Changing Climate; Bangladesh Facing the Challenge of Severe Flood Problems;
A Comparison of Flood Management between Bangladesh and the Netherlands

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ABSTRACT

Both Bangladesh and the Netherlands are the most flood prone countries in two continents Asia and Europe. Bangladesh is known to be highly vulnerable to floods. Frequent floods have put enormous constraints on its development potential. Unfortunately, the frequency of high intensity floods is increasing every year. So far the country has struggled to put a sizeable infrastructure in place to prevent flooding in many parts of the country with limited success. Where, the Netherlands has developed a massive success in their flood management. The paper will represents the present flood management situation of the two countries Bangladesh and the Netherlands and by making comparison of flood management between these two countries, give some recommendation for further flood management. Historically Bangladesh has developed the flood management laws but lack of implementation and continuous inconsistencies of these laws make Bangladesh backward in their flood management, in compare to the Netherlands. Bangladesh has been practicing the construction of earthen flood control embankments is an established practice for protecting people’s lives and homes, agriculture and infrastructures since the beginning of flood management. Where, the Netherlands has developed spatial construction to control flood and different strategies have been implementing to minimize the flood hazards according to their needs. On the basis of overall present situation in Bangladesh, the paper also tried to suggests some solutions to minimize the extent of flood hazards in the long run.

Keywords: Bangladesh, Netherlands, Flood Management, Climate Change.
Acknowledgement

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CHAPTER ONE

1. Introduction

1.1 General Discussion:
Worldwide harmful industrializations and increasing world population are changing climate. The severity of natural disasters such as storms, drought, rainfalls, floods and other natural calamities have been increasing in Asian countries and particular in Bangladesh. As a result of climate change threats on agriculture is increasing day by day which is the backbone of Bangladesh. Natural disaster has been increasing an adverse impact on Bangladesh, touching every corner of the poor country. Bangladesh as a poor country has not enough capacity to mitigate these adverse situations. With a limited resources they have take some measures to reduce the damages. Flood is a recurring phenomenon in Bangladesh. It is now understood that catastrophic floods have major adverse consequences for development of the country. Unfortunately, this country is likely have to face more devastating and frequent floods in the future, especially under the threats posed by projected climate change and sea level rise (global warming of 1.4° to 5.8 °C, on average, and sea level rise of 9 to 88 cm, on average, by 2001 are in prospect according to IPCC Third Assessment Report), which would increase flood risks, among other consequences, in temperate and topical Asia. And, given its location and climatic conditions, Bangladesh is at the forefront of the projected climate change and sea level rise and their consequences, particularly increased flood risks, both in terms of frequency and duration.
1.2 Research Questions

- What instrument used to protect floods both in Bangladesh and the Netherlands?
- What are the national plans to mitigate this worse situation?
- By comparison of both two country’s management techniques find new policies and strategies and use it to the future as flood control measures.

1.3 Methodology

The study has been carried out on the basis of hydrological data analysis, literature review and various international and scientific journals. River discharge, water level and rainfall data of various stations for different years were collected from Bangladesh Water Development Board (BWDB). Analysis of rainfall situation was made using rainfall data and images of rainfall pattern available in the internet.
CHAPTER TWO

2. Theoretical Approaches to Flood (risk) Management

2.1 Introduction
Flood protection has always received much attention. There is always the possibility of flooding. But how serious is this danger? It is difficult to say. Especially shortly after a (near) disaster the situation is perceived as unsafe. Embankments and water defences protect the country. Yet, there is no such thing as absolute safety against flooding. The question is what risks are acceptable and which ones are not. This is an ever-recurring socio-political consideration, which is fed by developments in the state of knowledge. In the last decade of the 20th century methods have been developed to determine the probability of flooding and its consequences.

2.2 Flood Management
Flood management is the process of assessing risk from flooding and after that using this information to implement appropriate management measures. These measures may be the construction of flood defenses, early warning systems or the development of policies which reduce flood risk. Thus flood management is the complete process of flood mitigation including flood risk management [42].

2.3 Flood Risk Management
Flood risk management in a narrow sense is the process of managing an existing flood risk situation. On the other hand in a wider sense, it includes the planning of a system, which will reduce the flood risk, Figure 1. Risk
management for the operation of an existing flood protection system is the sum of actions for a rational approach to flood disaster mitigation. Its purpose is the control of flood disasters, in the sense of being prepared for a flood, and to minimize its impact. It includes the process of risk analysis, which provides the basis for long term management decisions for the existing flood protection system. **Figure 1: Risk Management Options**[50]

Continuous improvement of the system requires a reassessment of the existing risks and an evaluation of the hazards depending on the newest information available on new data, on new theoretical developments, or on new boundary conditions, for example, due to change of land use. The hazards are to be combined with the vulnerability into the risk. The vulnerability of the persons or objects (the ‘elements at risk’) in an area, which is inundated if a flood of a certain magnitude occurs, is weighted with the frequency of occurrence of that flood. Risk analysis forms the basis for decisions on maintaining and improving the system, which is the second part of the operation of an existing system. A third part of the management process is the preparedness stage, whose purpose is to provide the necessary decision support system for the case that the existing flood protection system has failed. Even if the system always does what it is supposed to do, it is hardly ever possible to offer protection against any conceivable flood. There is always a residual risk, due to failure of technical systems, or due to the rare
flood which exceeds the design flood. The final part of operational risk management is disaster relief, i.e. the set of actions to be taken when disaster has struck. It is the process of organizing humanitarian aid to the victims, and later reconstruction of damaged buildings and lifelines [50]. Thus flood risk management is like to be similar as flood management but flood risk management is a process of flood management. Flood risk management is a way of how flood management should be developed.

2.4 Risk Based and Reliability Based Design
The risk-based hydraulic design is a procedure that evaluates alternatives by considering the trade-off between the investment cost and the expected economic losses due to failures. Specifically, the conventional risk-based design considers the inherent hydrologic uncertainty in the calculation of the expected economic losses. In the risk based design, the design return period is a decision variable instead of being a pre-selected design parameter value as with the return period design procedure [25].

Reliability analysis methods have been applied to design hydraulic structures with or without considering risk costs. Risk costs are those costs items incurred due to the unexpected failure of the flood defense and they can be broadly classified into tangible and intangible costs. Without considering risk costs, reliability has been explicitly accounted for in the design of various flood defense systems, such as storm sewer systems, levees, dams and spillways and storm surge protection work. The goal of a reliability analysis is to establish the probability of failure of the dike ring. Reliability-based design depends on the availability of a pre-defined failure probability requirement. In a situation where acceptable safety levels are defined in regulation, the acceptable probability of failure can be defined by
comparing the cost of protection to a characteristic value of the consequences of flooding. In a purely economic sense this leads to risk-based cost-benefit analysis [25].

2.5 Cost-benefit Analysis

The basic principle of cost benefit analysis (CBA) requires that a project results in an increase of societal welfare, i.e. the societal benefits generated by the project should exceed the costs of it. Every effect of an investment project can be systemically estimated and, wherever possible, given a monetary value. In addition, the cost-benefit analysis gives an overview of distribution effects, alternatives and uncertainties, since an overall assessment by politicians and others requires complete information [48]. This requires that all relevant effects, also the intangible effects, are taken into account. However, in the analysis of the costs and benefits of projects in practice, the analysis is often narrowed to the consideration of tangible monetary effects. An example is a study on the costs and benefits of six flood management projects [49]. In such a “limited” cost benefit analysis the economic benefits of an activity are compared with the costs of the activity. If the benefits are higher than the costs, the activity is attractive (it generates an increase in economic welfare). If the benefits are lower, the activity is not attractive. In flood management this means that the costs of measures for increasing the safety against flooding (for example dike strengthening of flood plain lowering) are compared with the decrease in expected flood damage. In the cost figure different types of costs have to be included: costs of investment (fixed and variable) and the costs of maintenance and management. The benefits include the reduction of damage costs, which are often subdivided in direct costs (repair of buildings and interior damage), costs of business
interruption of companies in the flooded area, and indirect costs outside the flooded area (mainly due to business interruption. It has to be noted that companies outside the flooded area may also benefit of the flood due to transition effects. Also the potential economic growth due to improved flood defence should be taken into account in a full cost benefit analysis. It can be stated that, a cost benefit analysis can provide significant rational information to the decision makers [35].
CHAPTER THREE
Case Study Bangladesh

3.1 Introduction to the Problem of Floods in Bangladesh:

3.1.1 Bangladesh: A General Overview

Bangladesh is a South Asian developing country located between 20°34’ to 26°38’ North latitude and 88°01’ to 92°4’ East longitude with an area of 147,570 sq km (Figure-2 Shows the location of Bangladesh). The country has about 156,050,883 (July 2009 est.) populations and it is one of the highly dense populated countries in the world. It is bordered on the west, north and east by India, on the south-east by Myanmar and on the south by the Bay of Bengal. A network of rivers are consisting of the Ganges, the Brahmaputra, and the Meghna and their tributaries and distributaries criss-crosses the country. The whole country consists of low and flat land formed mainly by the Ganges and the Brahmaputra River systems except for the hilly regions in the north-eastern and south-eastern parts [1].

Flood is a common problem in Bangladesh. Almost every year flood causes enormous damages to the people and the economy of the country. Floods of
different types and magnitudes occur because of the country’s unique topography and geographical location. At least eight extreme flood events occurred affecting about 50-70% of land area during last fifty years. Due to the floods economic losses were very significant, e.g. in two consecutive floods of 1987 and 1988 flood damage was estimated at US$ 2.2 billion and in 1998 flood damage was estimated at US$ 2.8 billion. Flood management in Bangladesh is, therefore, perceived as an indispensable component of poverty reduction initiatives [2].

About 80 percent of Bangladesh is composed of the floodplains of the rivers the Ganges, the Brahmaputra, and the Meghna as well as their tributaries and distributaries with very low mean elevation above the sea level; the rest of the country is made up of hills and elevated lands. Only in the extreme north-west land elevations exceed 30 meters above the mean sea level (MSL). There are two uplifted land blocks, known as the Madhupur and the Barind tracts, with elevations between 1 and 5 meters above the adjoining floodplains. In some places, however, they reach up to 25 meters higher than the adjoining floodplains. Hills along the northern and eastern borders of the country have elevations ranging from 10 to 1000 meters above MSL. In general, these hills have very steep slopes; certain areas have moderate or gentle slopes [2].
3.1.2 Hydrology of Bangladesh

Being a unique hydrological regime, Bangladesh has been divided into seven hydrological zones. A tropical monsoon climate with dry winters. Most of the annual flooding is caused by heavy monsoon rains. It has 230 rivers among them 57 are trans-boundary rivers (See in the figure-3). Three large rivers systems e.g. Ganges, Brahmaputra and Meghna, in the world covering a combined total catchments area of about 1.7 million sq. km. extending over Bhutan, China, India and Nepal flow through this country. Out of these huge catchments only 7% lies in Bangladesh [3].

3.1.3 Land Types of Bangladesh

It is better to have a look into the land types of Bangladesh to understand the flooding and flood management. Seasonal flooding regime has been characterized by means of inundation land types. The table 1; below shows the main cropping patterns by dept of flooding and land types (under normal flooding) and changes that can occur in irrigation. The impact of flood control and drainage is to reduce the flooding depth and to make it possible to grow higher yielding cropping patterns. Usually, it is classified into 5 categories which are the based on that used in the national water plan.

