Ideas for Flood Management
Ideas for Flood Management
1. Introduction

2. Flood prevention
   - 2.1 Increasing flow capacity and diversion
   - 2.2 Water retention
   - 2.3 Management of catchment areas
   - 2.4 Integrating drainage and flood prevention measures

3. Flood protection
   - 3.1 Innovations in engineering
   - 3.2 Integrating embankments with other measures
   - 3.3 Alternative protection measures
   - 3.4 Financial initiatives

4. Pre-flood mitigation
   - 4.1 Flood proofing
   - 4.2 Flood preparedness

5. Post-flood mitigation
   - 5.1 Evacuation
   - 5.2 Post-disaster communication
   - 5.3 Emergency relief
   - 5.4 Restoring livelihoods

6. Benefits of floodwaters and floodplains
   - 6.1 Using floodwater for irrigation
   - 6.2 Floods and fisheries
   - 6.3 Using floodwaters for groundwater recharge and water buffers

Annex 1: Reference sources
Annex 2: List of resources
1. Introduction
1.1 Flood Risks on the Increase?

Floods affect more people every year than all other natural and technological disasters put together. The damage caused by floods to people and property across the world has been extremely severe in recent decades. Of the 367,000 people that lost their lives in natural disasters between 1986 and 1995, more than half were victims of storm surges, river floods or flash floods. From 1998 to 2002, 683 flood disasters have been recorded around the world, with 97% of these floods occurring in Asia; the rest occurred mainly in Africa. On an average, about 140 million people worldwide are affected by floods every year (Douben, Ratnayake, 2005). Europe also suffers from floods. The Elbe floods of August 2002 caused numerous casualties, rendered several people homeless and resulted in property damages amounting to several billion euros across many European countries. More recently, in the summer of 2005, Bulgaria and Romania were hit by floods from the Danube River resulting in similar destruction. It appears that floods are becoming increasingly destructive and damaging. In China, for instance, flood damage has increased by an estimated 500% from the 1950s to the 1990s. As a result of human activities and climate change, the occurrence of floods will further increase in the years to come.
Types of Floods

Many different types of floods occur around the world every year. In general, they can be classified into five categories:

1. Riverine Floods:
   The majority of floods recorded globally are due to rivers overflowing as a result of long-lasting precipitation in the river basin. Melting snow and ice can also contribute to flooding.

2. Flash Floods:
   Flash floods generally occur due to local high-intensity precipitation in hilly or mountainous areas. The short warning time makes them difficult to predict. Discharges during flash floods are often much higher than normal flows in watercourses. Flash floods are particularly dangerous on steep slopes.

3. Coastal Floods:
   Areas along the coast may be flooded due to tsunamis, hurricanes or/and unusually high tides. Also long-term phenomena like subsidence and sea-level rise can lead to the gradual encroachment of the sea.

4. Stagnant and Urban Floods:
   Extreme rainfall in towns and cities combined with blocked drains can cause severe flooding. This often occurs in urban areas, where a large percentage of the surface is impermeable.

5. Lake and Canal Floods:
   High levels of precipitation or long-lasting inflows from streams can cause a substantial rise in water levels of lakes and canals that lack sufficient drainage capacity. Also, long periods of drought can cause man-made (peat) embankments to become unstable and fail – resulting in flooding.

(Source: N. Douben and R.M.W. Ratnayake – Characteristic Data on River Floods and Flooding: Facts and Figures)

Introduction

Since ancient times, people have chosen to settle down in flood-prone areas because of various advantages, despite the risks. Proximity to water took care of people’s irrigation needs, transport and navigation needs, drinking-water needs etcetera. Today, with growing population, there is great pressure on water sources and the number of people living in their proximity is increasing, as are flood risks.

There is a connection between global climate change and the increasing frequency of floods around the world. It is generally accepted that climate change is caused in part by the emission of greenhouse gases, which in turn is a result of human activities. It has been estimated that the mean global temperature rose by 0.6 °C during the 20th Century. This temperature rise was accompanied by an increase in precipitation in parts of the Northern Hemisphere and a decrease in precipitation in subtropical and arid regions.

Projected trends for the 21st century show a similar pattern. The Intergovernmental Panel on Climate Change has estimated that the mean global surface temperature will increase by 1.4 °C to 5.8 °C between 1990 and 2100 – with land areas warming up more rapidly than the global average. The projected temperature rise in the short term (between 1990 and 2025) ranges from 0.4 °C to 1.1 °C.

As a result of global warming, regional precipitation rates are expected to increase or decrease by 5% to 20%. Humid areas will become more humid and arid areas will become more arid. Precipitation rates in tropical storms may increase by 20% to 30%.
In addition to a projected global average sea-level rise of 0.09m to 0.88m by the year 2100, the frequency of floods is also expected to increase. The sea-level rise will decrease the drainage capacity of rivers (flowing into the sea), resulting in increased river floods. Extreme precipitation will result in more flash floods in hilly and mountainous areas (IPCC, 2001).

1.2 Flood management

A number of initiatives are being taken to manage floods. Initially, the focus of these initiatives was on solely placed on flood protection. Nowadays the scope has broadened.

Flood defence works have been very successful in protecting flood-prone areas from flooding. By confining and restricting rivers, however, their natural storage capacity has been affected. As a result, flood water levels in some cases have risen, posing a new threat to the protected areas. Moreover, the modified flow regime (of rivers) and the resulting morphological changes often have a negative impact on river ecosystems. In the Netherlands, for example, the downside of constructing flood defence works (like dikes) is that the increasing flood water levels pose a growing threat to the surrounding lowlands (where sediment is no longer deposited, and land is declining). Despite the evident benefits of constructing flood defence works, the shift brings with it corresponding negative effects as well. This points to the need for an integrated approach to flood management. A shift in thinking needs to be made from ‘purely defensive action against floods’ to ‘the management of flood risks’. A good example in this direction is the European Union’s Action Plan for Flood Protection, with its motto “to live with the floods”.

Flood risk = probability of occurrence * impact

Flood management should be based on a three-step approach: retaining water, storing water and discharging water. This implies that where possible, water must be retained on the spot. When this is not possible or when a location’s natural retention capacity has been fully utilized, storage areas have to limit the drainage peak and prevent flooding downstream. This ‘solidarity’ principle ensures that water management problems are not passed on to the lower reaches of the river basin. Only after the first two options are exhausted should water be discharged. In this entire process, river basins should serve as the basic units for all water-planning and management actions.
The EU Flood Directive

The Commission Services (EC) are currently developing the EU Flood Action Programme and a legislative proposal that may take the form of a Directive.

This Flood Directive would aim to achieve concerted, coordinated action to prevent or reduce risks (to people, property and the environment) caused by floods and to improve the overall level of protection against floods. Key features of the new Directive will include:
- The analysis of present and future flood risk through flood risk mapping;
- The elaboration and implementation of flood risk management plans; and
- The dissemination of information on flood risk to citizens, stakeholders and relevant authorities.

As envisaged by the EU, the development of the River Basin Management Plans (under the existing Water Framework Directive) and the Flood Risk Management Plans (under the Flood Directive) will be closely tied together since they are both elements of an integrated river basin management approach.


1.3 Aim of the Book

The aim of this book is to provide ideas and best practices on different aspects of flood management.

The term flood management is broad and addresses all actions that can be taken to reduce flood risk. In presenting ideas on flood management, the book follows the categorization used in the EU document Best Practices in Flood Management: Prevention, Protection and Mitigation (2003)1.

Flood Prevention
Flood prevention can be considered as the first step in flood management. Flood prevention measures are aimed at preventing floods in flood prone (high-risk) areas. The EC (2004) specifies that the objective of flood prevention is, “preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices.”

Flood Protection
Flood protection measures aim to protect flood prone (high-risk) areas against floods. According to the EC (2004), flood protection measures are, “both structural and non-structural measures to reduce the likelihood of floods and/or the impact of floods in a specific location.”

1 This is an update of the United Nations and Economic Commission for Europe (UN/ECE) Guidelines on Sustainable Flood Prevention (2000).
**Flood mitigation**

Flood mitigation aims to minimize the impact of floods. A definition by the Environmental Protection Agency and the United Nations International Strategy for Disaster Reduction (UNISDR) defines flood mitigation measures as, "measures to reduce or limit adverse impacts of floods."

