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Risk Management of Flood: The Case of Thailand

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The 2011 Thailand Flooding Crisis can be studied using a Risk management framework. The aim of this paper is to perform demonstrate a simple risk system approach for this crisis. This includes suggestions for the government to improve on qualitative planning issues like future flood prevention, flood early warning systems, preparedness, emergency response protocol during crisis, flooding mitigation systems arrangement and lessons learned. A review of flooding risk assessment on evacuation procedures and financial risk engines for insurance industries will also be included. This aims to put a prevention system in place in order to help reduce number of deaths, affected people and number of casualties. The purpose of this paper is to reduce the effects of flooding in the future in areas where scientific and engineering predictions of rainfall and flood management are feasible and human issues of planning and risk management are better structured.

Field of Research: Risk Management, Flood Management, Flood Risk Management

1. Introduction

A Risk Management (RM) framework is proposed with regards to flooding in Thailand. The introduction of flooding RM aims to reduce risk for future causes of flooding and to help the government and people become increasingly aware of the various ways the infrastructure and management system is exposure to a wide range of risks and the need to better manage such exposures will help the country devise better strategies, preparation and an early warning systems for flooding. Every measure of reducing risk which involves the human lives and livelihoods must be delicately designed with good gap analysis, adequate operation concepts, and well construct simulation method. The use of an operational RM system is new methodology to help reduce decision risk and lead the flooding RM in the real world practice.

There are four sections in this paper. The flood management with definitions and the exposures to Thailand flooding disaster is introduced first in the next section. The methodology and theoretical of operational risk implemented for this case study will be found and highlighted in the following section. The introduction of flood RM and the framework will be discussed in the forth section. The last section will summarise and conclude this study.

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2. Literature Review for Flood Management

In any risk study, the first thing we do is to understand the definition of the problem we are facing and the methodology we are using. The two terms we are facing here are “Flooding” and “Management”. The latter term is defined as managing risk in uncertain times. Flooding is defined as “an overflow of an expanse of water that submerges land” (Brandon, 2011). In general, there are two primary causes of flood. The first is related to human failure including the intentional or accidental failure of operations to control floods at a dam or an embankment system. The second is to do with the natural causes including long periods of heavy rainfall, high tides, high water flow rates, high sea water levels and climate changes. This new study of 2011 Thai flood is mainly due to the former reasons.

A catastrophic natural event like flooding is found throughout the world, and people have learnt to live with floods more than they have learnt to live with earthquakes or tsunamis. Thai people as a whole nation had managed floods by learning to live with it for centuries. This included helping each other than waiting for the help from external like local and central governments. This illustrates how it is possible for societies and nations to manage floods in a more strategic way using either quantitative or qualitative measures. We summarise the main causes of this flood event in this section.

2.1 Flood Disasters

Amongst the world natural disasters, flooding is recorded to cause about a third of the world’s economic losses and the dead also claimed to be more than half of all natural disaster-related deaths. The death rates due to floods have grown significantly around the world. Information provided from international media such as websites and newspapers reported that there have been catastrophic floods in many part of the world. In 1998, China experienced with its worst Yangtze River flood in 40 years resulting in 3,074 dead, 15 million homeless, 180 million people affected and $26 billion in economic loss. Historically, floods in Northern China have led to devastating death tools. The flood casualties of 1911 announced to 100,000, 145,000 in 1931 and 142,000 in 1935. The greatest number of death in China however happened in 1642 when 300,000 died when disaster was inadvertently caused by the government rather than natural causes (Wales, 2011).

In Thailand, the number of dead victims reached 602 by early November. and resulted in more than 700 casualties at the end of 2011. More than 2.3 million people (in a country with a 64 millions) were affected; with the majority living in Bangkok and Ayutthaya Provinces. This experience was the worst flooding in more than 50 years. More than 13.6 million people and 815 casualties were affected. This incident caused significant financial losses equivalent to $US 5 billion in less than 100 days and economic loss estimated to be about $US 45.7 billion (Tang, 2011).

In Bangkok’s flooding history, there were 7 major floods recorded from 1917 (known as the flooding of the Year of the Snake) until 1996. It has been predicted that by 2015, Bangkok will be one of the 23 cities known as “World Mega-Cities” with a population exceeding 10 million. If the flooding continues to worsen with no better

prevention system in place, then it is highly likely that even more people will suffer significantly from 2015 onwards.

2.2 Flood Mapping

Flood mapping is used to increase public awareness and provide information on high and low risk zones and to help reduce risk to people property and the environment. It is the responsibility of both local and central governments to set proper plans for high risk zones and to determine which should be sacrificed to help drain flood waters away towards the rivers and canals in time.