Figure 3: River system of Bangladesh [7]
Table 1: Land Types, Description & Area [4]

<table>
<thead>
<tr>
<th>Land Type</th>
<th>Description</th>
<th>Area in ha</th>
<th>% Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Land</td>
<td>Land above normal inundation</td>
<td>4 199 952</td>
<td>29</td>
</tr>
<tr>
<td>Med. High Land</td>
<td>Land normally inundated up to 90 cm deep</td>
<td>5 039 724</td>
<td>35</td>
</tr>
<tr>
<td>Med. Low Land</td>
<td>Land normally inundated up to 90-180 cm deep</td>
<td>1 771 102</td>
<td>12</td>
</tr>
<tr>
<td>Low Land</td>
<td>Land normally inundated up to 180-300 cm deep</td>
<td>1 101 560</td>
<td>8</td>
</tr>
<tr>
<td>Very Low Land</td>
<td>Land normally inundated deeper than 300 cm</td>
<td>193 243</td>
<td>1</td>
</tr>
<tr>
<td>Total Soil Area</td>
<td></td>
<td>12 305 581</td>
<td>85</td>
</tr>
<tr>
<td>River, Urban etc.</td>
<td></td>
<td>2 178 045</td>
<td>15</td>
</tr>
</tbody>
</table>

From the land types it is evident that except high lands, all other land types are subjected to flood inundation to different degrees. Normally, 20-25% of the country is inundated during every monsoon from June to September. In case extreme flood events 40-70% areas can be inundated. High lands are situated in some parts of the western, south central, northeastern and southeastern regions of the country. Excepting very low lands, human settlements can be found in all other land categories. Population density is high in the Medium High and Medium Low Lands. People live in the Low Lands building earthen mounds [4].
3.2 Floods in Bangladesh:
Floods visit Bangladesh regularly (See Figure 4 Flood Affected Area in 1998) and studies have mainly been conducted going back many decades to ascertain the causes and dimensions of floods. While the monsoon dominates the rainfall pattern in Bangladesh, flooding in the country is the result of a complex series of factors. These includes huge flows of water into the country from upstream catchment areas of the major rivers coinciding with heavy monsoon rainfall over Bangladesh, low floodplain gradients, congested drainage in order floodplain areas, the location and effects of the confluences of major rivers inside the country, and the influence of tides and storm surges in the Meghna estuary. Bangladesh generally experiences four types of flood and those are as follows [5]:

a) **Flash Flood**; it is occurred by overflowing of hilly rivers of eastern and northern Bangladesh (in April-May and September-November)

b) **Rain fed Flood**; it is occurred by drainage congestion and heavy rains.

c) **River Flood**; caused by major rivers usually in the monsoon (during June-September).

d) **Flood due Cyclonic Storm Surges**; caused by storm surges and tied.
3.2.1 Flash Flood: The flash flood is characterized by the rapid rise and fall in water levels. This flood occurred within a short time-period between few minutes to few hours. Flash flood generally happened in the northern area, north-central part, northeastern part and southeastern part of the country. Northern most, north-central and northeastern parts land areas are lying mostly at foothills but most of the hilly catchments in India. If it rains heavily in the Indian parts of the catchments the run-off quickly accumulates and flow to Bangladesh. Flash flood starts occurring in these areas from mid-April i.e. before the on-set of the southwesterly monsoon. Where, in the south-eastern area, it starts with the on-set of the southwesterly monsoon [6].

3.2.2 Rain-fed Flood: This kind of flood generally occurs in the moribund Gangetic deltas in the south-western part of the country where most of natural drainage systems are being deteriorated due to fall in up-land inflow from the main river Ganges. It also occurs in the flood plains where natural drainage systems have been disturbed due to human interferences mainly due to construction of unplanned rural roads and illegal occupation of river courses. When intense rainfall takes place in those areas, natural drainage system cannot carry the run-off generated by the rain and causes temporary inundation in many localities. This kind rain induced flood has on increase in the urban areas also. Urban population is increasing very fast and to create their new habitats low lying areas and natural drainage systems are being filled up continuously. More over, while new settlements are constructed, the issue of drainage is not always considered judiciously. As a result, in the urban areas flood has become very common phenomenon [6].
3.2.3 River Flood: The word flood is generally synonymous with the river flood. River flood is a most common phenomenon in the country from time immemorial. Normally, 25-30% of the area is inundated during monsoon season along the river. In case of extreme flood events 50-70% of the country is inundated extending the areas far beyond the river banks. The worst floods experienced by the country in last 14 years in 1987, ’88 and ’98. Flood of 1998 was the severest one in terms of magnitude and duration. The area affected by flood in 1998 is shown in figure-5 [6].

3.2.4 Flood due to Storm Surges: This kind of flood mostly occurs along the coastal areas of Bangladesh which has a coast line of about 800 km along the northern part of Bay of Bengal. Continental self in this part of the Bay is shallow and extended to about 20-50 km. Moreover, the coastline in the eastern portion is conical in shape. Because of these two factors, storm surges generated due to any cyclonic storm is comparatively high compared to the same kind of storm in other parts of the world. In case of super cyclones, hitting coast of Bangladesh maximum height of the surges was found to be 10-15 m, which causes flooding in the entire coastal belt. Worst kind of flooding occurred on 10 Nov. 1970 and 30 April 1991 caused loss of 300,000
and 130,000 human lives respectively. Apart from the effect of cyclone, coastal areas are also subjected to tidal flooding during the months from June to September when the sea is in spate due to southwesterly monsoon wind. Incidence of this kind of flooding is now on increase [6].

3.3 Causes of Floods in Bangladesh

Climatologically, the country has two distinct seasons; a dry season from November to May and the wet (flood) season from June to September (or October). Over 80% of the rainfall occurs during the monsoon or rainy season when flooding normally occurs. The normal annual rainfall of the country varies approximately from 1,200 mm in the west to over 5,000 mm in the east. Long periods of steady rainfall persisting over several days are common during the monsoon, but sometimes - local high intensity rainfall of short duration also occurs.(see figure the annual climate of different region in Bangladesh).

Figure 6: Climate of Bangladesh [7]
Floods in Bangladesh occur for number of reasons. The main causes are excessive precipitation, low topography and flat slope of the country; but others include:

- **The geographic location and climatic pattern:** Bangladesh is located at the foot of the highest mountain range in the world, the Himalayas, which is also the highest precipitation zone in the world. This rainfall is caused by the influence of the south-west monsoon. Cherapunji, highest rainfall in the world, is located a few kilometers north east of the Bangladesh border [7].

- **The confluence of three major rivers, the Ganges, the Brahmaputra and the Meghna:** The runoff from their vast catchment (about 1.72 million km²) passes through a small area: only 8% of these catchments lie within Bangladesh. During the monsoon season the amount of water entering Bangladesh from upstream in India through Farraka Barrage which is greater than the capacity of the rivers to discharge in to the sea [7].

- **Bangladesh is a land of rivers:** There are about 230 major and minor rivers in the country. The total annual runoff of surface water flowing through the rivers of Bangladesh is about 12,000 billion cubic meters [7].

- **Man-made environment:** The construction of embankments in the upstream catchments reduces the capacity of the flood plains to store water. The unplanned and unregulated construction of roads and highways in the flood plain without adequate opening creates obstructions to flow [7].
The influence of tides and cyclones: The frequent development of low pressure areas and storm surges in the Bay of Bengal can impede drainage. The severity of flooding is greatest when the peak floods of the major rivers coincide with these effects [7].

Long term environmental changes: Climate changes could influence the frequency and magnitude of flooding. A higher sea level will inhibit the drainage from the rivers to the sea and increase the impact of tidal surges. Deforestation in hilly catchments causes more rapid and higher runoff, and hence more intense flooding [7].

The land elevations are measured in respect to the sea level in an area as a result changes of land elevations causes by the change of sea level as well[8]. World wide sea level rising increasing the rates of land aggradations due to sedimentation, as a result land elevation decreases over time. The ultimate result of the decrease land elevations increased inundation by river overflowing at bank full stage. The rate of local relative sea level rise is 7 mm/year in the costal areas of Bangladesh [9]. According to Das, the local relative sea level at Chittagong port has increased by 25 cm between 1944 and 1964 [10]. The relative sea level in the Bay of Bengal is predicted to rise 83 to 153 cm by the year 2050 [11].

Increased sea level raises the basic level of rivers, which in turn reduces the gradients of the river flow. As a result, the river discharge decrease, and create a back water effect further inland. This situation happened by the rise of the sea level and resulted more flooding of lands from piled up river water inland. This is the one of the main causes of flooding in Bangladesh now-a-days.
Ganges and its distributaries are the most pronounced for riverbed aggradations. In recent years the riverbed has aggraded 5-7 meters from the border of India to the point where the Ganges meets the Brahmaputra River [12]. Riverbed degradation is one of the most common phenomenon in Bangladesh that changes riverbed level. The old Brahmaputra River was navigated for storms only about 30 years ago and presently it is an abandoned channel. The Madhumoti, Bhairab, Chitra, Ghorautra rivers are in a same positions. The rivers have lost its carrying capacity for riverbed degradations and resulted bank overflow. This situation causing increase of flooding in Bangladesh [13]. This riverbed degradation mostly caused for the Farraka Barrage (where the Ganges enter into Bangladesh) because it brings much of silt during monsoon. The tide of the Bay of Bengal in spring time retards the drainage of flood water in to the sea which increased monsoon flooding [13].

3.4 Effects of Flood:
Disaster flooding in Bangladesh effects in many ways. Flooding causes death and injuries to people and every year more than 300 to 500 people will die and millions of other people will become homeless and suffer starvation. Flooding brings too much water which leads to the damages of roads, collapse of bridges or traffic congestion, which affects the daily life of all concerned. It will also destroy farmland in rural areas. Flooding causes economic loss of about approximately USD 30 billion every year and after big floods government has to input many resources for aiding and reconstruction, which also bring extra economic stress to the public. Year wise flood affected area shown in the table-2 [7].
Table 2: Year-wise flood affected area [7]

<table>
<thead>
<tr>
<th>Year</th>
<th>Flood affected area sq.km</th>
<th>%</th>
<th>Year</th>
<th>Flood affected area sq.km</th>
<th>%</th>
<th>Year</th>
<th>Flood affected area sq.km</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>36,300</td>
<td>25</td>
<td>1985</td>
<td>11,400</td>
<td>8</td>
<td>1998</td>
<td>1,00,250</td>
<td>68</td>
</tr>
<tr>
<td>1972</td>
<td>20,800</td>
<td>14</td>
<td>1986</td>
<td>6,600</td>
<td>4</td>
<td>1999</td>
<td>32,000</td>
<td>22</td>
</tr>
<tr>
<td>1974</td>
<td>52,600</td>
<td>36</td>
<td>1988</td>
<td>89,970</td>
<td>61</td>
<td>2001</td>
<td>4,000</td>
<td>2.8</td>
</tr>
<tr>
<td>1975</td>
<td>16,600</td>
<td>11</td>
<td>1989</td>
<td>6,100</td>
<td>4</td>
<td>2002</td>
<td>15,000</td>
<td>10</td>
</tr>
<tr>
<td>1976</td>
<td>28,300</td>
<td>19</td>
<td>1990</td>
<td>3,500</td>
<td>2.4</td>
<td>2003</td>
<td>21,500</td>
<td>14</td>
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<tr>
<td>1977</td>
<td>12,500</td>
<td>8</td>
<td>1991</td>
<td>28,600</td>
<td>19</td>
<td>2004</td>
<td>55,000</td>
<td>38</td>
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<tr>
<td>1978</td>
<td>10,800</td>
<td>7</td>
<td>1992</td>
<td>2,000</td>
<td>1.4</td>
<td>2005</td>
<td>17,850</td>
<td>12</td>
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<tr>
<td>1980</td>
<td>33,000</td>
<td>22</td>
<td>1993</td>
<td>28,742</td>
<td>20</td>
<td>2006</td>
<td>16,175</td>
<td>11</td>
</tr>
<tr>
<td>1982</td>
<td>3,140</td>
<td>2</td>
<td>1994</td>
<td>419</td>
<td>0.2</td>
<td>2007</td>
<td>62,300</td>
<td>42.21</td>
</tr>
<tr>
<td>1983</td>
<td>11,100</td>
<td>7.5</td>
<td>1995</td>
<td>32,000</td>
<td>22</td>
<td>2008</td>
<td>33,655</td>
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<td>1984</td>
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<td>19</td>
<td>1996</td>
<td>35,800</td>
<td>24</td>
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</tbody>
</table>

Flooding brings many diseases such as malaria, dengue, yellow fever, encephalitis and filariasis from mosquito bite, since the mosquitoes grow very fast in dam water and spread diseases in the very same rate. Other diseases like dysentery, common cold, cholera, break bone fever, food poisoning etc. can also result from domestic waste or improper sanitation, as all the waste is carried by the flood and will float all over the streets and public places [16].
3.5 Flood Management in Bangladesh

Since the ancient time legal instruments have been using for flood management in Bangladesh. During the latter part of 19th Century, many acts and rules for flood management were introduced, such as Embankment Act, Drainage Act and Canal Act, etc. From the early sixties Government has introduced some more acts to manage floods. Since there are some inconsistencies found in implementing these laws it has been decided to promulgate a unified law and work is now going on in framing a National Water Code [6].

3.5.1 Institutions Responsible for Flood management

Flood management strategies adopted in Bangladesh have continuously evolved over the last 50 years, in three distinct phases of their development and with mixed experiences. At first, the emphasis was on structural measures through the implementation of some large-scale flood control, drainage and irrigation (FCDI) projects. Although, it was soon recognized that most of their implementations involved in the large investments, and a long term duration for completion. Then it was opted for the construction of small and medium scale FCD projects to get early benefits. After that, it was realized that water resources development should not be focused only on agriculture but take also into account other sectors related to water resources utilization and development. Environmental protection also came to the fore. As a result of such realization, since the 1960’s about 628 large, medium and small-scale FCDI projects have been implemented. They comprise levees and embankments, drainage channel improvements, drainage structures, dams and barrages, pumping systems, etc. They have provided flood protection to about 5.37 million ha of land, which is about 35% of the total area.
More than 53 central government organizations and 13 ministries are identified to be involved in water and different stages of flood management, and a National Water Council (NWC) was set up to coordinate all the various activities of the Agencies and Departments involved in the water sector. Among those organizations involved in different stages of flood management, the following may be mentioned [6]:

- **Water Resources Planning Organization** - macro planning of water resources management.