Mitigation measures can be classified as those taken prior to floods, to minimize potential damage (pre-flood mitigation) and those implemented after floods, to alleviate damage caused (post-flood mitigation).

Table 1 below classifies flood management measures under three main headings – flood prevention measures, flood protection measures and flood mitigation measures. Some of the tasks under these three headings are complimentary to one another. Usually, it’s a matter of experience, necessity and judgement as to what measures best suit a given area and situation (see Table 1).

**How to read this book**

The presented ideas are collected from a variety of sources. Nevertheless, the book does not pretend to be complete or exhaustive. It merely aims to present a range of options and activities, based on practical experiences worldwide. Due to the great variation in the size and characteristics of river basins within and between countries, approaches suitable for one location obviously are not automatically transferable elsewhere.

The book is set up in such a way that it need not be read in order from the front to the back. One can browse through

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### Table 1: a summary of the potential benefits and drawbacks of flood-management measures.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Potential benefits</th>
<th>Potential drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flood prevention</strong></td>
<td>• Additional benefits such as groundwater recharge, irrigation and drainage.</td>
<td>• May not protect against peak floods, which may still cause substantial damage.</td>
</tr>
<tr>
<td></td>
<td>• Investment can be multi-purpose.</td>
<td></td>
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<tr>
<td><strong>Flood protection</strong></td>
<td>• Protects critical and high-value assets.</td>
<td>• May interfere with inland fishery and aquatic ecosystems.</td>
</tr>
<tr>
<td></td>
<td>• Protects low-lying areas, where poor neighbourhoods are often situated.</td>
<td>• May reduce river storage capacity.</td>
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<tr>
<td></td>
<td>• Very high demand following flood disasters.</td>
<td>• Land acquisition may be difficult.</td>
</tr>
<tr>
<td><strong>Flood mitigation</strong></td>
<td>• Possibility of extensive coverage at low financial costs.</td>
<td>• High investment costs.</td>
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<tr>
<td></td>
<td>• No impact on natural processes.</td>
<td>• High recurrent costs that may not be affordable.</td>
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<tr>
<td></td>
<td></td>
<td>• Requires certain discipline, which in case of infrequent floods may be lost.</td>
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<tr>
<td></td>
<td></td>
<td>• Perpetuates insecurity.</td>
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<tr>
<td></td>
<td></td>
<td>• Without flood protection, it may be politically unacceptable.</td>
</tr>
</tbody>
</table>

the text and pick up ideas here and there. The different
types of flood management measures – flood prevention,
flood protection, pre-flood mitigation and post-flood miti-
gation are presented in Chapters 2 to 5. A sneak preview
of what is discussed in these chapters is given in Table 2.
since floods are not always a hazard and serve several ben-
eficial purposes as well, chapter 6 discusses the beneficial
use of floods and flood plains. The book concludes with an
annexed reference list of organizations involved in specific
areas of flood management.

Table 2: list of presented measures

<table>
<thead>
<tr>
<th>Chapter 2: Flood prevention</th>
<th>Chapter 3: Flood protection</th>
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</thead>
<tbody>
<tr>
<td>Retention basins</td>
<td>Embankments</td>
</tr>
<tr>
<td>Increasing river capacities</td>
<td>Dams</td>
</tr>
<tr>
<td>Emergency flood storage</td>
<td>Sand bags</td>
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<tr>
<td>Wetlands for flood storage</td>
<td>Innovative engineering works</td>
</tr>
<tr>
<td>Management of catchments</td>
<td>Partitioning</td>
</tr>
<tr>
<td>Drainage management</td>
<td>Flood boards</td>
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<tr>
<td>Chapter 4: Pre-flood mitigation</td>
<td>Chapter 5: Post-flood mitigation</td>
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<tr>
<td>Flood hazard maps</td>
<td>Evacuation</td>
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<td>Awareness campaigns</td>
<td>Direct relief measures</td>
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<tr>
<td>Flood proofing</td>
<td>Land restoration</td>
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<tr>
<td>Shelter construction</td>
<td>Emergency repairs</td>
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<tr>
<td>Disaster communication</td>
<td>Safe communication methods</td>
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<tr>
<td>Insurance</td>
<td>Compensation of losses</td>
</tr>
<tr>
<td>Evacuation drills</td>
<td>Rehabilitation measures</td>
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</tbody>
</table>
2. Flood prevention

Flood management should begin with flood prevention. This chapter deals with measures that must be taken to reduce the occurrence of floods. Often, integrated land use planning is seen as the key to flood prevention. This includes increasing and restoring the natural capacity of rivers to store floods, creating more retention capacity and designing better-linked drainage systems.
2.1 INCREASING FLOW CAPACITY AND DIVERSION

Many rivers have been realigned to suit the needs of the people and communities that live along them. Rivers have been narrowed, channeled and barricaded. This has lead to the obstruction of their natural flow and dynamics. Several remedial measures are possible to restore river beds to their natural state and/or enlarge their capacities to store floods. Such measures also help in groundwater recharge and in improving ecology.

INTEGRATED APPROACH TO FLOOD MANAGEMENT

Romania

The implications of (past) flood management policy on other water-related sectors have led the (Prut) basin Water Directorate to review past flood management policy and practice from a ‘integrated water resources management’ perspective. River bed regulation and dike construction works (river-shortening by cutting off the old meanders) contributed to lower flood levels (due to the riverbed decline: morphological changes caused by the modified flow regime) during high discharge periods. The riverbed decline, however, also lowered the water levels during low discharge periods (when the demand for water is highest). As a result, costly (yearly) temporary dams are now constructed during low discharge periods to head up and divert the water to the cut-off rivers arms. Stakeholder representatives in the Jijia Platform summarised the negative implications for the water supply which serves to: 1) flush the cut-off meanders (sanitation), 2) recharge (dropping) groundwater tables (drinking water), 3) deposit ‘rich’ mineral sediments.

EU VISION ON FLOOD MANAGEMENT

The Water Directors of the European Union have approved guidelines, which call for the development of flood management plans for European river basins. Consideration should be given to the aspect of solidarity within the river basin, that is to prevent, as much as is practically possible, the passing on of problems in one geographical area into another.

Flood management plans should be based on an integrated approach covering all relevant aspects of water management, physical planning, land use, agriculture, transport, urban development and nature conservation at all levels (national, regional and local). Decision makers at all levels, stakeholders and civil society should be involved in the development of the plan.

A typical flood-management plan should look into the following aspects:

- Integrated river-basin approach;
- Public awareness, public participation and insurance;
- Water-retention and non-structural measures;
- Land use, zoning and risk assessment;
- Structural measures;
- Early warning and forecast systems;
- Flood emergency measures; and
- Prevention of pollution.

(Source: European Union. Best Practices On Flood Prevention, Protection and Mitigation)
ment and water supply to arable land (agriculture), and 4) feed aquatic, and (water dependent) terrestrial ecosystems including a Protected Area (ecology). A Cost/Benefit Analysis (based on hydrodynamic model calculations, inundation mapping and flood risk analysis) and Multi Criteria Analysis (non-economic objectives) served to identify the ‘preferred solution’, namely a combination of (local) dikes to protect the ‘high risk’ areas and ‘Space for the River’ in ‘low risk’ areas.

**INTEGRATED PLAN FOR CAPACITY INCREASE**

**Tisza, Hungary**

The Hungarian Government has prepared an action plan to increase the capacity of the Tisza River. The plan includes the following measures:

- Removing wood and vegetation piled up on the river bed;
- Opening passages to increase water flow velocities;
- Rearranging the summer dikes;
- Landscape planning integrated with environmental management and nature conservation;
- Clearing up sand bars along the river bank; and
- Developing infrastructure (like sewage treatment, waste disposal, bicycle roads).