For example, after the failure of risk control in blocking water from three provinces: Ayutthaya, Pathum-Thani and Nonthaburi. Bangkok Post newspaper on 21st November said that the "Thai government decided to sacrifice 7 more Eastern Bangkok areas to drain massive amounts of floodwaters from the 3 provinces to save the city of Bangkok". This meant that the government planned to distribute the water flows of up to 120 million cubic metres per second to these 7 districts. One of these districts included "Don-Muang" international Airport which was already flooded in late October. It was also the first locations that the government decided to use as an emergency flood relief operations centre with 4000 affected people living in one terminal building.

The planning of this is vital. The management model must concern the optimum outcome of this decision as it could significantly cause damages and harm the residents in those areas. It is estimated that the Chao Phraya River can discharge less than 200 million cubic meters of water per day while the government attempted to divert floodwater via east and west of Bangkok which can drain only about 86 million cubic meters per day (Brandon, 2011). A good risk model can measure whether indeed the government made the right decision towards the zoning, the planning for the flood maps.

3. Methodology for Operational Risk Management

In RM study, risk is divided into three main types namely the market, the credit and the operational (McNeil *et al*, 2005). Operational risk is often used for organizations in particularly known as the enterprise risk or sometime refers to integrated risk. It had been increasing recognized by practitioners for managing risk within an organization over the last decade (Lam, 2005). Risk is usually refers to exposure of uncertainty or the chance of loss in any event (Surapaitoolkorn, 2011a). Basel II, 2005 defined operational risk as "the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events, and therefore includes legal risk and excludes strategic, reputational and systematic risk". With this definition we define flood management to be within the scope of operational RM.

3.1 Measuring Operational Risk

Measuring risk in any organization involves quantitative skills. Amongst the three main risks mentioned, operational risk is known to have face difficulties when it comes to measuring as it is almost impossible to derive the loss distribution to measure human error either by accident or intention (Surapaitoolkorn, 2011b). It is

still a challenge for BASEL II to provide several terms of quantification for operational risk. At present in order to assess or measure the impact of a loss occurring due to any particular risk, there are two dimensions used to capture losses in operational risk:

(1) Probability measurements such as the number of times flooding is likely to happen per year, perhaps once per year normally around August till December, with its peak in November and the conditional probability of a flood hazard in the affected area.

(2) The severity, measured in monetary units. The vulnerability of the area to undesirable consequences and economic loss from floods.

Once these two dimensions are captured then different risks can be measured against each other. Measuring of operational risk under the BASEL II accord for capital requirements are known in the banking area as (i) Basic Indicator, (ii) Standardised and (iii) Advance Measurement (Allen *et al*, 2005). This can use as a guideline for new policy risk within the Risk Appetites process explained in subsection 4.2.

3.2 Managing Operational Risk

Managing operational risk seemed to be possible and easier than measuring risk. However, case studies with real world events are not easily made available. This paper is the first to use Thailand's 2011 Flood as a case and aims to provide an operational risk framework that can be studied further and enable practitioners, engineers, risk specialists, Thai nation and Thai government to make use of this well researched resource.

To avoid social problems that could arise from the communities and societies, Figure 1 displays the 4 classifications of operational risks for flooding management that should be considered:

(1) *People*: School closures, workforce disruption, shortage of water and basic food such as eggs, rice, and bread, sand bags, water pumps, medicine and boats which led to the suffering of numerous people. Immediate supplies should be provided to those affected people quickly and efficiently.