- **Bangladesh Water Development Board** - feasibility studies, implementation, operation and maintenance of flood management projects, real-time data collection for flood forecasting and warning services, dissemination of flood information at national and regional levels.

- **Joint River Commission** - to conduct negotiations for data and information exchange on trans-boundary Rivers.

- **Bangladesh Meteorological Department (BMD)** - long, medium and short range weather forecasting and dissemination.

- **Local Government Engineering Departments** – implementation, operation and management of small-scale FCD projects.

- **Disaster Management Bureau (DMB)** - dissemination of all information on natural disaster, including flood information at community level, flood preparedness awareness building, etc.
- **Directorate of Relief** - conducting relief and rehabilitation operation in flood hit areas.

- **Local Government Institutions (LGI)** - implementation of small scale flood management projects, flood information dissemination, relief and rehabilitation of flood victims.

The principal national institution concerned with flood management is the BWDB. The JRC and BWDB carry out international and regional data and information exchange. BWDB disseminates all kinds of flood information to all related Government Departments and Organizations. Most of the flood management relating to water management at national level is co-coordinated by the abovementioned National Water Council and the Ministry of Water Resources. Flood management relating to disaster management is co-coordinated by the National Disaster Management Council, particularly by the Ministry of Disaster Management and Relief. Over-all coordination during the flood event is the responsibility of the latter Ministry and the Inter-Ministerial Disaster Management Committee [6].

In the early eighties, a National Water Plan was formulated by addressing various aspects of water uses and demand and the interests of different stakeholders involved in the water sector. A Flood Action Plan was implemented from 1990-1995, on the basis of which a National Flood and Water Management Strategy was formulated in 1996. It already included policy guidelines for peoples’ participation, Environmental Impact Assessment (EIA) and multi-criteria analysis during planning process in all future water sectors projects [5].
In 1999 the National Water Policy (NWPo) was introduced first, which guides all the activities in the water sector. Subsequently, a National Water Management Plan (NWMP) was prepared in 2001, cross-cutting different sectors of national economy in the light of Integrated Water Resources Management, to address conflicting water needs and to ensure equitable water use and balanced economic growth, into the next 25 years. The Plan includes also the management of water-induced disasters, e.g. floods, erosion and droughts. A Comprehensive Disaster Management Plan (CDMP) and Disaster Management Guidelines were also prepared, in which the responsibilities of different agencies involved in disaster mitigation activities are delineated during pre-disaster preparedness, rescue and evacuation operation during disaster and post-disaster relief and rehabilitation [6, 14].

3.5.2 Flood Management Strategies

Flood Management Strategy has been under continuous change since early sixties of the last century. The types of water management and flood management Systems in Bangladesh vary widely. Each WM-System is unique and possesses its own distinct set of water management challenges. This wide diversity makes it necessary to classify WM-Systems in Bangladesh. In the past, a typical distinction was made between FCD, FCDI, D (Drainage) and I (Irrigation) systems. Flood Management strategies can be divided into three distinct phases of its development, which are as follow [6]:

a. Phase-I: 1960 to 1978
b. Phase-II: 1978 to 1996
c. Phase III: 1996 to 2000 onwards
Phase-I:

Just after the two consecutive disastrous floods of 1954 & 1955, United Nations commissioned a Mission led by Mr. Krugg to look into the problems of flood in this country and to suggest remedial measures. In 1956 the Krugg Mission finalized its Report and submitted it to the then Government of Pakistan. Principal recommendations of Krugg Mission were following:

- To formulate a Master Plan for Water and Power Development;
- To constitute a statutory body to deal with water and power development;
- To conduct intensive hydrological survey and investigations.

Krugg Mission mainly focused on protecting the agricultural lands from the flood because of the fact that at that time agriculture was the mainstay of economy. Moreover, self-sufficiency in food was the cornerstone of the Government policy. As a result, a Water Development Master Plan was prepared in 1964 where structural options having large project portfolios were given priority. Accordingly, Government started implementing large projects with the objectives of providing flood protection, improving drainage and providing irrigation. Implementation of large and medium Flood Control and drainage (FCD) projects were time consuming and during the implementation of these projects some medium scale flood occurred specially one in 1968 which caused lots of suffering to the people. As a result the Government realized that only through structural measures flood problems couldn’t be solved or mitigated. In 1972 the Government decided to also go for non-structural measures also developing e.g. flood forecasting and warning system to mitigate flood problems.
Phase-II:

With the implementation of some large Flood Control, Drainage and Irrigation (FCDI) projects, the Government came to realize that the implementation of large projects involves large investments as well as longer duration; as a result it takes long time to derive benefits. Government then opted for implementation of small and medium scale FCD projects to provide early benefits. While all these projects were implemented the Government came to realize that water resources development should not be focused only on agriculture rather it should take into account other sectors related to water resources utilization and development for economic as well public goods. Environmental protection also came to the fore. As a result the issue of formulation of a National Water Plan (NWP) came to the notice of the Government. The Government took initiative in 1982 to formulate a NWP looking into various aspects of water use and the demand and interest of different stakeholders involved in the water sector. NWP was finalized in 1986 but it did not receive Govt.’s approval due to some of its drawbacks. After disastrous floods of 1987 & 88, formulation of a National Water and Flood Management Strategy came to forefront again for obvious reasons. All the international Development Partners supported a project entitled Flood Action Plan (FAP) from 1990 to 1996 to formulate a national Flood and Water Management Strategy. FAP was mainly a study project involving 26 components. On the basis of FAP activities the Government formulated Bangladesh Flood and Water Management Strategy (BWFMS) in 1996. In BFWMS some policy guidelines for water resources development and management were envisaged i.e. Peoples Participation, Environmental Impact Assessment (EIA), Multi-Criteria Analysis during planning process were made mandatory in all future water sector projects.
Phase-III:
At the end of FAP studies, Government realized that all the issues concerning the water resources development and utilization have not been addressed in the light of Integrated Water Resources Management (IWRM) in these studies. Then the Government again embarked on formulating a National Water Management Plan (NWMP) cross cutting different sectors of national economy in the light of IWRM in 1998. In order to guide the preparation of NWMP, the Government formulated a National Water Policy (NWPo) in 1999. NWMP was prepared in 2001 with 25 years projection. Program period was divided into three phases e.g. short term for 5 years, medium term with 10 years. And long term with 25 years period. It was formulated with a program approach, not with a project approach. This is no doubt a shift in the Government policy. It identified various conflicting water needs and to ensure equitable water use and balanced economic growth. NWMP has 84 programs cross cutting 11 different sectors of economy. Access to Safe Drinking Water and Sanitation has been given topmost priority. In the NWMP the issue of poverty reduction has not been addressed explicitly, but the Government wants to put it as a top most economic goal.

3.6 Efficacies of Strategies:
Structural options being the principal strategy in all the above phases provided some benefits specially increase in agricultural production at earlier period but some adverse effects were observed latter on. Specially, the construction of high embankment along the both banks of the rivers in some cases resulted in rise in bed levels and obstruction to drainage. In the coastal areas, although the construction of polders prevented salinity intrusion, but resulted in restriction of the movement of the tidal prism, sedimentation of
tidal rivers and obstruction to the gravity drainage. Another important impact on agriculture was found to be that the crop diversification was seriously rather the farmers in most cases opted for production of cereal crops, especially HYV rice enjoying a flood free situation. Structural measure caused many adverse effects on the aquatic lives especially on open water fisheries. Fish resources have been depleted rapidly. Introduction of non-structural option i.e. Flood Forecasting and Warning System as a secondary strategy started from early ‘70s and contributed to the improvement of the capacity for flood preparedness and mitigation of flood losses. The importance of this strategy has been realized after the floods of 1987, ’88, ’98 [15].

3.7 Flood Mitigation Strategies: Flood Mitigation is any action taken prior to, during or after a flood that reduces or eliminates the disasters potential to cause damage to persons or property. In Bangladesh two types of action taken to mitigate floods.

3.7.1 Structural Measures:
Considering the issues of securing peoples’ life and property, livelihood, food etc. the Govt. put emphasis on protecting Medium High and Medium Low Lands from floods through construction of embankments. According to this method, the necessary areas are bounded of in order to protect them from flooding. DND

Figure 7: Present Flood Status [6]
embankment which protect Dhaka, Narayanganj, and Demra from the adjoining Buriganga and Shitalkhya rivers, Brahmaputra right hand embankment which protect from Brahmaputra-Jamuna river channel are some of the examples. Also there are many other embankments that are constructed along various stretches of many other rivers [6].

The Meghna-Dhonagoda embankment and others that have been constructed to protect cities and towns like Rajshahi, Shirajganj, Chandpur, Khulna and Barisal are belonging to this category. These embankments let the river water remain confined only to their channels and pass directly to the sea. Since 1960s Bangladesh has implemented about 628 numbers of large, medium and small-scale FCDI projects. Total investment was to the tune of US$ 4.0 billion. It provided flood protection to 5.37 million ha of land, which is about 35% of area. A picture flooded, non-flooded and flood protected area is shown in figure-7. A picture of structural measures works are given in table 3 [6].

Table 3: Picture of Structural Measures for Flood Management [6]

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankment</td>
<td>10,000 km</td>
</tr>
<tr>
<td>Drainage Channel</td>
<td>3500 km</td>
</tr>
<tr>
<td>Drainage Structure</td>
<td>5000 nos.</td>
</tr>
<tr>
<td>Dam</td>
<td>1 no</td>
</tr>
<tr>
<td>Barrage</td>
<td>4 nos.</td>
</tr>
<tr>
<td>Pump House</td>
<td>100 nos.</td>
</tr>
<tr>
<td>River closure</td>
<td>1250 nos.</td>
</tr>
</tbody>
</table>
3.7.2 Non-Structural Measures:

In spite of all the structural activities, it was found that the people living in the Medium High and Medium Low Lands are not immune to flooding during moderate to extreme flood events. Government considered that the minimizing flood loss through non-structural means is also very important. Early warning on flood can save life and property. With this end in view, Flood Forecasting and Warning System (FFWS) were established in 1972 with 10 Flood Monitoring Stations on the major river systems. After disastrous floods of 1987 & 88 the Government realized the importance of FFWS and took steps to modernize the system. New FF model was developed on the basis of Mike-II hydrodynamic model and flood-monitoring stations were increased to 30 in 1996. In 1998, flood FFWS was found to be very useful providing the early warning and information on the flood. With the experience of 1998, flood the Government decided to improve it further to cover all the flood prone areas of the country under real time flood monitoring. A project was under taken from January-2000 to improve the FFWS further. It now covers the entire country with 85 Flood Monitoring Stations and provides real time flood information with early warning for lead-time of 24 and 48 hours. FFWS currently, helping the Government, the disaster mangers and the communities live in the flood prone areas in matters of flood preparedness, preparation of emergency mitigation plan, agricultural planning and rehabilitations etc [6].
3.8 Climate Change and Floods in Bangladesh

Over the last 100 years, global mean surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased by 0.4–0.8°C. This value is 0.15°C larger than that estimated by the Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change (IPCC) for the period up to 1994. The additional increase in temperature is because of the relatively high observed temperature during 1995–2000 and application of improved methods for processing the data (IPCC WG I, 2001). Analysis of mean annual temperature over India during the period 1901–1982 indicates about 0.4°C warming [52]. The warming is found to be more pronounced on the west coast, the interior peninsula and the north central (Ganges basin) and northeast regions (Brahmaputra and Meghna basins). Pant and Kumar (1997) analyzed a slightly longer time-series (1881–1997) data for temperature for India and found a significant warming of 0.57°C. In the Bangladesh region, from the latter part of the last century, there has been, on average, an overall warming of about 0.5°C, comparable in magnitude to the observed global mean warming (Warrick and Ahmad, 1996) [51].