**ARTIFICIAL ‘BOTTLENECKS’ TO FILL FLOODPLAINS**

**Romania**

Several studies have been carried out to find out what measures could best help to reduce the frequent flooding of the Bahlui river. It was finally concluded that the best solution to the problem would be the construction a ‘hydraulic bottleneck’. To do so, the floodplains would have to be closed off by dikes and the main river channel would have to be constricted to just a quarter of its original width. This would cause the water upstream to flow into the floodplains, thereby resulting in better usage of their storage capacity. At the same time, the amount of water flowing out from the bottleneck will be less, so the peak flow during floods will be reduced.

**ENLARGING RIVER BEDS AS PART OF INTEGRATED PLANNING**

**The Netherlands**

To prevent excessive flooding of the IJssel river in the city of Zutphen, there are plans to enlarge its riverbed. Based on urban expansion plans along the river’s path, an integrated
**Flood prevention**

A master plan has been developed for the area that borders the city and the river. The plan from Arcadis entails the reuse of a historic water course of the IJssel river in cases of high river discharge. The plan advocates the use of low-lying areas for water storage and higher areas for urban expansion. Landscape development and nature conservation projects are also being incorporated into the master plan.

**Diversion channels**

**Canada**

In Canada, the Government has constructed a diversion channel for the Neebing River after it flooded severely four times in a row, causing extensive damage to the city of Thunder Bay. The diversion structure at the top of the channel is designed to divert excess water into the channel in order to reduce flood damage to residential properties downstream.

**Dike relocation**

**Arnhem, The Netherlands**

A number of projects are underway in the Netherlands to clear debris and residue from the Rhine’s riverbed, thereby creating more space for its flow. The first dike relocation in the Netherlands was implemented for a branch of the Rhine near the city of Arnhem. A new dike was constructed along the inner side of the existing dike, hereby creating a larger floodplain and a reduction of the water level by 7cm downstream.

**Flood diversion through existing rivers**

**Vietnam**

When the dikes and flood retention basins around Vietnam’s Red River are unable to handle a flood, water is diverted into the Day River which has the capacity to absorb such large discharges. This strategy allows for more manageable flow in the Red River.

**Creating new rivers by sand and gravel extraction**

**The Netherlands**

With water levels in rivers expected to rise around the world due to changing climatic patterns, there is a proposal in the Netherlands to create entirely new rivers. A benefit of such a move would be that it would lead to a decrease in flooding. It can also trigger new ideas and projects in spatial planning and development. Since rivers have a positive influence on the environment, the surrounding regions will also benefit. Pathways for the new rivers would be formed by excavating sand and gravel along the proposed paths. The project costs could be shared by those profiting from the land value increase such as property and real-estate developers.

**Altering groyne dimensions**

**The Netherlands**

In the Netherlands, groynes are used at a number of places to regulate river flow and ensure that water depth is safe for navigation. Due to global climatic changes, the frequent flooding of rivers in the past few years has drawn attention. Several research studies have been carried out to investigate how existing groynes can be used to regulate flooding,
in addition to maintaining water depth. The studies showed that specific changes to groyne design could make them more useful. Most of these design changes involve the downstream slope of the groyne, the slope of the groyne head and the hydrodynamic texture of the groyne’s top layer. Once modified so, groynes could significantly help regulate flood water discharges.

2.2 Water retention

Emergency flood storage areas
The Netherlands

In order to cope with the future flooding of river Rhine and Meuse, the Dutch Government is planning to construct emergency flood water storage areas in different parts of both rivers. These emergency-storage reservoirs would come up on the landside of the dikes along these rivers. In case water in the rivers exceeds safe levels, it can be temporarily retained in the storage reservoirs and thereby regulated. This would prevent flooding in the downstream areas of the river where economic losses would be higher. The emergency reservoirs could also serve other functions like groundwater recharge or ecology. However, the proposal is still being highly debated, and it is important to engage all parties – particularly those that live in and near the proposed flood storage areas – before arriving at a final decision.

Beersche spillway

The “Beersche Overlaat” (Beersche Spillway) is a proposed emergency flood storage reservoir in the south of the Netherlands. From the 15th to the 20th centuries, it was at this point that the Meuse River flooded. In 1921, the National Water Board sealed the spillway and since then the area has never been flooded again. There is a proposal now to partly restore the Spillway.

(Source: www.monumenten.n)
**Flood prevention**

**Retention and expanding rivers**
*Germany*
The State of Baden-Württemberg in Germany has decided to create a retention reservoir with a volume of approximately 67 million m$^3$ to prevent future floods of the Rhine. One of the proposed projects is the Ingelheim Polder which involves the construction of one large combined inlet and outlet built into the Rhine Dike. In addition, two new dikes are to be constructed and several landscape planning measures are to be undertaken. These include the restoration of an old side channel of the Rhine and the creation of ecological flooded areas.

**Small storage reservoirs on tributaries**
*Poland*
After the Vistula River flooded in 2001, local authorities in Poland decided to take measures to improve flood protection for the Gdansk area, especially in the region of the Radunia Channel. To decrease the extent of flooding in the area from intense rainfall, the government decided to construct 18 small storage reservoirs on all the streams flowing into the channel. To handle unexpected, excessive flooding resulting from extremely strong storm surges, two additional flood polders are proposed.

**Creating retention areas from extraction pits**
*Nordwestern Europe*
Pilot projects to research the use of sand and gravel extraction pits as retention basins are being carried out in the Netherlands, France and Germany.

**Flood detention areas**
*Meuse, France*
The French Government is planning to construct a ‘flood detention’ area to manage floods in the River Meuse. This area, which is intended to slow down a flood, is created by constructing a dam that only overflows during exceptional floods (which are the most damaging for the whole watershed). This dam also creates additional water storage in the naturally submerged parts of the river valley.

**Stakeholder involvement in planning**
*The Netherlands*
After the Dutch Government had identified the Overdiepse Polder as a potential flood water retention area, the locals started getting actively involved in the project. Citizen participation was high because everyone wanted to be certain about the project’s implementation, even if it meant that they might have to relocate. Once the State Secretary approved the project, the planning process was taken up by the steering committee together with Habiforum, an expert organization in multiple land use. Local private citizens and businesses played a leading part in the deliberations. The final outcome of this participatory exercise was that the polder should be converted into a peak flood retention basin, with homes and businesses moved to the south of the area where they can be rebuilt on a dike.

**‘Search Conference’ on flood management**
*Romania*
Within the framework of the Netherlands-funded project titled ‘Flood Management related to an Integrated Approach to Water Management’ (FLOMIA), a wide range of
stakeholder representatives from various ministries, the 11 river basin authorities and non-governmental organisations were invited to participate in a ‘Search Conference’ to brainstorm and contribute to the elaboration of a national Flood Management Strategy (FMS). The 3-day program consisted of plenary sessions focussing on the existing flood management policy & practice in Romania, with Dutch state-, water board and private sector specialists (Arcadis) presenting ‘lessons learned’ and ‘best practices’ in The Netherlands (from a national and regional perspective). An outline of the EU ‘Best Practices on Flood Prevention, Protection and Mitigation’ served as a basis for follow-up discussions in small groups on (priority) topics identified by the participants.

The recommendations presented by each group during the final plenary session were incorporated in the advice to the Romanian Waters National Administration (ANAR) and presented at a final workshop attended by Ministry of Environment & Water, ANAR and River Basin Authority staff.

The Netherlands
After the government announced plans to widen a narrow section of a branch of the Rhine River near Nijmegen, local residents and some special interest groups came up with an alternative proposal. The residents were against the government proposal because it involved their relocation. Their alternative proposal suggested the deepening of the flood plains and river banks, and the construction of a large dike. This way, the residents would not have to relocate. However, if the river’s water level were to rise above the danger mark in future, the government’s plan would then have to be implemented.

The alternatives presented by the government (left) and by the inhabitants(right)

Dike relocation to the north. Construction of a large embankment and deepening of flood plains.
**Flood prevention**

**Decision making**

Retention reservoirs can reduce or prevent flooding on a local or regional scale. Before the decision to build a reservoir is made, the following considerations must be taken into account:

- A reservoir is very expensive and difficult to construct and maintain, especially in remote mountainous areas. A flood manager should analyze whether it is worth it or whether other flood prevention measures could be undertaken.
- The reservoir should be so designed that its dam does not fail. When a reservoir dam collapses, the flood disaster is bigger than without the presence of a reservoir.
- The design of the reservoir determines its effectiveness against flooding. Not only the geometry, but also the operation and the location of the reservoir are very important.
- Computer models of reservoirs can help to assess their effectiveness. This helps to decide whether to build a reservoir and, if so, how it should be designed to maximize its effectiveness.