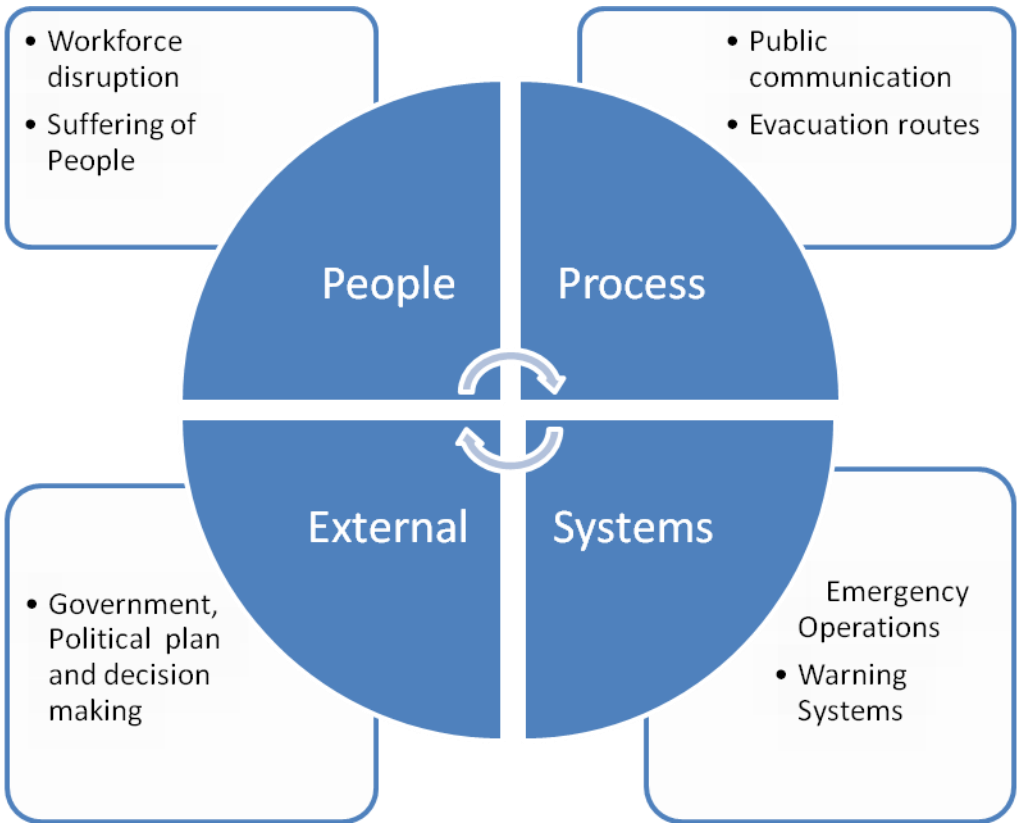
(2) *Process*: Public communication and education about flood risk and protocol should be available to local people in all flooding areas. People need to be educated in particular young people about flooding disasters. Evacuation route plans must be supplied and provided for people before or during the flooding period for emergency operations. Failure to do so occurred frequently in current Thailand flooding disasters and thus should be improved significantly with proper planning and communication processes.

(3) *External*: This refers to the need for both local and central governments to prepare and maintain flooding defence infrastructure. Announcements should be clear and adequate regarding their decisions about water gateways, flood water flow directions and to what area should be sacrificed, and for what reasons, and

what forms of compensation should be offered. Political interference should be avoided to ensure smooth and efficient flood management.

(4) *Systems*: Flood mapping needs to be assessed to provide easy to understand warning systems and for emergency rescue operations. Red, Amber, Green (RAG) are the processes that usually use in operational risk assessments. Risk Appetite can be introduced and used to perform in areas with high, medium and low risk of flooding respectively.

Figure 1: Types of Operational Risk for Flooding Management



3.3 Further Work in Risk Management

Allen *et al*., 2005 highlighted that all risks are often correlated. After flooding; catastrophe bonds must be derived in insurance industries within the financial risk area. Van *et al*., 2005 found that loan interest rates towards housing, car, and credit cards can be flexible for customers in credit scores framework, and thus the government should help those affected people in the 7 sacrificed areas by lower their interest rates for credit loans to prevent failure in banks with retail and small and medium sized enterprise (SME) clients. The impact on individuals, families, communities and industries need to be fully reported. It is only by preparing these risks and getting real data on the scale and facts of the problem that we can mitigate the impact of future flood.

4. Flood Risk Management Analysis

Flood RM aims to reduce the impact and likelihood of floods. Woods, 2001 defined RM framework as "the culture, processes and structures directed towards the effective management of potential opportunities and threats to the Government achieving its objectives". The aim is for all government staffs and people to develop the necessary skills and experience to be able to work through five steps of RM framework below.

4.1 Flood Risk Identification

Flood Risk identification must consider a project plan: damage and harm due to flooding must be classified into categories where specific action could be taken to address the risk. Risk assignment to the central government (who has sufficient authority) and the Bangkok Metropolitan Administration (which implements the plans) for its monitoring and management must be carried out. Examples of five most common risk categories for flooding are displayed in Table 1.

Table 1: Examples of Flood Risk Identification

N^{o}	Risk Category	Example
1	Political	-Decision making about water gate ways -Failure to communicate between central and local governments
2	Macro economics	-Unemployment -GDP decreased significantly.
3	Micro economics	-Industries and SME collapsed -Workforce disruptions
4	Environmental	-Waste disposal, -Climate change, Diseases
5	Financial	-Insurance (establish catastrophe bonds) -Bank non-performing loans (from housing and small business loans)

4.2 Flood Risk Assessment Results

After risks have been identified, they are grouped and ranked according to the likelihood of their occurrence and their expected impact. Let us consider the 4 P's risk types with risk scores on the impact and likelihood scales of 1 (lowest) to 10 (highest) in Table 2. Impact can be classified in term of costs "how expensive to recover" and output "ability to meet objectives" with high, medium and low indications. Likelihood suggests the frequency of its occurrence. For example, the political risk is extremely high with risk score of 10. This indicates that there is a lack of confident or trust with the current government in dealing with flooding management for this event. Policy risk is low with score of 1 where advance risk measurement is unlikely to happen in this country, a basic indicator has more potential to occur. A more efficient method that could be used for further work is where probability distribution is well specified for each risk types.