Mirza et al. (1998) analyzed long-term annual precipitation records of meteorological sub-divisions of the Ganges, Brahmaputra and Meghna river basins and found no general significant change, with slight exceptions in a few meteorological sub-divisions. No distinct long-term trends were noticed in precipitation records at the 78 stations distributed across Nepal. However, Rackhecha and Soman (1994) found a more than 10 percent increase in 1–3 days extreme precipitation over a small area in the Brahmaputra basin in India [51].
Thus, in the last 100 years, broadly speaking, there has been no discernible increasing or decreasing trend in annual precipitation in the greater Himalayan region. Over the period 1990–2100, the global average surface temperature is projected to increase by 1.4–5.8°C. Similarly, based on global model simulations and for a wide range of scenarios, global average water vapor concentration and precipitation are projected to also increase during the 21st century (IPCC WGI, 2001). An examination of the frequency distribution of daily monsoon rainfall over India in the model-simulated data suggests that the intensity of extreme rainfall events is likely to be higher in future, a consequence of increased convective activity during the summer.

3.8.1 Changes in Occurrence of Floods

Changes in the magnitude of a mean annual flood imply that the return period or probability of occurrence of extreme floods will also change. For the present analysis, possible future changes in the magnitudes and return periods of such events, as a consequence of climate change are examined, assuming that the coefficient of variation of future floods remains unchanged. The standard deviations of the peak discharge values for the three rivers were altered by the proportion of change projected to occur in the respective mean peak discharge under climate change scenarios. For the present analysis, a 20-years flood was selected for the Ganges, Brahmaputra and Meghna rivers at the irrespective discharge measurement stations, Hardinge Bridge, Bahadurabad and Bhairab Bazar [51].

Looking into the future, climate change is likely to exacerbate flooding for a number of reasons, including the following:
• **Increased glacier melt**: Higher temperatures will result in more glacial melt, increasing runoff from the neighboring Himalayas into the Ganges and Brahmaputra rivers. Given the altitude of the mountains and the enormous size of the glaciers, this problem will most likely continue over the century.

The problem could be of even greater concern as there is evidence to show that temperatures in the Himalayas (where the glaciers are located) are rising at higher rates, thereby contributing to enhanced snow melt.

• **Increased precipitation**: While this is not certain, the climate models tend to show increased precipitation, particularly during the monsoon season. This will contribute to increased runoff. For example, Mirza and Dixit (1997) found that a 2°C warming with a 10% increase in precipitation (close to the mean GCM projection for 2100 June-July-August) would increase runoff in the Ganges, Brahmaputra, and Meghna rivers by 19%, 13%, and 11%, respectively.

### 3.9 Aims of Flood Management:

To save the agricultural land is the main aim of flood management and water management in Bangladesh. The major objective of the long term flood control plan proposed under the study carried out by a Japanese team of flood control experts include; a) Minimizing the potential flood damages, b) Creating flood free lands to accommodate the increasing population, c) Enhancing agricultural land use to facilitate the adoption of high yield crop varieties, d) Enhancing conditions for effective development of commercial and industrial enterprises. The essential target of the long term flood control plan is to mitigate flooding on the central part of the country by means of
appropriate measures against flooding by the three major rivers [5]. The UNDP Agriculture Sector Review emphasizes the considerable potential for agricultural growth in Bangladesh. With improved water controlled, the development of new varieties of rice and other crop varieties suited the varied agro ecological conditions in the country, and improved input supply and extension, Bangladesh can greatly increase agricultural output. Flood control along the Brahmaputra-Jamuna secured the Kharif crops; Aus, jute and transplanted Aman in the north and center, deepwater Aman in the south. The same is true along the Ganges. To gain full benefits from such measures embankments, improved water control through smaller projects behind the main embankments has constructed. [5]
CHAPTER FOUR

Case Study: The Netherlands

4.1 Introduction to the Problems of Floods in the Netherlands

4.1.1 The Netherlands: General Overview:

The Netherlands is a delta country, located in the North West Europe; its border in the North Sea to the North West, Belgium to the south and Germany to the east. The Netherlands is a river delta and geographically it is a low-lying country, about 20% of its population located below sea level, and 50% of its land lying less than one meter above sea level. Most of the land area has been gained through land reclamation preserved by an elaborate system of polders dikes. Many parts of the Netherlands are formed by the estuary of three important European rivers the Rhine, Meuse and Scheldt delta, together with their distributaries. Most of the country is very flat, with the exception of foothills in the far southeast and several
low hilly parts in the central see figure 8. The geography of the Netherlands is that much of its land has been reclaimed from the sea and is below Sea level, protected by dikes. More over most densely population and highly urbanized is one of the most important factors that has influenced its physical appearance. The country can be split into two areas [55]:

- The low and flat lands in the West and North which including the reclaimed polders and river deltas, made up about half of its surface area and are less than 1 m (3.2 ft) above sea level, much of it actually below sea level. An extensive range of seawalls and coastal dunes protect the Netherlands from the sea, and levees and dikes along the rivers protect against river flooding [55].

- The higher lands with minor hills in the East and South which is mostly flat; only in the extreme south of the country does the land rise to any significant extent, in the foothills of the Ardennes Mountains. This is where the Vaalsbergen hill is located, the country’s highest point at 322.7 meters (1,059 ft) above sea level [55].

Due to its location, the Netherlands is always threatened by floods. Life in the delta of the Rhine and the Muse not only involves risk but has also enabled the Netherlands to develop into one of the main gates of Europe. In the past river floods provided the fertile soils and clay for brickworks, but also negative effects occurred such as the loss of goods and cattle and the danger of drowning. As welfare increased the population density increased
and better protection systems were built to prevent flooding. Since the middle ages more and more dykes and quays as well as hydraulic structures have been constructed. Whether the protection against water is sufficient, is an all time question.

4.2 Causes of Floods in the Netherlands

The Rhine catchment consists of a number of sub-basins, each of which is characterized by very different meteorological conditions. Rhine floods become catastrophic when extreme runoff is discharged from several of these sub-basins at the same time. For example the December flood in 1993 and the January event in 1995 originated in the uplands of the Middle and Lower Rhine. A rain period from 7 to 18 December 1993 in the flood source areas brought precipitation that equaled nearly 100% of the long-term December mean. In January 1995, a similar effect was produced by melting snow and frozen soil in the higher uplands. Large parts of the Rhine catchment were thus ‘ideally’ prepared for high runoff coefficients. Further heavy precipitation resulted in catastrophic runoff events. The amount of rain falling during these periods was equivalent to 200% of the 30-years means of December and January, respectively. In some areas 50 to 70% of the precipitation entered the watercourses without great delay. In 1999, two other flood events affected the Upper Rhine. The melting of the enormous snow cover in the high Alps and heavy rainfall produced flood peaks at the gauges of Basel and Maxau exceeding the discharge thresholds for the activation of flood retention facilities along the Upper Rhine [39].
4.3 Introduction to Flood management in the Netherlands

The flood-prone areas in the Netherlands are divided in so-called dike ring areas (see Figure 9). These are the areas protected against floods by a series of water defenses (dikes, dunes, hydraulic structures) and high grounds. For most dike ring areas the land level is below the water level. Safety standards have been derived for each of the dike ring areas. The fundamental principles underlying the determination of these standards were identified by the Delta Commission. This Commission was installed to investigate the possibilities of a new approach towards flood protection after the 1953 flood disaster, which caused major damages in the southwestern part of the country, and the killing of over one thousand people. The Commission came up with proposals for new flood defense works and new safety standards for the entire country. Van Dantzig (1956) developed a general formula for the optimal level of flood protection through dikes, requiring investments at regular intervals [35]. His formula gives a fixed exceedance probability after each investment in the relevant safety structure, i.e. the probability that the water level exceeds the top of the dike, resulting in overflow and breaching of the dike and thus flooding of the land behind the dike. A so-called design level with a certain exceedance.
probability is used to express the required height of the dike. The current design criteria and the safety evaluation of flood defenses are based on these design levels. The safety levels of flood defenses per dike ring area are laid down in the Flood Protection Act of 1996 [35].

Most of the economic values in the Netherlands are located in the low-lying western part of the country, which is also the most flood-prone part. In these areas, failure of one of the elements in the flood defense system will most likely lead to the flooding of large parts of the dike ring area from the rivers Rhine and Meuse, the North Sea and the big lake in the centre of the country, the Ijsselmeer. A serious flood in this part of the Netherlands thus would mean a disaster with severe consequences for the whole country [35].

4.3.1 Organization Related to the Flood Management

In order to understand the flood management strategy of the Netherlands, we have to grasp the role of the water management board even if in the last 10 years, the emphasis in water management policy has increasingly shifted from a classical command-and-control, or top-down, approach, towards a more consensual, or interactive, approach.

4.3.2 Legal Framework for Water Management

In the twentieth century, water management policy and water management legislation have become increasingly interrelated [32]. The system of legal regulations concerning water management, or the law of water management, can be found in legislation at the central government level, and regulations at
the regional and local level. The legislation at the central government level consists of:

- Classic water management legislation;
- Modern water management legislation;
- Institutional legislation.

Classic water management legislation refers to acts that came into force around the turn of the century. The year 1970 marks the beginning of modern water management law as the Act on Pollution of Surface Waters (Wet verontreiniging oppervlaktewateren) entered into force.

With this act, a period started of a more central role of the State in the assignment of tasks and competencies. In the period prior to 1970, the provinces had almost autonomous powers to assign tasks and competencies. Institutional legislation refers to rules elaborating the administrative structure of water management. Table 4 presents an overview of the prevailing Dutch water management legislation [42].

The formal water management legislation has generally the character of framework legislation which has to be elaborated by the executive authorities at the governmental, provincial, municipal and water board level. The Dutch law of water management, however, lacks a general umbrella act. In recent years, it was frequently discussed whether such an act would be necessary to achieve truly integrated water management. However, the government has decided to refrain from legislative activities for the time being [32]. It preferred to get first a more practical experience with the concept of integrated water management [42].
Table 4: Overview of formal water management legislation in the Netherlands [32]

<table>
<thead>
<tr>
<th>Classic water management legislation</th>
<th>Modern water management legislation</th>
<th>Institutional legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Administration Act 1900</td>
<td>Act on Pollution of Surface Waters 1971</td>
<td>Water Board Act 1991</td>
</tr>
<tr>
<td>Rivers Act of 1908</td>
<td>Groundwater Act 1981</td>
<td></td>
</tr>
<tr>
<td>Delta Act 1958</td>
<td>Water Management Act 1989</td>
<td></td>
</tr>
<tr>
<td>Delta Damage Compensation Act 1971</td>
<td>Delta Act Large Rivers 1995</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water Embankment Act 1996</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Act of State Water Authority Operations 1997</td>
<td></td>
</tr>
</tbody>
</table>

4.4 Structure of Water Management

4.4.1 Formal Water Management Structure

The Netherlands is a constitutional monarchy with a parliamentary system. The central government consists of the ministers and the ministers have full responsibility. Decentralization is an important feature of the Dutch State organization. The governmental hierarchy consists of the national, provincial and municipal level. For water management, functional government units exist at the regional and local level. Public water management was first introduced in the Netherlands in the twelfth century. It had traditionally a strongly decentralized character, resulting in a large regional variety of public bodies dealing with water issues. The basic principles, which still rule the current division of authority, were originally laid down in the
Constitutions of 1814 and 1815. Since then, local and regional water management rests with the water boards, under the supervision of the provinces and the supreme supervision of the central government. With the Constitution of 1848, a strict separation of water management and other administrative concerns was carried through [31].

The revision of the Constitution in 1983 provides another important landmark in the historical development of water management, because the water boards got a constitutional position comparable to those of provinces and municipalities. The revision finally led to the coming into force of the Water Board Act (Waterschapswet) in 1992 which confirms the central position of the water boards in regional and local water management. Until then, there had been big differences in autonomy between the water boards mainly because of divergent provincial regulations and viewpoints. The present administrative structure and division of responsibilities concerning Dutch water management is based on the Articles 21 and 133 of the Constitution, and the Articles 1 and 2 of the Water Board Act (Waterschapswet), focusing respectively on the central government, the provinces and the water boards. The constitutional regulations are further elaborated in the Water Administration Act 1900 (Waterstaatswet 1900) which contains provisions on the supervision of the provinces and the supreme supervision of the central government. Recent legislation, including the Water Board Act (Waterschapswet) and the Water Embankment Act (Wet op de waterkering), has largely replaced the Water Administration Act 1900 (Waterstaatswet 1900) [36].
Due to the patchwork of legislation regulating different water management tasks, the administrative structure of water management in the Netherlands is rather complex. However, there has been some improvement since the entry into force of the Water Management Act (Wet op de waterhuishouding) in 1989 which provides the instruments to tune the policies of different water managing authorities. In addition, regional responsibilities are presently being rearranged aiming at a situation of ownership, management and maintenance by only one administrative unit, preferably an all-in water board. Table-5 summarizes the main competencies in Dutch water management [42].