(Source: Arcadis, Flood Management in Zakarpattia Region, October 2005)

**Crop insurance in retention areas**

**China**

China has experimented with crop insurance in the Yangtze River Basin, where flooding is usually extreme. The idea of flood retention reservoirs had run into trouble because residents were opposed to the use of their villages and agricultural land as retention basins. During a trial period, a crop insurance program for inundated areas was implemented in the flood diversion and retention areas of the Huaihe River Basin. Participation was compulsory and 70% of the premium cost of the insurance was paid by the government. The program helped overcome the residents’ resistance to use the basins for flood retention. Also, the cost of the scheme was spread more equitably by including beneficiaries living outside the retention basins as contributors.

**Maximizing effectiveness of retention reservoirs**

**Ukraine**

The Zakarpattia Flood Protection Program focuses on the construction of four retention reservoirs in the upper Teresva catchment. Computer programs are to be used in the operation of the reservoirs to determine when the river is about to overflow and when to start operating the reservoirs.

**Combining retention with other functions**

In some cases water retention can be achieved by making use of existing landscape features. In fact, sometimes these landscape features, wetlands for instance, can even be improved. Resistance from local residents to flood water retention, if any, will also generally be less in such cases.

**Wetlands as flood buffers**

Wetlands store heavy rainfalls well, preventing possible flooding downstream. By storing water in the ground or retaining it in surface water sources like lakes, marshes etc, wetlands reduce the need for expensive, engineered structures. Wetland vegetation also plays a role in slowing down the flow of flood water.

By restoring the wetlands in floodplains and managing the ecology of river basins, governments will not only save huge
damages caused by floods, but also restore other ecological features like underground aquifers.

Wetland as flood buffer

**Mitigating climate change**

Wetlands play a critical role in mitigating the effects of climate change. They are very important for the management of greenhouse gases, especially carbon dioxide. Wetlands have been identified as significant storehouses (sinks) of carbon. This means that the destruction of wetlands will release carbon dioxide, while wetland restoration and creation will increase the storing of carbon.

(Source: Ramsar Convention – http://www.ramsar.org)

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**Flood prevention**

**Wetlands as retention basins**

**Zambia**

The Barotse floodplains, which occupy much of western Zambia, retain seasonal flood waters and release them down the Zambezi River throughout the year. Without the floodplains, during the rainy season, the Zambezi Delta would be devastated by floods all the way to the Indian Ocean.

**Advantages of wetland water retention**

Wetlands function as natural sponges. They trap and slowly release surface water, rain, snowmelt, groundwater and flood waters. Trees, root mats and other wetland vegetation also slow the speed of flood waters and distribute them more evenly over the floodplain. These two effects combined help to lower flood heights and reduce erosion. Wetlands within and downstream of urban areas are particularly valuable, as they counteract the greatly increased rate and volume of surface-water runoff from pavement and buildings. The water-holding capacity of wetlands helps control floods and prevents water logging of crops. Preserving and restoring wetlands, together with other water retention measures can often achieve a degree of flood control that otherwise would need to be provided by expensive dredge operations and levees.

**Retaining capacity of unaffected wetlands**

**USA**

The wetlands along the Mississippi River once stored at least 60 days of floodwater. Nowadays, most of these wetlands have been filled or drained, which makes them only capable of storing 12 days of floodwater.
**Flood prevention**

**Farmland retention**

*China*

China has been shifting its focus from flood control to flood management. The government now promotes reduced reliance on structural flood control measures, and increased use of non-structural measures like flood damage insurance and greater use of retention basins and wetlands. A number of recent projects have been aimed at restoring farmlands into their former function as wetlands. Along the Yangtze, Yellow, Huai and Hai rivers, the government is re-converting 98 areas from their rural functions to their intended flood retention functions. Although this disrupts the lives of 18 million people, the government has been successful in winning their confidence in its ability to mitigate flood risk while also improving the capacity of households to cope with controlled flooding within the retention basins.

*Tisza Valley, Hungary*

Plans are afoot to build a flood retention reservoir for the Tisza River to water levels by 60 cm. However, since permanent storage will be too expensive and harmful from an ecological viewpoint, water will only be stored temporarily. This way, farming can also continue to be practiced unhindered.

**Using hydroelectric plant reservoirs for retention**

*Vietnam*

In addition to a large system of dikes, the Government of Vietnam has constructed multi-purpose reservoirs on the banks of the Red River. Though these reservoirs are normally used for hydroelectric plants, their primary function becomes flood water control and regulation during the rainy season.

2.3 Management of catchment areas

During heavy rainfall, a number of measures can be taken to retain and store water in upper catchment areas to reduce flood peaks.

**Soil conservation in the uplands**

*China*

Most flood related deaths in China are caused by flash floods, landslides and mudflows in hilly areas. During the last five years, the Government of China has converted large parts of the sloped farmlands into vegetation areas. This vegetation is meant to prevent future erosion in the hills.

**Reducing impervious surfaces**

In urban areas, many surfaces are impervious to water. This means water is not retained on the spot, but runs or flows off to other areas. It is therefore necessary to minimize impervious surfaces so that groundwater retention in such...
areas increases. Methods of reducing impervious cover include critically examining parking needs, using narrower roads, reducing building setbacks to reduce the length of driveways and service walks, and using permeable paving materials.

Selective use of permeable surfaces
Seine-Normandy Basin, France
Permeable road surfaces are now being used, where possible, to limit surface rain runoff. This reduces sharp flood peaks and increases infiltration of rain water into the soil and hence groundwater recharge.

Increasing vegetation to prevent erosion
Reforestation is considered one of the best measures to reduce erosion and the impact of floods. However, trees are not always the best way to prevent erosion, because they need to be planted very densely to be effective. One useful solution in this regard could be to plant vetiver grass on steep hillsides, for instance. These grasses have extensive root systems which bind the earth and reduce erosion within a year of being planted. Vetiver hedgerows are not invasive and are raised by cuttings only. Though their planting is labor intensive, they require little maintenance once planted. In time, natural terraces begin forming behind vetiver hedges.

2.4 Integrating drainage and flood prevention measures

Integrating drainage and flood prevention measures is very important for a number of reasons. For one, when an area is ‘overdrained’, storm water may quickly accumulate and surge, causing sharp flood peaks. Large drains could sometimes themselves be sources of local floods. The chances of such floods increase when these drains are not well-maintained or otherwise obstructed. In other cases, proper drainage may avoid water logging and increase the capacity of the soils to ‘buffer’ floods. It should be remembered that the converse is also true.

Water table management
Drainage can be used to prevent flooding. When severe precipitation is expected, draining out water from groundwater tables will bring down their water levels, thus increasing their storage capacity. So when it rains heavily, most of this water is absorbed by the groundwater tables, which reduces the chance of flooding downstream.

Modern drainage systems
In the past, drainage systems were designed to convey as
much water as possible out of an area. The idea was that if water was moved fast enough to another place, there would be a smaller chance it would flood the area where it has rained. However, planners now feel this a bad idea as it only ends up shifting the problem from one area to another, rather than finding a solution to the problem. That is why emphasis is now on storage capacity of drains instead of their conveyance capacity. For example, increasing roughness on the internal surfaces of drains creates friction to the flow of water and reduces water flow velocity. This way, rainwater is retained longer in drains which reduces the risk of flooding in downstream areas.

### Slowing down storm water

Bad drainage infrastructure can aggravate floods downstream. This happens when the network of drainage pipes and canals do not have the facility to store or slow down the runoff. Without such a system, storm water is transported quickly to water courses and rivers, which may not be able to absorb the extra discharge. Also the opportunity to recharge groundwater tables is lost. It is therefore advisable to incorporate into the drainage network a system of storage or/and slowing down of water.

