed with garbage and household waste, is remarkable. In addition, the sprawling of urban areas, close by the poor level of awareness and the restricted endeavors of numerous partners towards flood chance decrease are basic issues undermining conceivable endeavors towards tending to the peril. High density places are noteworthy impasse in Phnom Penh, subjecting the zone to lack of space for the myriad of human activities, which regularly shows itself in muddled human settlements, overcrowding, slum, pollution, illegal structures, and other social and environmental disorder. The continued advance of urbanization serves as a threat to the preservation of ecosystems through the fragmentation of the environments. This has resulted in the development of isolated green spaces in urban areas which segregates populations of different species. To be sure for the most developing countries have problems of water supply, sewage treatment and control of the quantity of runoff in urban drainage have been solved. "In the latter case, priority has been given to control by means of non-structural measures that oblige the population to control the impacts of urbanization at source. Meanwhile, an insufficient drainage system that's frequently clogged by residents' garbage or blocked by construction can't get rid of the water quickly enough" (Tucci.M 2007). Overall, this demonstrates that Phnom Penh's urban development is having a significant impact on the water systems in this region. In Phnom Penh the sewerage coverage ratio is 20%, with the coverage ratio decreasing considerably in the area outside it 10 km radius. There is

about 732 Km of drainage in total and 44,807 wells. In Phnom Penh, inundation damage is frequent. This is because the maintenance work was not conducted on storm water drainage facilities during the civil war from 1970-1980, causing and the drainage capacity to be decreased. As a developing country, no doubt the government has very limited budget to develop the city and mostly are loaned from non-governmental organizations (NGOs) or from partner countries such as Japan, China, South Korea, and many international agencies (ADB, WB, EU). The lack of comprehensive, strategic planning is a very big issue, in particular for land, soil, and water is missing in Cambodia at present as well as a land policy that brings the private rights and the state rights for these resources into equilibrium. Take a look at the legislation and the strategic foundation for flood management, it is cleared that there are too general and several authorities involve in. In case there is an obstacle, no one tend to take responsibility. What is similarly vital, if not more in this way, is the change in the administrative structure of regional city governments. It is already well known that city governments in Cambodia are local governments under the supervision and control of the Ministry of Land Management Urban Planning and Construction. Even though all districts operate under the administration of Phnom Penh Municipality, whose executive officers are directly elected by the local people, these authorities (districts) still come under the strict control of the Ministry of Land Management Urban Planning and Construction as to their fiscal and administrative autonomy. Without sufficient self duty in monetary and in addition regulatory issues, the city governments can't play out their people's needs in their regions. The challenge is under control of the Ministry of Land Management Urban Planning and Construction. Until there is a change in the self-governance of city governments in Cambodia, administration of the urban zones will keep on being moderate and hesitant. Additionally, most urban centers all around the globe are 60% to 90% impermeable, this is similar to Phnom Penh. Because of the absorption of rainwater have reduced gradually due to the expansion of urbanization (buildings, impermeable roads and lack of vegetation) therefore, small scale of drains cannot cope with and for sure we cannot stop the rains from falling or stop flowing surface water from bursting its banks. People should have free space to enjoy, learn, interact and socialize. Yet only 0.66 square kilometers of Phnom Penh are officially public parks, representing only about 0.1% of the entire city, and mostly are in downtown. Although the city's outskirts for now have plenty of open space, none has been designated as a public space. This is cleared that the country in dire need of flood management strategies and to strengthen flood forecasting. In particular, knowledge of flood risk planning to help in drawing up solutions. Control of flooding aims to mitigate the population being affected, in rainy season the river naturally leave their minor beds to occupy their flood plains. Generally speaking, the objective of this thesis is to illustrate the impacts of flood in daily life and to find suitable solution to address the issue in the capital city of Phnom Penh. After going into deep to study this issue, I could assume, flood is very important to study about, it is a hot issue happening all over the world, due to the effect of climate change as a result it is even harder to estimate when will it be happened and how long it lasts. It is overwhelming to study about flood, because it is a natural phenomenon nothing cannot stop, and however it is possible to minimize the damage. Not only the least developing country such as Cambodia, but even developed countries such as Singapore, Australia and most of the European countries still working on to mitigate. And finally I found the most challenge which is a major obstacle to manage flood in Phnom Penh, I am convinced that government plays the most significant role to develop to control the city, government has the most power, unfortunately, weak government enforcement lead to numerous problems, from uncontrolled city development by filling lakes, to corruption and to waste management. That is the main reason, Phnom Penh is more and more vulnerable to flood.

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