Table 5: Main competencies in Dutch water management [36]

<table>
<thead>
<tr>
<th>Government levels</th>
<th>Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central Government</strong></td>
<td>Strategic national water policy</td>
</tr>
<tr>
<td></td>
<td>Water management legislation</td>
</tr>
<tr>
<td></td>
<td>Management of national surface waters</td>
</tr>
<tr>
<td></td>
<td>Supervision over provinces, water boards and municipalities</td>
</tr>
<tr>
<td><strong>Provinces (12)</strong></td>
<td>Strategic ground- and surface water policy</td>
</tr>
<tr>
<td></td>
<td>Operational groundwater policy</td>
</tr>
<tr>
<td></td>
<td>Supervision over water boards and municipalities</td>
</tr>
<tr>
<td><strong>Water boards (65)</strong></td>
<td>Operational surface water management</td>
</tr>
<tr>
<td></td>
<td>Flood risk management</td>
</tr>
<tr>
<td><strong>Municipalities (572)</strong></td>
<td>Sewerage management</td>
</tr>
</tbody>
</table>

At the government level, the ministry of Transport, Public Works and Water Management (V&W) is responsible for water management in general, including strategic water management policy and formal legislation. Its operational department is called the State Water Management Authority (Rijkswaterstaat). In addition, several other ministries have responsibilities concerning water management policy. The most important are the ministry
of Spatial Planning, Housing and the Environment (VROM), and the ministry of Agriculture, Nature Protection and Fisheries (LNV).

The provincial governments (12 in total) formulate strategic and operational water management policy within the framework set by national policy. They are directly responsible for groundwater quality and quantity management. Further, the provinces have the authority to establish water boards, and to define their tasks and powers. The water management tasks of the municipalities are in general limited to the construction and maintenance of the sewerage system. Furthermore, they fulfill important tasks in local land-use planning and environmental policy. The water boards, organized according to geographical and hydrological units, are responsible for regional and local water management. Their tasks may include quantitative and qualitative water management, and flood risk management [42].

4.4.2 Informal Water Management Structure

Water management is not only determined by its formal structure. It is even stated that in the Netherlands the informal structure is far more important than the formal structure [36]. This informal structure consists of all kinds of interactions between stakeholders that are not ruled by law. Among the stakeholders of water management are the general public, consumer organizations, environmental organizations, press, farmers, industry, drinking water suppliers, professionals (especially technicians), scientists, politicians, and public officials. These stakeholders may exert their influence individually, or in some kind of institutional arrangement. Public authorities, for example, meet each other in official associations at all state levels,
including the Association of Provinces (InterProvinciaal Overleg), the Union of Water Boards (Unie van Waterschappen), and the Association of Dutch Municipalities (Vereniging van Nederlandse Gemeenten), and the Commission Integrated Water Management (Commissie Integraal Waterbeheer). Private and business interests usually have their own organizational structures. Because of the importance of the informal interactions, it has been concluded that water management policy in the Netherlands is not the result of an open debate in formal "arenas" such as parliament, but is formulated in an "iron ring" around the formal arenas, consisting of public officials and the different affected interests. Formally, policy tasks and competencies are shared by numerous public authorities at the national, provincial, municipal and water board level. However, due to the rather low political profile of water management and the technical expertise required, most water management policy is in practice formulated by public officials in consultation with economic stakeholders and environmental NGOs. Privately owned companies play no significant role [36].

4.5 Flood Risk Management in the Netherlands

Flood risk management in the Netherlands concerns the protection of the land against the risk of inundation. Because of its geographical position, this has always been a major concern in the Netherlands. It is therefore not amazing that flood risk management has largely influenced the structure of total water management.
4.5.1 Legal Framework and Administrative Structure for Flood Risk Management

The legal framework for flood risk management is largely similar to the framework for general water management. The most important legislation concerning river dikes and other embankments only entered into force in the last few years, partly in response to the flooding disasters of 1993 and 1995. Table-6 provides an overview of the formal legislation relevant for flood risk and disaster management [42].

Table6: Overview of formal legislation relevant for flood risk management. [42]

| Flood risk management legislation: | Water Administration Act1900  
Delta Act1958  
Delta Damage Compensation Act1971  
Delta Act Large Rivers1995  
Water Embankment Act1996  
Act of State Water Authority Operations1996 |
|---------------------------------|--------------------------------------------------------------------------------|
| Disaster management legislation: | Disaster Act1985  
Act on Compensation of Financial Losses due to Disasters and Serious Accidents1998 |
| Institutional legislation:      | Water Board Act1991 |

The primary responsibility for dike maintenance and management is in principle in the hands of the water boards. As far as dikes are still under the management of the central government, the present decentralization tendency will lead to a further transfer of authority to the water boards. Eventually, only a small number of dikes will stay under the management of the central government, because of financial and technical reasons.
The provinces have supervision on the flood risk management performed by the water boards, whereas the central government has the supreme supervision. The central government also plays an important role in conducting technical research and in establishing the national policy concerning flood risk management [42].

4.5.2 Development of Flood Risk Management

Twentieth century history of river Rhine flood management starts in 1926. By the end of that year the discharges of the river Rhine had increased to 12,000 m$^3$. (Measured in Lobith, the place where the river Rhine crosses the Dutch border (average flow of the river Rhine is 2,200 m$^3$)) [30]. The year 1953 is the landmark for flood risk management in the Netherlands because in this year the historical flood occurred and 20% of the Netherlands was inundated which caused death of 1800 people. This disaster was the immediate cause for putting flood risk management high at the national policy agenda and as a result the so called Delta Act was passed in 1958. This act encompassed a programme to reduce flood risks from sea surges by dike reinforcements and closing of the river arms in the South-West of the Netherlands (the delta of the Rhine and Meuse rivers). Until the flooding disaster of 1953, flood risk management was in the hands of small water boards with consequently restricted financial resources. The flooding disaster made clear that the protection against flooding was inadequately organized and decided that it is the time to start process of scaling-up of the water boards [31]. In 1960, non-legally binding standards were established concerning the Delta projects, after consultation of the Delta Commission [32]. The commission advised to base the protection standards on socially acceptable risks of flooding and it
first advised to introduce the principle of dike ring areas, which implies that
dikes (and other water infrastructure) around that area should provide a
single level of protection against high water.

In 1969, far more extensive ideas for reclaiming land were developed into
corresponding plans by the State Water Management Authority. Flood risk safety
was only a minor argument and the plans were defended mainly from
economic and demographic point of views. A second major decision that
proved the importance of environmental concern in Dutch flood risk
management was to build sluices in the dike that closes the Oosterscheldt
wetlands. This dike was engineered under the Delta Act (Deltawet), and its
completion would have meant a tidal estuary (wetland) turning into a fresh
water lake. The 1970s discharge of 9,500 m³/s at Lobith led to critical
situations on a number of river dike locations. In 1975, in the aftermath of the
1970's discharge, the ministry of Transport, Public Works and Water
Management (V&W) enacted the Commission River Embankments. The task
of the commission was to evaluate risk limit [33]. At present the mean
discharge of Rhine at Lobith where it enters in the Netherlands is 2,200 m³/s
and the highest discharge estimated 12,000 m³/s in 1926 [33]. On the other
hand the mean discharge of Meuse at Borgharen where the river enters in the
Netherlands is about 1500 m³/s. On the basis of these discharge the
Netherlands has developed risk based flood management analysis [33].

Around Christmas 1993, there was a riverine flooding in the Meuse valley in
the province of Limburg. After February 1994, the ministry of Public Works
and Water Management and the provincial authorities of Limburg installed
the Commission Flood Disaster River Meuse. This commission also named
Commission Boertien II. The commission took account of climate change in
its considerations to design criteria for evaluating the strategies. The commission recommended [33]:

a. To deepen the Meuse in Northern and Central Limburg;
b. To broaden the Grensmaas, while simultaneously developing nature and landscape values;
c. To provide additional protection by the construction of embankments.

In the beginning of 1995, there was again a riverine flooding in the Meuse valley. In reaction to the flooding in the Meuse valley and the near flooding of the Rhine, the government decided to establish a Delta Plan Large Rivers (Deltaplan Grote Rivieren) in 1995. The Delta Plan aims to speed up the process of river dike reinforcements, and the implementation of the recommendations of the Commission Boertien II [33]. Since the Delta Act Large Rivers (Deltawet grote rivieren) had only a temporary character, that was considered necessary to give a high priority to the establishment of an act dealing on a more structural basis with water embankment projects. The Water Embankment Act (Wet op de waterkering) finally entered into force on 15 January 1996. The Water Embankment Act aims to guarantee a certain level of protection against flood risks. It introduces new concepts, such as outside water (buitenwater), dike ring areas (dijkringen) and primary embankments (primaire dijken). According to the act, a dike ring area should be protected against flood risks by a system of primary embankments.

Since 1995, flood risk management has also been put on the agenda in international forums. In 1995, the EU Council of Environment Ministers signed the Declaration of Arles, stating that action plans on flood protection should be prepared for the Rhine and the Meuse. Both action plans...
prepared by the International Rhine Committee, the other by the Flood Working Group of the Meuse, have been presented in 1998. They aim to reduce the risk of loss and damage by lowering high water levels, improving prediction and warning systems, and raising awareness of the possibilities and consequences of floods. While reducing flood risks the plans also aims to improve the ecological values of the rivers Rhine and Meuse. More specifically, the objectives of the Rhine Flood Action Plan are [34]:

- To stabilize the damage potential by 2005, and to decrease it with 10% by 2020;
- To lower high water levels up to 30 cm in 2005 and up to 70 cm in 2020;
- To improve early flood warning;
- To increase awareness.

Another international initiative was taken by the ministers of spatial planning of the Rhine and Meuse countries. The so-called Working Group Strasbourg aims to develop a plan to solve high water problems by spatial measures in the whole catchment area. At present, the countries involved are making inventories of possible measures and their effects [34].

### 4.6 Flood Management in Netherlands

Flood management is an important part of life in the Netherlands. As mentioned, the Netherlands is formed by the deltas of three rivers- the Scheldt (rain-fed, originating in southern Belgium), the Meuse (rain-fed, originating in northern France), and the Rhine (glacier and rain-fed, originating in Switzerland). Moreover, the country also borders the North Sea, with the Scheldt River connecting the sea to the Antwerp Harbor. The
Rhine is the largest of the three rivers, splitting into three branches (the Ijssel, the Lek, and the Waal) as it crosses the border into the Netherlands [17].

The Netherlands have a long history of attempting to control floods. As early as the ninth century, the Dutch started building dikes to protect reclaimed bog land [18]. These dikes started as local, individually-owned structures, but communities soon realized that closed dike rings were necessary to protect all sides of the region. These dike rings eventually became waterschaps or “waterships,” regional districts charged with water management including drainage and dike building. These districts are still the administrative body for flood defense [19]. The 14th century saw the first major recorded floods in 1313 and 1315, leading to the famine from 1314-1317 that killed 5-10 percents of the population. Periodic flooding continued through much of the Netherlands’ history. As sediment settled between the dikes, dikes grew taller. During the 19th century, reorganization of the water districts occurred and a national body was formed. Military engineers took over the construction and maintenance of the dike system [20].

During the 20th century, trained engineers and the central government took over flood control efforts, the analysis of appropriate techniques and construction increased [21]. Prior to 1953 dikes were built to the height of the previously known high-water level plus a margin of safety [22]. After the catastrophic flood of 1953, the Delta Committee was formed to advise the government regarding flood control [23]. One recommendation of the Committee was to establish an optimal exceedance frequency of the design water level based on risk of flooding and cost of protection.
Van Dantzig’s 1956 paper described this risk-based calculation and proposed that flood management required integration of three areas with noted problems: statistics, hydrology, and economics. In the past 50 years, significant effort has been devoted to expanding on van Dantzig’s work and working on solutions to the problems he noted and the assumptions he made. Increased computing power, additional rainfall and hydrologic data, and watershed models have all added to the understanding of flooding while increased emergency preparedness and response have enhanced protection of land, homes, farms, businesses, and lives. And all these measure has been taken under the cost benefit analysis of flood management. Now the Netherlands has been exercising their flood management by assessing the risk of flooding in a particular time and analyzing the cost and benefit of building flood control measures [42].

4.6.1 Dutch Flood Control Structures

The Netherland’s flood defenses have three components: dunes, dikes, and special structures. Natural sea dunes protect coastal areas from tides and storm surges. The dunes are planted with helm grasses to hinder erosion. Where there are no dunes, the Dutch built dikes. The dikes, initially constructed along the river, have become dike rings to provide protection on all sides. The 1500 miles dike system in the Netherlands includes some massive engineering and construction accomplishments. The Afsluitdijk dike, for example, prevents North Sea intrusion into the Zuiderzee and has created the IJsselmeer freshwater lake. The dike is over 90 m wide and 32 km long. Cross dikes are used to protect against upstream dike bursts. An early example was constructed between the Lek and Linge rivers in 1284 [24].
Figure 10: Shows the Dunes, Afsluitdijk Dike and Special Structure in the Netherlands [24&56]

Special structures include the Maeslankering storm surge barrier that closes to protect Rotterdam and surrounding towns from flooding from abnormally large storm surges. Each of the two barrier “arms” is as tall as the Eiffel Tower if placed upright [24]. Other special structures include cofferdams, gates, and retaining walls. In general, these special structures are in place as temporary solutions in response to a flood event or storm surge.