### Golf course ponds for retention

Golf-course ponds can be used in storm-water management in addition to irrigation of the property. These ponds are designed to blend into the surrounding landscape, creating visual interest and strategic difficulties throughout the fairways. Retaining water in such ponds could prevent flooding of low-lying areas.

### Roads and drainage

Roads and other infrastructure often cause drainage congestion and water logging. Adequate cross-drainage is therefore important. On the other hand, roads can also be used to retain water, which could help in groundwater recharge and the prevention of floods. There is great scope to integrate road planning and flood management.

### Pakistan

Authorities in Pakistan used drainage systems effectively in a long-term initiative. Under a series of salinity control and reclamation projects, they invested in vertical drainage systems to drain excess water from high water tables. Once this was done, water tables came down to acceptable levels – a new equilibrium set in with farmers pumping fresh groundwater to supplement canal water supplies. This kept water tables in check in most of the fresh groundwater zones and allowed closure of public vertical wells which were very expensive to operate.
DRAINAGE TO PREVENT FLOODING IN LOW-LYING LANDS.
Kolkata, India
Urban growth on the eastern fringe of Kolkata City has been partly spontaneous and partly initiated by the government.
This resulted in disrupting the natural course of surface drainage of basins and creating local floods at low-lying land areas. Some proposals are under consideration to mitigate the effects of flooding in this area, a combination of which could provide an effective solution. These include:
1. The creation of a number of channels to accommodate the drainage of water run-off into the Kulti River;
2. The creation of water bodies to act as reservoirs of water run-off; and
3. Provision of parks for infiltration and retention.

RECYCLING STORM WATER FOR NON-DRINKING USES
Sydney
In the Sydney Olympic Park, storm water is recycled by using advanced biological treatment and membrane filtration technologies. This way, the water is suitable for irrigation and non-drinking uses such as toilet flushing. The recycled water is supplied through lilac-colored water meters while the drinking water is supplied through green-colored meters. The bill for both recycled and drinking water will contain separate, detailed information regarding rates, charges and water usage. By using large retention ponds in the Park, water is stored in the area.

STORM WATER USE IN HORTICULTURE
The Netherlands
Instead of using drinking water, the horticultural area of Maasbree in the Netherlands uses storm water for watering plants. To collect storm water, there are proposals to create buffer areas under the ground. One of the options is the use of ASR (Aquifer Storage and Recovery), which means water will be stored in a water containing layer in the soil. This eliminates the need to construct large and expensive surface reservoirs.

RECYCLING STORM WATER FOR GROUNDWATER RECHARGE
Kolkata, India
The Kolkata Municipal Corporation has stipulated that storm water from roofs in residential areas is to be channeled through separate conduits into a storage tank where it is filtered, treated and then recharged into groundwater aquifers. This system will help reduce drainage problems in the city. The collection of large monsoon precipitation can also become a primary source of clean water. Rainwater harvesting provisions (like water channels and storage tanks) must therefore become a part of building architecture and construction. This also will help to minimize loads on regular drains. Further, large open areas in big housing and commercial projects should be set aside as ‘green cover
zones’ to be used as children’s playgrounds or recreational areas. This will prevent storm water run-off and improve groundwater recharge.

**Storage of Storm Water**

**Melbourne**
Melbourne has a drainage system that carries rainwater from roofs, roads and buildings through gutters, drains and channels and discharges it into rivers and creeks, where it eventually flows to the bays. An important issue is that the drainage system is kept clear of litter and debris to avoid blocked drains that can cause flooding. Retarding basins have also been built around the city, which slow down the flow of storm water being carried in the drainage system by storing it for a period of time. The basins also serve other functions such as parking places or parks.

**Sustainable Drainage Systems**

**The Netherlands, Sweden, Germany and Norway**
The FLOWS (Floodplain Land Use Optimizing Workable Sustainability) project has undertaken to implement Sustainable Urban Drainage Systems (SUDS) in several countries of Europe. These SUDS aim to reduce flood risk, improve water quality, recharge groundwater and enhance the potential for biodiversity. SUDS techniques make use of filter strips, filter drains, permeable surfaces, infiltration devices and basins and wetlands. These techniques allow water to infiltrate into the ground where it can be retained for long periods of time.

**Avoiding Clogging of Drains**

**Mumbai, India**
After heavy recent floods, government authorities in Mumbai City decided to ban the use of plastic bags in the city. This was because the city’s drains were clogged with plastic bags during the flood and blocked the outflow of water, which worsened the flooding. Plastic is non-biodegradable and these all-present plastic bags are an environmental menace. To make the ban work, the government is planning to educate the public about the hazards of plastic waste.

**Survey of Water Infrastructures**

**The Netherlands**
Once a year, local water boards across the Netherlands perform a survey to check the cleanliness of rivers, streams and brooks, in addition to checking water levels and water-flow velocities. This is done because throughout the year, vegetation like grass and weeds grow along river and stream beds, hampering the smooth flow of water. This, when coupled with high rains or precipitation, causes water courses to overflow resulting in flooding.

**Bulgaria**
To prevent clogging of water courses, the Bulgarian government has as objective of regular cleaning of the main river bed from willows, poplars and bushes, urban solid waste and large-size industrial waste. The rivers will be checked before and in human settlements. Attention will also be paid on clogged sediment in the river soil.
3. Flood Protection

For many years, flood management was equated with flood protection. Constructing dikes and embankments has been the most commonly-adopted flood protection measure in the past. This is still the case. Only, in addition to flood protection by levees, dikes and embankments, now the scope of flood management has increased to include flood prevention and flood mitigation.

This chapter does not discuss the development of dikes and embankments, as this is textbook knowledge by now. Instead, it presents some innovative ideas related to flood protection – particularly on engineering, financing, alternative flood protection measures and on integrating embankment construction with other functions.
3.1 Innovations in Engineering

Designing Optimal Embankments

The Netherlands
Reliability Based Design Optimization (RBDO) of flood defence works enables in testing the limits of their reliability and robustness at the design stage itself. For instance, this means that the failure probability of a dike design can be determined before it has been built. Therefore, it is possible to arrive at the most optimum structural design for each individual embankment. For larger systems of defences, the method can be used to first compute the probabilities of failure of individual structures. These computations can then be combined to arrive at the maximum flooding probability for the entire system.

Checking Embankments with Airborne Techniques

Embankments can be checked upon by using airborne techniques such as Fast Laser Imaging and Mapping Airborne Platform (FLI-MAP). One of its main applications is the detailed mapping of water embankments to assess their geometric structure. Laser altimetry is a fast, accurate and cost-saving method to obtain reliable and accurate terrain models and topographic maps. Quick and timely access to this information may help in the prevention of floods.

3D-Embarkment Modelling

Information and data on embankments can be obtained by laser altimetry using a helicopter. With this technique, developed by Arcadis, a 3D-structure of the embankment can be computer-generated to an accuracy of less than 5cm in height and 2cm in length and width. Special software uses the laser-altimetry data to generate 3D-models of the embankment before and after measures are taken. The advantage of this technique is that construction work can start sooner as the 3D-design of the embankment is already available. Also, calculations on material and soil quantities are made much easier. It’s even possible to operate bulldozers from a distance, without a driver, using 3D vector files.

Reinforcing Embankments

Embankments can be reinforced in many ways to prevent them from breaching. One popular method is to strengthen the inner slope and crest of the embankment with strong...
Stacking sandbags
29

grass vegetation, for instance. This can then be reinforced by a geo-synthetic wire mesh or an open concrete-block system. The objective is to slow down the process of erosion on the embankment’s inner slope and crest after an initial breach. This method also causes reduction in the width of the breach. An erosion-resistant layer in or near the embankment will be effective in preventing the breach from becoming a deep scour hole.

**Using volunteers for emergency inspection**

*The Netherlands*

In the Netherlands, it is the responsibility of local Water Boards to conduct quality checks on embankments and take precautionary measures when needed. In extreme conditions, when water levels are high, volunteers can be deployed to guard some of the embankments.