Table 2: Examples of Flood Risk Assessment Risks

Risk Type	Risk Appetite	Impact	Likelihood	Score
Political	Lack of confident or trust	High (extremely)	Significant	10
People	Self assessment to floods survivor	High	Occurred throughout the whole nation	9
Policy	-Basic Indicator -Standardized -Advance Measurement	High Medium Low	-Potential to occur -Likely to occur -Unlikely to occur	8 5 1
Propriety	Finance/Insurance failure with unexpected loss of homes, car, businesses	High	Occurred throughout affected area	9

4.3 Flood Risk Monitoring

The key elements in flood risk monitoring processes are as follows:

- Maintain and update with full statistical data records of at least 10 years of the country's annual rain fall, and the capacity and water in/out flow rate of different, reservoirs and dams. This data should be available for public use; and even online if possible.
- Figure 1 should be reviewed per year for a proper risk assessment plan.
- Conduct external Risk reviews by local/central governments to help recover and regenerates the environment and economic activities in the flooded areas of 20 out of 50 affected areas in Thailand.
- After the flood recede, a review of the flood management activities should improve the process, and planning for future events in all affected areas and more generally, elsewhere must be performed.

4.4 Flood Risk Control

Lam, 2003 discussed that a change to proactive flooding management requires not only risk identification and risk assessment but also establishing of policies of flood risk control of the following *5 P*'s strategies:

(1) Prevention: Industries and housing constructions should be avoided in Red and Amber zones. Green zone is optimized for a better green living with good environments.

(2) Protection: Quantitative and qualitative measurements must be used to reduce floods like estimating the maximum flow of flood water with the consideration of water flow rates, capacity of dams in all locations and sea levels together.

(3) Preparedness: Provide adequate information about flooding, the risks involved and steps to handle the flood.
(4) Planning: Emergency response plans in case of severe flooding must exist long before the flood appears. Recovery plans should also be considered and announced publicly after the floods.

(5) Population: After the floods, people need to return to normal conditions as soon as possible. Lessons learn from flooding will help mitigate social and economic impacts and on the affected population.

4.5 Flood Risk Model

A Flood Risk Model needs to be well established, capable of forecasting floods. The first step in any time series, statistical, and forecasting modeling in both theoretical and application is the gathering of data (Wilmott, 2007). With flooding, the information such as rain fall, capacities level of water gates and dams, history data of water flows in and out of each dam; radar stations, the position of water tunnels, urban population, floods map, landscapes, water flow rates, river basin levels and climate changes must be taken for data analysis.

The final step is to consider appropriate models used for the optimum solution in flooding risk. The key questions we must consider are:

- The time period preparation before the next flooding.
- The time taken for the arrival of flooding before it reaches each district.
- Capacity of draining from each water gate station should not exceed the optimum level.
- Decision of draining water levels must be considered together with sea levels for the optimization of draining capacities.
- Efficient direction of water flow to avoid high level and wide spread flooding.
- Water flow rates at above and below dams in locations North of Bangkok must be fully justified.
- Once the flooding takes place, the model should be able to estimate the right height of the flooding level and to exactly how long the floods will remain.
- The amount of water flow and draining system must be integrated to avoid prolonged flooding.

If we decide to use a probability distribution based on the normality assumption then all of above will be treated as parameters. If we like to try the non-normality assumption like extreme value theory (the common approach used for earthquakes) then higher dimension of estimation method must be proposed. Furthermore, a Bayesian approach might be useful for the estimation of more natural posterior parameters such as sea level versus the draining water level from water gate. A stochastic process can also be introduced for the movement of water, water gate, sea level and climate change.

5. Conclusion

It is possible to provide a good operational risk system to prepare for Thailand's future floods. Such a system can also be applied to other countries as well. The optimum solution to reduce and forecast floods so that mitigating measures can be taken in time is an implementation of adequate quantitative flood risk model. This is difficult but *possible* where experienced statisticians and scientists authorized, and are given the responsibility to do so, in hopes of reducing not only the number of dead and affected people, but also economic and financial losses. The government should be responsible for all decisions made regarding areas that were sacrificed and a proper flooding management procedure established during the time of this disaster event. The lessons that should be learnt to avoid future floods are to ensure thorough and adequate preparations under a risk framework as suggested in this paper.

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