Now-a-days, the Netherlands using the cost benefit analysis method in their all decision making on a desired flood protection strategy. The basic principal of cost benefit analysis indicates weather a project results in an increase of economic welfare, which means the benefits generated by the project exceeds the cost of it and all the flood management strategies running on the basis of the cast benefit analysis.

4.6.2 Risk-based and Reliability-based Design

Flood management policies and system designs of the Netherlands are established to reduce flood damages. Engineers today use two strategies to evaluate flood management solutions:

a. Risk-based

b. Reliability-based design.
Risk-based design focuses on minimizing the future costs of flooding by taking preventative measures today. Risk has two components - the chance an event will occur and the consequences of that event [25]. A subset of cost-benefit analysis, the optimal risk-based design results in the minimum total cost, from summing all costs multiplied by their probabilities for each alternative, and choosing the least expensive alternative. Risk-based design requires having a pre-established flood probability distribution, as well as reliable estimation of the damages from different flood levels. A discount rate is applied to future costs to give a net present value for evaluating different protection levels. A benefit of the risk-based approach is that it allows choices based on comparison of expected outcomes and costs of solution alternatives [25].

Reliability-based design is based on a pre-established “acceptable” failure probability target. Legislation, insurance policies, or other parties may determine an acceptable failure probability based on different preferences regarding loss of life, infrastructure investment, or economic loss. Acceptable failure levels may be based on the previously discussed risk-based design using the failure rate with the best net present value for the flood protection system and probable damage during flood events. Reliability-based design allows engineers and planners to develop a
solution set of alternatives that provide the target level of protection and then choose the lowest-cost alternative.

Flood protection systems can incorporate both methods. For example, risk-based design requires substantial data for a given floodplain. By evaluating just one section of that region with risk-based design, a target failure probability can be established and applied in a reliability-based approach to the entire region, provided other parts of the region have similar flood hydrologies, costs, flood damages, and benefits. Currently the Netherlands is using a minimum acceptable flooding probability for flood protection (at Lobith of $18,000 \text{ m}^3/\text{s}$ around 2100). The reliability-based design standard is based on an economic optimal value, or risk-based evaluation. The safety standard for a dike ring protecting a heavily populated city and its suburbs is higher than the standard for a dike ring protecting agricultural land. This integrated method results in the reliability design standards summarized in Figure-11 [26].

4.6.3 Resistance and Resilience Strategies of flood management in Netherlands

Evaluation of risk and reliability-based designs considers the two factors of flood risk: the frequency of flooding and the consequences of flooding. Resistance strategies are designed to reduce flood risk by reducing the frequency and magnitude of flood events. Historically, the Netherlands has been using this strategy and these are the most common and include dike or levee systems, and reservoirs and dams.
Resilience strategies focus on minimizing the consequences of a flood. These strategies include allocating land as floodplains, developing better emergency response systems, and expediting flood clean-up and recovery. Often resilience strategies are described as ways of “living with the flood” instead of “fighting floods" [27].

4.7 Recent Developments in Dutch Flood Management:

4.7.1 Room for the Rivers

The Dutch are increasingly incorporating resilience strategies in their flood management policies. This is increasingly important as the economic value protected by the flood management system increases faster than dike heightening can occur. Two strategies are receiving the most attention as potential resilience methods to minimize economic consequences of flooding: storing flood waters and increasing maximum flow capacity of channels [27].

In the Netherlands, these two strategies are part of creating “room for rivers,” an initiative led by the Dutch government to provide better flood protection and use spatial planning for long-term development. The plan includes implementation of resilience measures in the four ways, by dike or levee relocation (setbacks), flood bypasses or “green rivers”, lowering floodplains between the river and the levees, and developing flood detention areas [28].
The Dutch are currently building a flood bypass along the Ijssel branch of the Rhine to protect the towns of Veessem and Hoenwaard from flood waters. This channel is being built in a mostly agricultural area. As part of the same government measure to ensure flood protection objectives are met by 2015, the Dutch are also moving dikes along the Meuse between Geertruidenberg and Waalwik. By moving the dikes further from the river, the area known as the Overdiep Polder will be expanded and water levels in the area will drop up to 30 cm [29]. Although both measures reduce developable land, the goal is to maintain agricultural use while protecting more populated areas [28].

Detention of floods in compartments requires designating areas for temporary water storage and subdividing existing dike rings. The compartmentalized sections will have different flood probabilities resulting from a pre-determined order for rerouting flood waters to the compartments. Upstream compartments are filled first to reduce the flood peak’s height and duration further downstream. Typically, the compartments designated to receive flood waters first should be designated as natural or agricultural lands to minimize economic damage. These detention compartments also can be managed to help recharge groundwater supplies, reduce river bed erosion, and improve biodiversity.
Green rivers or flood bypasses are one method to increase the maximum flow capacity of part of a channel. Green rivers are designated areas where water flows only during flood periods and may be used for agriculture or ecological habitat at other times. In the Netherlands, green rivers typically flood during the off-season for agriculture, providing an economic benefit.

The last two final strategies for creating room for the rivers are relocating existing levees or lowering flood plain levels. These strategies require having enough undeveloped or minimally developed land available to adequately set back the levee or lower the floodplain. In the Netherlands, this is often difficult because of flow capacity restrictions, or bottlenecks, most often in urban areas with little undeveloped land [28].

4.8 Climate Change and a New Approach to Water Management in the 21st Century

4.8.1 Climate Change

Future climate changes could influence precipitation levels to such a degree as to result in extreme discharges in the Rhine and Meuse. Under such circumstances, the Netherlands assumed that flooding and/or supplementary water storage measures along the upper Rhine would lead to an upper limit to the discharge in the downstream direction. An approximate analysis taking flooding along the Upper Rhine into consideration shows that, assuming a 4°C temperature increase in the next century (the highest estimate for the climate effect in 2100), a discharge increase at Lobith of 18,000 m3/s around 2100 cannot be ruled out [53]. If floods and storage measures along the Upper Rhine are not taken into account, a 4°C
temperature increase would mean a discharge at Lobith of more than 19,000 m³/s.

For the last 1,000 years, sea water levels measured along the Dutch coast have become higher and higher. This is not solely caused by the sea level rise, but also by subsiding coastal areas. The combination of these two effects is called relative sea level rise, and it amounts to 20 cm per century. It is expected that this trend will continue in the near future. Like river discharges, the consequences of climate change on sea level must also be taken into account. Various scenarios have been developed for this situation. The mid-range estimate of a 1°C increase in temperature around the year 2050 would cause a relative sea level rise of 25 cm. The highest estimate of a 2°C increase corresponds to a sea level rise of 45 cm around 2050. The sea level rise in 2015, the year envisioned for achieving sustainable flood defense in the Netherlands, can be derived from these previous figures; the highest estimate will then be around 15 cm [53].

4.8.2 New Approach
For centuries, spatial planning in the low-lying Netherlands has been a matter of separating land and water and maintaining this separation. However, climate change increases the likelihood of floods and other water-related problems (e.g. droughts and rising sea level). In addition, the population density continues to grow, as do the potential of the economy and, consequently, the vulnerability of the economy and society to flood and drought disasters. These developments add up in terms of safety, creating a growing risk with even greater consequences. As such, the safety risk is growing at an accelerated pace (safety risk equals probability of flooding
multiplied by flood damage). In 1999, the Secretary of State for Transport, Public Works and Water Management and the president of the Union of Water Boards established the Advisory Committee on Water Management in the 21st Century [54]. This Committee was charged with developing recommendations for desirable changes to the water management policy in our country, focusing on the consequences of other water-related problems such as climate change, rising sea levels and land subsidence. In 2001, this Committee produced some guidelines for future water management in the Netherlands. The Dutch government enacted these guidelines in the new approach to ensure safety (mainly flood risk management) and to reduce the other water-related problems in the 21st century. This approach comprises:

- **Awareness;** citizens are insufficiently aware of problems associated with water. The government will improve communication on the nature and scope of these risks and, in addition to its own efforts, will offer individuals the opportunity to contribute to risk reduction.

- **Three-step-strategy;** the need for a new approach to ensure safety and reduce water-related problems founded on a number of underlying principles [54];
  - anticipating instead of responding;
  - not shifting water management problems to others, by following the three-step strategy (retaining, storing and draining) and not shifting administrative responsibilities to others;
  - allocating more space to water in addition to implementing technological measures.

- **More room for the river;** in addition to implementing technological measures, allocating more space for the (occasional) storage of water
is required. Wherever possible, this space must also serve other objectives that are compatible with water storage.

- **Spatial planning:** the primary goal is maintaining the discharge capacity of the river by legislation preventing non-river-linked human activities (such as housing and industrial estates) in the floodplains and by adapting municipal zoning schemes. Furthermore, within the context of spatial planning, a so-called “water test” is being added to the present legislation. This test must examine the future effects of proposed zoning schemes on water systems and prevent the gradual decrease in the space allocated to water caused by land-use, infrastructure, housing and other projects [54].

- **Knowledge:** the new water management approach imposes new demands on the coordination and distribution of knowledge and on education relating to water and river management (e.g. including new insights in social studies, spatial planning and public administration).

- **Responsibilities:** the government, provincial authorities, water boards, and municipal authorities are all responsible for ensuring safety and limiting water-related problems. Administrative agreements about the division of tasks and cooperation must ensure rapid and effective implementation of measures. A review has been conducted to assess the suitability of the relevant present legislation for a rapid implementation of “room for the river” projects and to see if this legislation needs to be adapted [54].
- **Investments;** developments in terms of climatic change and land subsidence, as well as the new approach, require repeated additional investments in both the national and regional water management systems.

- **International cooperation;** international cooperation on flood protection and water management must be intensified.
CHAPTER FIVE

5. The European Union and Flood Management Strategies

5.1 Introduction:
The European Union developed an integrated water management directive for the member states. In order to make planned water management throughout the individual member state, the EU developed water framework directive and make it active by specializing it work in different water sector. My aim to incorporate this chapter in my work is; first and most important is that the Netherlands is a European country, where the European Union has a common policy of water management for the individual member states. Secondly, the EU has developed a law “Water Framework Directive” for water management across the member states which influence the Netherlands national water management’s policies. Finally, how the EU influences the Netherlands flood management as a member of the Union.

5.1.1 EU Water Framework Directive
The water managers of the EU countries have long regretted of their own powerlessness on forms of land use which have a great impact on the quality and resources of water. In spite of warning, new urban development still continued on flood prone areas. The governmental problem is partly territorial and partly administrative political. The authority of the river and the water generally posses limited influences on land uses and water. They mainly exercise on the field of direct bearing on water quality and quantity issues, notably land use planning, agriculture and forestry, hydro electric
power, navigation, nature conservation and economic development [45]. The EU has developed water framework directive adopted in *December 2000 (EC, 2000)* so that they can overcome the above problems. The water framework directive institutionalizes river basin management across the EU, including the water management plans. Incorporating a water management policy throughout the river basin the EU expect to encourage a more holistic and territorially integrated approach to solve water related problems [45].

The Water Framework Directive of the EU establishes a common framework of sustainable and integrated water management. It encompasses groundwater, inland surface waters, transnational waters and costal waters as well as it has taken in to account all impact factors and economic implications. The overall goal of the water directive is to achieve a good status of all water bodies in the EU member states and associated states by 2015. Integration is the key factor of the water framework directive which takes under consideration all natural and entropic factors which can influence the quality and quantity of water resources [45].

**5.1.2 The Purpose of Water Framework Directive:**

To prevent further deterioration as well as protect and accelerate the status of aquatic ecosystems, and contribute to continue reduction of discharges, emissions and losses or priority substances in water. According to the water framework directive economical instrument used by the member states will be considered as a part of the programme measures. Including the environmental and resources expenses of water service cost, associating the damages or with negative impacts on aquatic environment must be taken
consider which is the principle polluter pays. For this purpose, an economical analysis on water services, based on long term forecast of water intakes and water demand at watershed level is required. The Pollution prevention and control policies must be based on a combined approach, using source control pollution, through establishing maximum allowable limits of emissions and environmental quality standards [46].