**Reinforcing embankments at an early stage**

Currently, not much attention is given to preventing disasters such as embankment breaches. When there is danger of an embankment breach, sand bags can be used to strengthen it, in some cases in combination with a geo-textile foil. However, these measures may prove to be ineffective or there may not be sufficient time to accomplish them in the last minute. That is why preventive measures should be taken. One method is to strengthen the embankment’s inner slope and crest with strong grass vegetation, for instance, further reinforced by a wire mesh or an open concrete-block system. Additionally, an erosion-resistant layer in or near the embankment will be effective in preventing the breach from becoming a deep scour hole.

**Sand bags**

Sand bags can be used in two ways. First, they can be used as reinforcements for existing embankments. For this, bags must be placed on the side of the embankment. Second, they can be used to build a new embankment. In order to do so, the bags must be stacked upon each other so that the structure’s width decreases with height. Plastic sheeting must be used to make the embankment waterproof.

**Filling sandbags**

Fill sandbags to half. Sand is preferable if readily available. However, sand is not mandatory and soil may also be used. Fold the top of sandbag down and rest the bag on its folded top.

**Stacking sandbags**

Care should be taken to stack the sandbags in accordance with the illustration. Place each sandbag as shown, completing each layer before starting the next layer.

*(Source: EMA, Australian Emergency Manual Series)*

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Stacking sandbags

*Flood protection*
NAILING DOWN EMBANKMENTS
One method to restore old embankments to their original strength is by nailing them down to the ground. This technique of land reinforcement is comparable to reinforcing with concrete. The nailing provides the embankment with more strength, which results in a lower chance of the embankment collapsing.

ENVIRONMENT-FRIENDLY EMBANKMENT REINFORCEMENT
'Mixed-in-Place' is an innovative reinforcement technique in which stabilized ground columns are created at the foundation of the embankment. This is done by adding a thickening agent to the humid soil at the foundation, negating the need for piles to be driven into the ground. Therefore, there is less impact on groundwater flows, which makes the procedure a relatively environment-friendly and cheap.

EXPANDING COLUMNS TO STRENGTHEN SOIL
A new method has been developed to strengthen weak soils around embankments. This involves pushing a column, with an inflatable mantle wrapped around it, into the ground. The mantle is then inflated, which pushes and compresses the soil surrounding it. This makes the soil stronger. The bottom of the column is secured to the underlying sand layer, which makes the collapse of the embankment less likely. (Arcadis)

REPAIRING EMBANKMENTS WITH STONE-DUMPING VESSELS
Many damage-control measures can be adopted after a dike has been breached. One method is to deploy a stone-dumping vessel which can dump rock-fill material into the breach. The vessel itself can then be lodged in the breach along with the dumped rock-fill, thus closing off the greater part of the breach. With further help from helicopters or pontoons, the complete closure of the breach can be accomplished.

3.2 INTEGRATING EMBANKMENTS WITH OTHER MEASURES

SERIES OF PROTECTION MEASURES
Ukraine
To protect the village of Kvasoso in the Ukraine from the River Borzhava’s floods, the following protection measures were proposed:
- Heightening of the existing dike along the village;
- Construction of a new dike near the school;
- Construction of a flood wall;
- Enhancing the Borzhava’s capacity to absorb the surplus
water generated by surface run-off; and
- Heightening and/or reconstruction of the pontoon bridge over the river.

**Combining partitioning with wise land-use planning**

Studies have shown that partitioning flood-prone areas from the rest of the landscape can be a very useful preventive measure. This approach can yield maximum benefit when land use is wisely planned. This means that residential areas must be located in the zone with lowest flood frequency, while pastures could be located in low-lying, high-risk zones. The result is that, when a flood occurs, the high-risk zones are flooded more rapidly but damage is relatively low because of the minimal loss to life and property.

**Partitioning areas**

**Germany**

The Government of Germany has researched the possibility of partitioning high flood risk areas into compartments. This method will decrease the risk of inundation of large chunks of land, and also increase the lead time to take preventive measures for people in areas that are not immediately affected. Existing structures like motorway- and railroad-embankments could be used to construct these partitions. This way, a large volume for the temporary retention of water can be created without changing the topography of the area too much.

**The Netherlands**

There are plans to partition a part of the province Zuid-Holland to restrict floods to only the isolated area. By directing floods to areas that are sparsely inhabited and easy to evacuate, there is more time to take mitigation measures in densely-populated areas. The newly constructed partition dikes can also be used as an evacuation route.

**3.3 Alternative protection measures**

**Inflatable barrier**

*Kampen, The Netherlands*

The unique, inflatable storm-surge barrier at Ramspol consists of three huge bellows made of rubberized cloth, which fill with water and air when flooding is imminent. In their normal state, the bellows rest deflated on their foundation in the lake. With a diameter of 8m each, the bellows are the largest in the world. This type of flood barrier is used elsewhere only for controlling water levels during normal circumstances, while the Ramspol Dam is designed to han-
**Flood protection**

due substantial storms. This flood barrier provides effective protection from high tide, does not obstruct navigation and is relatively cheap.

**Maeslant Flood Barrier**  
*The Netherlands*

The Maeslant Flood Barrier is a mobile flood barrier in the Nieuw Waterweg near the Hook of Holland. This commanding storm-flood barrier consists of two colossal, hollow, arched doors, each 300m long. When a storm surge reaches three metres above NAP (Dutch term for Normal Amsterdam Water Level), a computer-monitoring system shuts the barrier and seals off the Nieuw Waterweg.

**Steel River Barrier**  
*London, United Kingdom*

The Thames Barrier is a series of ten separate movable gates positioned end-to-end across the river. Each gate is pivoted and supported between concrete piers that house the operating equipment. Closing the barrier seals off part of the upper Thames from the sea. When not in use, the six rising gates rest out of sight in curved recessed concrete cills in the riverbed, allowing free passage of river traffic though the openings between the piers. If a dangerously high tidal surge threatens, the rising sector gates are moved up and the four radial gates are bought down into the closed defence position. The gates thus form a continuous steel wall facing down-river ready to stop the tide.

**Tsunami protection constructions**

Although tsunamis cannot be stopped, their impact can be lessened by undertaking certain measures and constructions. These include:

- Slowing techniques – constructing forests, ditches, slopes etc which create friction and reduce the destructive power of waves;
- Steering techniques – constructing angled walls and ditches which guide the force of tsunamis away.
Deployment of a flood board from vulnerable structures and people; and
- Blocking techniques – constructing walls including compact terraces and berms which acts as barriers to the waves.

**CITY WALLS AS FLOOD BARRIERS**

*Kampen, The Netherlands*

Because dams around the city of Kampen were not adequate to handle existing water levels, some old structural remnants from the Middle Ages are used to protect the city from the IJssel River. These additional flood defence structures include old city walls, some houses and gardens. While reinforcing these old structures to strengthen them, their characteristic physical attributes are being retained as much as possible, to maintain their aesthetic appeal.

**MANGROVE TREES AS FLOOD BARRIERS**

*Vietnam*

It was noted in Vietnam that mangrove trees lining some parts of the country’s coast, initially planted by the Red Cross for environmental reasons, functioned as a good, strong green wall in protecting sea dikes against strong typhoon waves. With a sufficient number of trees, waves as high as 1.5m can be completely neutralized.

**FLOODING BOARDS**

*Dordrecht, The Netherlands*

With water levels expected to rise in the future, houses in the city of Dordrecht are being designed to become part of the city’s flood defence system. Since a number of shops are situated on the city’s dike, each of their doorways is a potential gap in the flood defence system; necessitating their closure in case water overtops the dike. This is achieved with the help of flood boards. Since all the doors have the same standard size, standardized flood boards are used for the purpose. The local Water Board holds a stock of these flood boards; every year an exercise is conducted during which all these boards are tested by sealing off the doorways. An inspector is appointed for every street who then checks the boards for failures. (Arcadis)

**ARTIFICIAL REEFS FOR COASTAL PROTECTION**

*The Netherlands*

A plan is being developed to protect the North Sea Coast in The Netherlands from erosion and rising sea level. By placing an artificial reef on the bottom of the sea, about 50 % of
the energy of waves can be absorbed. Three alternatives have been presented – ranging from a small, limited number of reefs that will only protect the weakest areas, to a large string of reefs that would make the coastline risk-free.