5.1.3 The Aims of EU Water Framework Directive:

In order to establish a new and common management for the water policy, the EU Water Framework Directives represents a new set of overall objectives.

- Expand the scope of actions to protect water from all forms of naturally occurring water in the environment, including surface and ground water.
- Protect further deterioration and enhance the status of aquatic ecosystems, with regards to their water needs, terrestrial ecosystem and wetlands
- Promote sustainable water use based on long term protection of available water resources.
- Takes specific pollution control measures, by reducing or eliminating discharge and emissions and loss of priority toxic substances to enhance the protection and improvement of the aquatic environment
- Reduce pollution of the ground water
- Contribute to mitigating the effects of floods and droughts
• To take measures for achieving good water status for all waters within a predetermined timescale

Water Framework Directive imposes to member state a series of obligations regarding planning, applying legislative measures, monitoring, public consultation and report [46].

5.1.4 Under Practical Aspect, Directive Demands:

• More wider field of instruments for water monitoring and classifying, in the purpose of assessing the ecological status;

• An authorizing and registration system for water intakes;

• An official planning system at watershed level and applying suitable measures for diffuse water pollution control.

The main mechanism by which the WFD will attempt to achieve its goals is by compelling each member state to divide its territory into River Basin Districts (RBDs) each administered by a River Basin Management Plan (RBMP). Where a basin crosses national boundaries, the responsibility should be shared between governments and one single vision created. The integrated management of rivers and lakes as natural geographical and hydrological units, as opposed to administrative or political ones, is a new innovation for the European Union. From the perspective of the land-use planning system, it is this innovative feature of river basin or catchment focus that could have a significant impact [46].
5.1.5 The Role of the River Basin Management Plan

The purpose of the RBMP is to outline the objectives that have been set for the water bodies within the RBD and to explain the programme of measures designed to achieve those objectives. Also included in the plan will be the analyses that have been used to inform the process of objective setting and the programme of measures, as well as information on monitoring arrangements and the status of the water bodies operating within the river basin district. The plan can also include any other programmes and management plans that have already been prepared for that area, for example, covering, sub-basins, sectors, issues or water types [47].

The EU Water Directive requires that the format of appropriate objectives and setting up of the programme of measures as well as the targeting of monitoring are determined by investigation into each individual RBD. The RBMP must thus include:

- An analysis of the characteristics of each water body, e.g. diffuse and point source pollution present, identifying special protection areas, size, quality, salinity;

- The impact of the human activity on the status of surface and ground water, that means a spatial investigation of pressures and impacts as well as an analysis of human activity.

- An economic analysis of water use, e.g. the costs associated with water services and how to recover them.
There are a number of other important aspects of the Directive. First, it recommends that there should be further integration of the aims of sustainable water practice and management into other EU and domestic policies which may interact with, and therefore potentially either support or undermine the Directive, such as agriculture, transport and regional policy.

Second, RBMPs must be updated every six years, following the initial publication of plans in 2009, with an important responsibility to ensure public participation in both the creation and revision of RBMPs. Third, the RBMPs should take the existing natural flow conditions and hydrological cycle into account, and fourth, with regard to diffuse pollution. As with domestic legislation the WFD also advocates utilization of the precautionary principle with regard to achieving environmental aims and it is advocated that where possible the polluter should be made to pay [47].

The Directive states that enforcement will happen if either the integration process is not followed within a certain timescale or if good water status is not eventually achieved. However, it is unclear how strict the penalties will be, or how stringently any potential loopholes may be tightened [47].

5.2 Rational of the EU Water Framework Directive to flood management
The publication of the European Union (EU) Water Framework Directive (European Union, 2000) has highlighted the growing need to explore the interconnectivity between land-use planning and water pollution as well as flooding and here the relationship between water framework directive and flood management in the Netherlands. The flood management of European Union specifically in the Netherlands is a part of European Union Water
Framework Directive. The new water management strategy (WFD) represents the retention-store-drain strategy, broadening of riverbeds, the designation of flood-areas and co-operation between water managers and spatial planners has been accepted by the member states. As a result if we want understand the water management and flood management strategies of the Netherlands clearly it is important to know the EU water framework directive clearly.

5.3 European Union’s Strategies on flood management

A number of large scale floods around Europe increased to over 120 major events causing some 345 fatalities and an estimated economic loss of at least €12 billion [38]. A result of climate change the scale and frequency of floods are likely to increase in the future mostly as (European Commission, 2005), inappropriate river management and infrastructure development in flood prone areas. The strategy in prioritizing flood protection measures has changed over time from the traditional technical engineering approach to management of risk and “living with floods [37]. This change in the EU strategy on flood risk management is first and foremost identified officially through the new EU Flood Directive. On 26th November 2007, the Directive 2007/60/EC of the European Parliament and Council about the assessment and management of flood risks entered into force. This directive, herein referred to as the Directive, now requires Member States to identify areas adjacent to their water courses and coast lines which are at risk from flooding, to map the flood extent and assets and humans at risk within these areas and to take adequate and coordinated measures to reduce flood risk. The Directive also reinforces the rights of the public to have access of the related information and to have a say in the planning process [38].
The main objective of the Water directive are to establish a framework for the assessment and management of flood risk to reduce the adverse consequences of flood regarding to the human health, environment cultural heritage as well as economic activity. The water directive applies for all kinds of flooding like rivers, lakes, urban floods and costal floods including storm surges and tsunamis as well as the member states should implement a unifying process of three steps:

Step1.
**Preliminary estimation:** The member states of the EU will undertake a preliminary study for flood risk assessment in their each river basin and associated costal zones by 2011; in order to identify areas where potential significant flood risk exists. Where a significant flood risk is found, further action will only have to be taken regarding either current or future conditions [38].

Step2.
**Flood hazard and risk maps:** For areas with significant flood risk, the member states must develop flood hazard maps and flood risk maps by 2013. These maps will delineate areas with a medium and low probability of flooding by indicating also expected inundation depths. Other types of information on these maps will include the number of inhabitants at risk, the economic activity in the area of risk and the environmental damage potential. The flood maps are expected to increase public awareness in the flood-prone areas, to support the processes of prioritising, justifying and targeting
investments and to support the development of flood risk management plans, general spatial plans and flood emergency plans [38].

**Step 3.**

**Flood risk management plans:** In fine flood risk management strategies must be drawn up for zones that identified in 2nd step at the river basin or the sub-basin spatial scale. These include measures to reduce the probability of flooding and its potential consequences thus becoming the operational instrument for flood risk management in its entire area. Although the primary focus will be on the prevention, by refraining from construction of houses and industries in the present and future flood-prone areas or achieving the future flood risk, protection by reducing probability and impacts of floods in a specific location and preparedness by giving instruction to the people what they should do during the event of flooding.

As a result of flooding nature much of flexibility in the objectives and measures is left to the member states in a view of the principle of subsidiary. In the case when a river basin fall in the entirely within the EU but shares between several member states or extending beyond the boundaries of the EU, in such a case the above mentioned measures should be elaborated across the whole management unit of river basin or sub-basin [38].

The maintained strategies need to be reviewed every six years in cycle coordination and synchronized through the implementation cycle of the Water Framework Directives [38].
CHAPTER SIX

6. Comparison of Flood Management Technique

6.1 Comparison:

As a natural phenomenon, through most of the world floods and flooding in most cases are not appreciated by people living in the affected areas. In order to prevent the negative consequences of the flooding, flood management and flood control measures has been introduced in many places. The probability of flooding and flood damage are called flood risk. Flood risk management is the long tradition of the Netherlands, which gradually developed towards a flood defence approach in the 1950s. At first the settlers lived on higher grounds and in this way kept damage as low as possible. Damage reduction was their main concern. In the course of time the higher ground were connected by dikes to protect the land behind the dikes from flooding.

On the other hand in Bangladesh, some 50 years ago, the people of Bangladesh simply used to build houses above the expected (on the basis of their assumption) flood water level on previous years. This suited a population of only 40 million people. But since then, population has grown to in excess of 150 million, requiring a substantial increase in agricultural production. From the time of independence in 1971, controlling floods has been a national goal. Recently, the aim of controlling floods has been broadened to a more structured flood management.

For centuries the Dutch have reclaimed and drained land and raised dikes to protect themselves against floods. The 1953 storm surge, which caused the
death of some 1850 people, was an important policy catalyst for better protection. It soon led to the installation of the so-called Delta Committee (DC), which performed many studies and came up with (independent) advice to the government. According to the Delta committee the safety standard on flood risk, indeed as a combination of flood probability and flood consequence, in balance with the construction costs for realizing a certain flood probability was established. The results of this analysis - actually a cost-benefit analysis - were used to establish engineering guidelines for dike heights.

In Bangladesh the modern policy shift was catalyzed by the 1987–88 floods, which was followed by the Flood Action Plan as coordinated by the World Bank. After the 1998 flood, Bangladesh government has adopted a world bank sponsored Flood Action Plan (FAP) which resulted hundreds kilometers of tall embankment construction along the great rivers of Bangladesh that also included enormous drains, and compartment on the flood plains [40]. Building of earthen embankment, polders, and drainage are the mainly limited flood control measures in Bangladesh. The total 5695 kilometers of embankments, which include 3433 km in the costal areas, 1695 flood control /regulating structures and 4310 km drainage canals have been constructed by the Bangladesh Water Development Board [41].

Due to geographical difference and economically weakness, the flood control strategies or management of Bangladesh are not similar to the Netherlands. Although both two are delta country and suffered for serious flood problems. Bangladesh is the most flood prone country in the south Asia and the Netherlands is the most affected country in the Europe. Both two
countries are dominated by the major rivers and the river system influences the national economy. The question is how the Netherlands achieved a better structured flood management and Bangladesh is till now under undeveloped flood management. The following table 7 will represent a clear picture of both of the two countries Bangladesh and the Netherlands water and flood management strategies.

Table 7: shows both two country’s flood management strategies.

<table>
<thead>
<tr>
<th>SL.NO</th>
<th>Netherlands Flood Management Strategies</th>
<th>Bangladesh Flood Management Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Developed different laws for flood management.</td>
<td>Developed different lows for flood management.</td>
</tr>
<tr>
<td>2</td>
<td>Different organizations in central, provincial and regional level are responsible for flood management (The government level, the ministry of Transport, Public Works and Water Management).</td>
<td>Different organizations in different stages are responsible for flood management and flood control (Local Government Institutions, Bangladesh Water Development Board, and Disaster Management Bureau).</td>
</tr>
<tr>
<td>3</td>
<td>Developed Massive engineering and spatial constructions to protect flood.</td>
<td>Absence of Massive engineering and spatial construction.</td>
</tr>
<tr>
<td>4</td>
<td>Develop a good system of hydrological data collection all over the country.</td>
<td>Develop a good system of hydrological data collection all over the country.</td>
</tr>
<tr>
<td>5</td>
<td>Developed the rules or laws for the dike reinforcement and care(The Water Embankment Act 1996).</td>
<td>No developed rules or laws for the dike reinforcement and care, as a result high rate of dike breaching.</td>
</tr>
<tr>
<td>6</td>
<td>Developed their flood risk management on the basis of cost-benefit analysis.</td>
<td>Absences of Risk management on the basis of cost-benefit analysis.</td>
</tr>
<tr>
<td>7</td>
<td>Primarily considered the necessary to give high priority to the establishment a more</td>
<td>Primarily considered the necessary to give high priority to the establishment a more</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td>Netherlands</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>8</td>
<td>Established Dike Ring.</td>
<td>Establish only dikes along rivers (DND embankment which protect Dhaka, Narayanganj, and Demra from the adjoining Buriganga and Shitalkhya rivers and).</td>
</tr>
<tr>
<td>10</td>
<td>Provincial governments (12 in total) formulate strategic and operational water management policy.</td>
<td>In an emergency period special committee was formed in regional level for relief and rehabilitation during inundation.</td>
</tr>
<tr>
<td>11</td>
<td>Water management is not only determined by its formal structure, informal structure is far more important than the formal structure.</td>
<td>No informal water management structure.</td>
</tr>
<tr>
<td>12</td>
<td>Structural flood defenses have three components: dunes, dikes, and special structures.</td>
<td>Structural flood defense has only one component: dikes along the rivers.</td>
</tr>
<tr>
<td>13</td>
<td>Involvement of public private partnership. Public-private enterprises can help finance flood system improvements.</td>
<td>No public private partnership in the water and flood management.</td>
</tr>
<tr>
<td>14</td>
<td>Common water and flood management laws among European countries (EU water Framework Directive).</td>
<td>There is no common law for trans-boundary rivers management or water management.</td>
</tr>
<tr>
<td>15</td>
<td>In 1998 The Netherlands spent 1 percent of its national income (US $ 3.14 billion) on water management - 15 percent of which was for flood protection (US $ 444 million).</td>
<td>During last 40 years the Govt. has invested only approximately Tk. 200 billion (US$ 4 billion) in the water sector.</td>
</tr>
</tbody>
</table>
Similar to Bangladesh where, the three big rivers, Ganges, Brahmaputra and Meghna came from India. The Netherlands is formed by the deltas of three rivers- the Scheldt (rain-fed, originating in southern Belgium), the Meuse (rain-fed, originating in northern France), and the Rhine (glacier and rain-fed, originating in Switzerland). Which are also generated from different countries. Both two countries have been suffering from flood disaster, where flood causes in Bangladesh mainly by heavy rainfall and in the Netherlands heavy rainfall and snow melting together causes flooding.