3.4 Financial initiatives

Comparing costs with benefits
To decide on feasibility of projects, policy makers can conduct a cost–benefit analysis. The basic objective of a cost–benefit analysis is to see if a particular project results in increased economic welfare, which means that the benefits generated by the project should exceed its costs. If the benefits are greater than the costs, the project is attractive. If the benefits are lower, the project is not attractive. In flood management, this means that the costs of measures taken to increase safety against flooding (like dike strengthening, for example) are compared with the amount of decrease in expected flood damage.

Finding optimal solutions
Another way to analyze the costs of different flood management measures is to add the required investment for each measure to the possible damage. This allows decision makers to compare the total costs for each of the measures and to determine the ‘optimal’ solution, which is indicated in the picture.

Financial compensation

China
As part of its flood management efforts, the Chinese Government is strengthening weak flood defence structures and compensating local people living in flood diversion areas for the losses incurred by them due to floods. After the huge floods of 1998, initiatives have been undertaken to accelerate reinforcement of main embankments along large rivers and to increase investments for river treatment. Further, many reservoirs have been repaired and restored to their original flood regulation capacity.

Special protection measures for high-value premises
A cost-effective way of flood protection is to take special measures to protect property that has a high social or economic value. There are many ways to protect buildings from water flooding into the premises. These include:
1. Shielding – this measure keeps the water away from a
When a building is sealed, measures are taken to make the construction waterproof. This will protect valuable assets against flood damage during the flooding in 1999.

1. Shielding – this is a very efficient and cheap method to protect new buildings. A construction can be elevated by the use of:
   a. Supports, which leaves possibilities for creative development. Also the space under the building can be used;
   b. Walls, which extends the buildings’ possibilities of use; and
   c. Dams, which is cheap in cases of slopes nearby and is useful when groundwater levels are high;

2. Elevation – this is a very efficient and cheap method to protect new buildings. A construction can be elevated by the use of:
   a. Supports, which leaves possibilities for creative development. Also the space under the building can be used;
   b. Walls, which extends the buildings’ possibilities of use; and
   c. Dams, which is cheap in cases of slopes nearby and is useful when groundwater levels are high;

3. Permanent or mobile flood walls – the construction of an embankment or wall is a permanent measure. Temporary measures are constructions that may be lifted or tipped up. In case of longer warning lead times, mobile systems using stop logs, and sand bags may be applied.

**Switzerland**

The business premises of the Seehof in Luzern, Switzerland, is a building that has been sealed to prevent flooding. The construction consists of four basement floors and four upper floors. All the technical installations of the building are located in the basement floors. If the construction had not been sealed, a flooding would cause a disruption to business activities for several months. The sealing consists of mobile defences that protect the low-lying entrances. Although the measures were expensive to implement, they protected and preserved the premises from large damages during the flooding in 1999.

**RED FOR BLUE**

**Netherlands**

Red for Blue is an innovative concept in water management. Red stands for bricks or real estate, and therefore signifies the real-estate industry. Similarly blue stands for water, and signifies the water board or water authority. There are opportunities for the real-estate sector to participate and profit from flood management for instance by investing in measures constructing water-storage facilities. Since this service is provided to the water company/authority for a fee, the real-estate sector registers a ‘value addition’. Such strategies require intense collaboration between private-party developers and the government. An example of such an integrated project is the ongoing ‘Nieuwe Hollandse Waterlinie’. The master plan for the project includes an area of 20,000 ha which has to integrate concepts of water- and flood management, urban plan-
Flood protection

ning and design, landscape architecture, and housing. The project is managed by a board representing regional authorities. Sensing the potential of the project, several private-property developers took the initiative to invest in it. Of the 180 million euro cost of the project, nearly 40% was recovered from real-estate investments.

Flood damage in Bulgaria
4. Pre-flood mitigation

Even with prior knowledge that flooding will occur in some areas, it will not always be possible to keep flood waters away due to several logistical or practical reasons. In such cases, there are measures that can be taken to minimize flood impact. These include flood proofing, raising awareness and flood preparedness. Often, such measures and plans are based on flood-hazard maps.
4.1 Flood Proofing

Flood proofing measures aim to make building constructions flood resistant. This can be done either by designing constructions to withstand water intrusion or by elevating buildings above the ground.

Preventing Building Collapse by Letting in Water

When floods threaten a building, the tendency is to keep the water out as long as possible. This is a good idea only as long as the building is still stable, which is usually when the waterdepth is less than one meter above the ground. Studies show that masonry structures start to fail when this water depth rises above 1.5m. If the water level continues to rise, it is best to flood the building with clean water or let water in from outside.

(Source: Kreibich, H. et al., Precautionary measures reduce flood losses of households and companies – insights from the 2002 flood in Saxony, Germany)

Flood-Adapted Infrastructure

Flood-adapted infrastructure can help minimize the damaging impact of floods on people and property. This can be achieved by:
1. Improving construction of houses and buildings – that is, constructing houses with raised plinths, cement, baked brick walls and flat roofs (on which to build storage lofts in case of emergencies) etc;
2. Elevating villages above normal inundation levels. This way, the water cannot enter homes during normal floods;
3. Designing water supply systems that cannot be easily polluted. Installing hand pumps at roof level is also an effective measure in this regard;
4. Constructing flood drainage systems. It is important to develop designs for roads, railways and other infrastructure that increase rather than restrict drainage; and
5. Constructing irrigation systems that are resilient to flood damage.

Flood Adapted Interiors

One of the best ways to prevent loss to property during floods is to make sure that the cellars and lower floors are not expensively designed and furnished. Instead, designing flood-prone parts of a building with water-proof building material and designing interiors with small, movable furnishings would be a better idea. Further, having tiled floors instead of carpeted ones and installing electric and heating utilities on higher floors can reduce damage significantly, for instance.

Flood Adapted Construction

When building a new house, it makes financial sense to take the risk of flooding into account. There are many ways to reduce damage in case of flooding. These include:
1. Avoiding the construction of a cellar or basement floor in the building.
2. Using water-proof material to insulate oil-based heating systems. Alternatively, installing a gas heating system instead of an oil heating system may
also help reduce costs.

3. Installing master switches and electricity distribution boxes above inundation levels allows the use of the upper floors even during floods.

4. Using water-resistant materials in the construction and/or finish could help lower cleaning costs.

**USE OF LEVEES**

*The Netherlands*

In the past, when there was inadequate flood protection in low-lying areas, farm-houses in many areas were constructed on levees. When floods occurred, property was spared and only farmlands were flooded. The idea of constructing houses on levees built of sea/river sludge is being explored again. With sea-levels rising and encroaching on land due to global warming, it is expected that there will be much dredging sludge available in the decades to come. Levees built with such sludge could be inland extensions of river dikes and could function as backyards of houses. Over time, the soil in the levees will bind together and finally form a solid layer of ground.

**CONSTRUCTING HIGH-LYING EVACUATION ROADS**

*Vietnam*

In areas prone to extreme flooding, landfill is brought in to create elevated ‘anti-flood’ platforms for entire villages. The process also requires the construction of high-lying evacuation roads leading to the villages to ensure access during floods and to use as escape routes.

**FLOOD-FREE TERRACES**

*India*

For many people in India, living in cement-and-brick houses with high flat roofs (pakka) has proved to be invaluable in protecting their property and assets. In times of flood, valuables can be stored on the terrace roofs where they are out of the reach of water. Even to take refuge, people can climb on to their terraces without leaving their houses and are therefore able to protect their valuables from theft. If the terrace has walls and a roof, belongings can also be hung with ropes and nails.

**USING VEGETATION TO PREVENT EROSION**

*India*

When houses or entire villages are built using mud, they become very vulnerable to erosion. To prevent such erosion of houses and entire villages, people from flood-prone areas in India grow vegetation like bamboo, grass, creepers etc to bind the earth together and thereby strengthen it.
**Pre-flood mitigation**

**AMPHIBIOUS HOUSES**

*The Netherlands*

Amphibious houses are structures built on land and are one of several innovative ideas to counter the threat of floods. When rivers swell above their banks, these houses rise upwards as well. An amphibious house comes with foam built into a hollow concrete basement. When the water rises, the houses float to up to 5.5 meters above ground by sliding along two mooring poles at the front and rear of the buildings. All the electrical cables, water and sewage flow through flexible pipes inside the mooring piles.