Although organizationally The Dutch law of water management is not like as a general umbrella but functional government units exist at the regional and local levels which always implementing strategies under central law of water management policy. On the other hand, in Bangladesh only the central water development board responsible for the water management. There are regional water development boards which only implement the central command. The flood control management is not an umbrella act at all; it is like a scattered one, and there is always contradiction between the organizations related to the flood management strategies.

After the 1950, Dutch has developed massive engineering and spatial strategies to save the country from floods. Where before the 1950s the determination of required heights of dikes was based on the historically know water level now they are using the statistical data to manage the flood disaster [42]. Bangladesh also has developed a good system of hydrological data collection all over the country. It has also developed a structured hydrological database with about 40 years of data. It has the system of real time Water Level and Rainfall data collection from a selected numbers of stations all over the country for FFWS during
monsoon months. All these data are used for National Water Management Planning (NWMP), planning and design of different types of hydraulic structures, construction of different infrastructures.

- Where the Netherlands developed the rules for the dike reinforcement and care as well as a clear instruction who will take care of the dikes (The Water Embankment Act 1996), but in Bangladesh there is no clear rules or authority that who will take care of the dikes along the rivers. As mentioned earlier most of the dikes are made of earthen so it can easily breach and can be damaged by riverbank erosion. Most of the embankments in Bangladesh have been breaching and erosion more than one time during their constructions, Table 7. In many cases the effectiveness of embankments has been questioned in other countries as well.

Table 8: shows some Breached embankments [27].

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Regions/District</th>
<th>Location of Embankment</th>
<th>Date of breach</th>
<th>Damages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cox’s Bazar, Teknaf</td>
<td>Cox’s Bazar Cross Dams</td>
<td>05.06.2007</td>
<td>150 Houses</td>
</tr>
<tr>
<td>2</td>
<td>Dhaka, Bagtoli</td>
<td>Gabtoli Mitford connection embankment</td>
<td>11.06.2007</td>
<td>Connecting road damages</td>
</tr>
<tr>
<td>3</td>
<td>Sirajgonj, Khosbari</td>
<td>Jamuna River Khosbari embankment</td>
<td>13.06.2007</td>
<td>1200 meters breached</td>
</tr>
<tr>
<td>4</td>
<td>Gaibandha, Polashgonj</td>
<td>Korotoa River Embankment</td>
<td>14.05.2007</td>
<td>Soil moved away and make huge damaged</td>
</tr>
<tr>
<td>5</td>
<td>Patuakhali, Baufal</td>
<td>Baufal Upazilla Embankment</td>
<td>18.05.2007</td>
<td>12 Villages flooded and 2000 acres land damaged</td>
</tr>
</tbody>
</table>
Figure 13: Shows Jamuna river bank erosion, Damaged Embankment inundated agricultural land and Faridpur Town Protection Embankment at Dharar [The Daily Prothom-alo, 13.04.2010]

- The Netherlands developed their flood risk management on the basis of cost-benefit analysis and taking all decision of flood management on the basis of this system by assessing flood risk. The Engineers today use two strategies to evaluate flood management solutions, Risk-based and Reliability-based design. The risk is estimated by the discharge of the major rivers. Currently they are using a minimum acceptable flooding probability (at Lobith of 18,000 m³/s around 2100 of the Rhine) for flood protection. On the other hand, in case of Bangladesh till now there is no such a system developed. They only have been establishing embankment along the river to protect agricultural land and people from inundated.

- Both Bangladesh and the Netherlands considered necessary to give high priority to the establishment a more structural basis with water embankment projects from the very beginning of flood control strategies. But now-a-days the Netherlands implanting new policies, like storing flood water, room for river and flood bypass rather than embankments. Where in Bangladesh still now has been practicing the old strategy establishing embankment along the big rivers the Ganges, Brahmaputra and Meghna.
In the Netherlands the societal acceptance of further heightening of the dikes along the river is very low despite attempts to reduce impacts to the landscape to a minimum. In Bangladesh, they are only making dikes along the rivers. Whether, the construction of earthen embankments and polder may reduce floodplain storage capacity during flood and which increase water levels and discharges in many cases [44]. Embankments can also create a false sense of security among residence living within embanked areas. For example, breaching of Gumti embankment at Etbarpur during 1999 flood caused substantial damage to the environment and property [44].

Where the Dutch are increasingly incorporating new strategies in their flood management policies. Two strategies are receiving the most attention as potential methods to minimize economic consequences of flooding: storing flood waters and increasing maximum flow capacity of channels. Bangladesh is only thinking of their indigenous knowledge of making dikes or embankments along rivers.

In the Netherlands, at the government level, the ministry of Transport, Public Works and Water Management (V&W) is responsible for water management in general, including strategic water management policy and formal legislation. But in Bangladesh only Bangladesh Water Development Board (BWDB) play a central role of implementation, operation and maintenance of flood management projects, real-time data collection for flood forecasting and warning services, dissemination of flood information at national and regional levels.
The provincial governments (12 in total) in the Netherlands formulate strategic and operational water management policy within the framework set by national policy. In Bangladesh, flood management relating to water management at national level is co-coordinated by the National Water Council or board and particularly by the Ministry of Water Resources. Flood management relating to disaster management is co-coordinated by National Disaster Management Council particularly by Ministry of Disaster Management and Relief. Both activities are also coordinated at local levels by appropriate bodies.

In the case of the Netherlands, water management is not only determined by its formal structure. It is even stated that in the Netherlands the informal structure is far more important than the formal structure [20]. This informal structure Figure 14: Shows the villagers making a small dike [57] consists of all kinds of interactions between stakeholders that are not ruled by law. Among the stakeholders of water management are the general public, consumer organizations, environmental organizations, press, farmers, industry, drinking water suppliers, professionals (especially technicians), scientists,
politicians, and public officials. These stakeholders may exert their influence individually, or in some kind of institutional arrangement. Such case is absolutely absent in Bangladesh’s water management policy. In some cases in a particular place the inhabitants of a specific village or small region make small dike to protect their irrigated land or their living area, see Figure 14.

- The Netherland’s structural flood defenses have three components: dunes, dikes, and special structures. Natural sea dunes protect coastal areas from tides and storm surges. The dunes are planted with helm grasses to hinder erosion. Where there are no dunes, the Dutch built dikes. The dikes, initially constructed along the river, have become dike rings to provide protection on all sides. Cross dikes are used to protect against upstream dike bursts. Special structures include cofferdams, gates, and retaining walls. In general, these special structures are in place as temporary solutions in response to a flood event or storm surge. In compare to the Netherlands, Bangladesh’s flood protections is going on only one component dike or Embankment. For example DND embankment which protect Dhaka, Narayanganj, and Demra from the adjoining Buriganga and Shitalkhyya rivers and The Meghna-Dhonagoda embankment and others that have been constructed to protect cities and towns like Rajshahi, Shiraiganj, Chandpur, Khulna and Barisal. In Some cases very simple scale spatial structures have done like small gates and preventing riverbank erosions measure.
Then Netherlands developed Insurance against Climate Change and Flooding in the Netherland through enacting law, moreover they have The Water Board Bank was formed in 1954. The local water boards were too small on their own and formed the collaborative to allow long-term borrowing at favorable rates. Where in Bangladesh there is no flood damaged based insurance. Recently some companies are trying to start for agriculture insurance that is still in darkness.

Public-private enterprises can help by finance for flood system improvements. Two recent partnerships include gravel and sand production and urban planning in the Netherlands. The Grandmas project combined private gravel and sand extraction with floodplain lowering. Private enterprises have also presented plans for floating villages, which allow for river dikes to be moved further inland and maximize the public’s willingness to pay for riverfront property. But in Bangladesh this case only shows when the flood occurred many private organizations, non government organization and person individually participate to advocacy for relief and Rehabilitation of flood victims.

Both Bangladesh and the Netherlands are dominated by the three transnational rivers. As a member of the European Union the Netherlands water management and flood management strategies goes under a common laws and regulations of EU, but in the case of Bangladesh there are some laws on Trans boundary Rivers also. But lack of there implementation make Bangladesh highly plod prone. A common problem in Bangladesh is Farraka Barrage on the Ganges, high discharge in moon soon time and a low discharge in winter time due to Farraka Barrage,
Figure 15 shows the Farraka Barrage and the situation of low discharge in winter or dry season and high discharge in monsoon.

Figure 15: Shows the Farraka Barrage, during the low discharge and at time of high discharge at the Ganges basin.[57]

➢ As a developed country the Netherlands spend a huge amount of money for their water and flood management sector. In 1998 (the most recent year with published information), The Netherlands spent 1 percent of its national income (US $ 3.14 billion) on water management - 15 percent of which was for flood protection (US $ 444 million). In the next ten years, the Dutch anticipate spending $2.9 billion on flood protection. Where in Bangladesh, has invested approximately only Tk. 200 billion (US$ 4 billion) during last 40 years in the water sector mainly for FCDI projects. Annually the Govt. spends about Tk. 10 billion (US$ 200 million) in the water and flood management.
CHAPTER SEVEN

7. Recommendation and Conclusion

7.1 Recommendation and conclusion
The aim of this study is to find out the possible solutions to protect flood from any further devastating damages in future in Bangladesh. In this study, I have compared between the flood management strategies of two countries, Bangladesh and the Netherlands. As a poor country with high population density, Bangladesh has been trying to mitigate the floods using an old system of establishing dikes or embankments along the rivers. Due to its poor resources, flood may not be controlled completely. As a result, Bangladesh trying to reduce flood damages using structural and non-structural strategies, like early warning system, real-time information, relief distribution and integrated flood management and so on in combined. Despite being haunted by the all enveloping and devastating calamity like flood, the Bangladeshi people come back to the main stream of their life only because of their morale. In comparison to the Bangladesh, the Netherlands a developed country in the Europe using a massive engineering structures and incorporating new policies in their flood management. From this study an approached of some solutions can be formulate which would be helpful to the people in Bangladesh.

Bangladesh needs to further strengthen its institutional and technical capabilities, developing and launching, as needed, effective flood mitigation programmes in a coordinated fashion in which the people, the voluntary agencies, the government, and the other actors play their respective roles within a properly synchronized framework.
Bangladesh can take under consideration of three major alternatives to decrease the propensity of flooding: upstream storage; Drainage of the river basin or as Netherlands said “Room for Rivers” and making flood bypass or “Green River” throughout the countries, more preferable in the cities.

The government should take under consideration immediately about the dike or embankment reinforcement and care, who will take care of the embankments, as in the Netherlands the water embankment act 1996. Structural measures other than embankment construction—such as the proper maintenance of already constructed embankments, and the construction of additional sluice gates will help mitigate the effects flooding.

Bangladesh has many laws enforced at different times for flood plain and flood management. Considering the importance of bringing harmony and consistencies among the laws the Govt. should take proper steps.

Building of embankment across the rivers and construction of polder in costal areas in Bangladesh as structural solutions may not solve the problem of flooding, moreover resulted many adverse environmental, hydraulic, ecological, economic, and geological situations. The problems can be solved by adopting and exercising water-shade scale best management practices which incorporate floodplain zoning, planned urbanization reconstruction of abundant channels and lakes, dredging rivers and streams and good governance.
Community participation in decision making as well as in planning and implementation of flood management strategies would be the key to success of flood management.

Bangladesh is a small country of large hydrodynamic system that comprises several countries. As a small part, mutual understanding and cooperation among the countries should be necessary to formulate any long term and permanent solutions of the flood problems.

The flood control and policies measures should be directed thorough the mitigation of flood damages rather than flood preventions, on the basis of cost benefit analysis, so that they can perform the best use of their limited resources on flood management. Emphasis of the resources should be allotted for helping people to adopt a life which conform their natural environment. Pragmatic solutions by changing the housing structures and crop patterns can reduce flood damage, as the Netherlands practicing floating house now-a-days.

A region-wide structured approach based on comprehensive data sharing and joint modeling and scenario development efforts among the GBM countries should be highly useful in managing floods and mitigating its impacts in all the regional countries.
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