![Drawing of a floating villa](image)

**4.2 Flood preparedness**

To mitigate the damaging impact of floods, it is very important to take flood preparedness measures. This includes having evacuation plans and emergency relief measures (see also chapter 5) in place. It is also very important to create awareness among people about the risks of flooding, the preventive and protection measures that must be taken, and finally about emergency evacuation plans (so that people know what to do when a large flood is approaching).

**Creating awareness**

**AWARENESS CAMPAIGN TO BUILD SUPPORT FOR WATER POLICY**

*The Netherlands*

The government started an awareness campaign – “The Netherlands lives with water” – to explain its policy of “giving water more room” and obtain support for it. A nationally-renowned weather expert figured as the government’s spokesperson in the awareness campaign to explain the policy in simple terms to the public. The expert educated people about the diverse measures and efforts being undertaken by national and local authorities to keep the country safe and dry.

**GUIDELINES FOR PUBLIC AWARENESS**

To increase public awareness, the European Commission underlines the need for authorities to ensure that information regarding flood prevention and protection is easily understood and accessible to the public. This can be achieved through the use of flood-hazard maps, geographical information systems (GIS) and by carrying out educative flood awareness campaigns. Information about floods must be disseminated early and actively, and should involve public participation.

(Source: European Union. Best Practices On Flood Prevention, Protection and Mitigation)

**THE IMPORTANCE AND NEED OF SPREADING AWARENESS**

Rhine river basin

The International Commission for the Protection of the Rhine (ICPR) has published a report detailing some examples of non-structural protection measures that can be taken during floods. Such protection measures are to be taken on the
basis of the following information:
- Complete knowledge of the danger – all parameters of flooding like probability, kind and extent of impact must be known. This knowledge must be shared with all actors clearly and effectively.
- Flood-hazard maps that point out areas at risk should be available, as these are necessary for planning. Flood marks indicating danger levels should also be set up in the areas.
- Flood awareness campaigns should give people prior knowledge of emergency evacuation and relief measures planned by the authorities, including the degree of relief planned on the basis of extent of damage.

**Flood recollection**
Ironically, it is the floods themselves which often prove to be most effective in making people aware of the damage they can cause. It is found that just after the occurrence of a flood, the awareness is usually the highest; this will however decrease in time when no new flood occurs. A German research study showed that after the Elbe floods of 2002, more than 40% of the people in the flooded area took risk-reduction measures for a potential next flood.

**Preparing flood marks**
HR Wallingford, a consultancy and research company in civil engineering hydraulics, has specified the following guidelines for the preparation of flood marks:
- A flood mark should be painted or carved as a line on a concrete or stone structure to record the maximum height of the flood;
- The line should be dated by day, month and year;
- The mark should be placed on a permanent structure like a huge rock, a building, on a bridge parapet, or a purpose-built column;
- The location of the flood mark should be easily approachable and visible to the public; so it needs to be maintained well (repainted for example); and
- The flood mark must be updated from local observations with each major flood, whether or not they exceed previous maxima.

(Source: HR Wallingford Ltd., Source book for sustainable flood mitigation strategies)

**Flood marks for awareness building**
There are many ways to educate people of the degree of recent flooding; one way being to show how high the water level came to. This can be done using flood marks, which show the maximum height the water reached. Flood marks can be derived from several sources, including:

Marks that indicate flood depths in the past.
Pre-flood mitigation

- Water-level marks on measuring scales to indicate peak water levels. These levels must be marked permanently so they do not fade away;
- Anecdotal information provided by residents about water depths during the floods;
- Marks made by garbage/trash on walls or wallpapers in houses; or debris such as plastic bags that got stuck on the branches of a tree indicate water levels; and
- Photographs that were taken of the floods or the marks it has left.

Flood preparedness plans

Emergency plans Switzerland
The asbestos-cement industry in Niederurnen, Switzerland, developed a flood emergency plan that helped the industry avoid flood damage that could have run into millions of dollars and could have caused long-term physical disruption to their businesses. The plan consisted of:
- Organizing a team of trained flood-relief volunteers;
- Organizing a team for filling sandbags;
- Planning for an emergency power-supply back-up system;
- Testing and retrofitting tank installations to prevent them from floating;
- Setting up a floodwarning alarm station; and
- Having emergency plans for different degrees of flooding.

Emergency Management Australia (EMA)

EMA assists states and territories in Australia to develop their emergency management capabilities. The EMA also coordinates Australian Government physical assistance to states and territories, upon request, during major disasters. The EMA promotes a national approach to emergency management in Australia through comprehensive measures which embrace prevention, preparedness, response and recovery activities.

(Source: EMA, Australian Emergency Manual Series)

Community flood management plans Bangladesh
The World Meteorological Association (WMO), is implementing the ‘Community Approaches to Flood Management’ project in Bangladesh as part of its mission for South Asia. The project has specific plans regarding:
- Weather-bulletin dissemination;
- Relocating marooned people;
- Flood shelter management;
- Health care;
- Distribution of potable water; and
- Livestock management.
Mock drills

India
The Orissa Disaster Management Project (ODMP), a collaborative project between the Government of Orissa and the UNDP, has prepared community contingency plans for 1,600 villages in the state of Orissa, starting with participatory risk assessment and mapping. These plans included the identification of school buildings that could double as flood shelters, installation of raised tube wells, construction of warehouses for storage of nets and dry fish, repairs of roads and embankments, and exploring alternative building technologies. Mock drills followed up the contingency plan.

Disaster plans
The ODMP has also recommended that the following measures be undertaken in case of disasters:
- Integration of community plans into sub-district disaster management plans;
- Establishment of trained, local task-force groups to manage first aid, rescue evacuation, water and sanitation, shelter management and body disposal; and
- Development of a radio network to be used during emergency and establishment of control rooms in the sub-districts.

Volunteer training

Bangladesh
In Bangladesh, volunteers have been trained to warn and help people in case of disasters such as cyclones. They regularly undergo simulation drills and hold meetings to raise awareness and disseminate useful information.

India
The World Meteorological Association (WMO) is implementing the ‘Community Approaches to Flood Management’ project in India as part of its mission for South Asia. The project involves the training of volunteers to assist and support the Flood Management Committee during and after floods. The volunteers attend extensive, one-day training workshops in the areas of their tasks, which include:
- Agriculture, plantation and aquaculture/fish culture;
- Health and sanitation;
- Livestock management; and
- Rescue, temporary flood shelters and relief operations;

Further, the members of the Flood Management Committee are asked to send regular reports as part of their monitoring process to enable taking advance measures, thereby reducing the negative impact of floods.

Training of fishermen in flood-prone areas

Thailand
The Food and Agricultural Organization (FAO) has drawn up a list of medium and long-term measures that need to be undertaken in flood-prone areas of Thailand. The follow-
ing measures have been specified for villages:
- Educating fishing communities regarding natural disasters and sea safety;
- Training fishermen in boat building and repairing;
- Capacity-building measures for village fishermen organizations in micro-credit financing and revolving fund management;
- Training in alternative marine-based livelihoods such as sea farming or offshore cage culture of fish; and
- Planning for disaster recovery with village fishermen organizations, with particular focus on improving quality of life.

**Flood Committees**

**Bangladesh**

In Bangladesh, a flood committee was established in each flood-prone area to take active part in local governance and decision making. The committee maintained close liaison with the administration and would place written demands for relief and rehabilitation assistance, as needed. Volunteers at the community level collected flood-damage information and passed it to the committee, which used the information as a basis to arrive at the extent of flood damage and identify its worst victims.

**Preparedness Actions for Businesses**

**Safe Storage of Hazardous Substances**

During a flood, hazardous effluents and substances may get released into the environment not only from industries and factories, but also in residential and agricultural areas. Oil, chemicals and pesticides are a couple of such examples. To avoid wastage of these substances and to prevent them from polluting the environment, they must be stored in elevated areas out of the reach of water, or transported away. It is important to have an idea of such stored substances on the basis of their toxicity, their inflammability, explosiveness and their ecotoxicity.

**Emergency Plans for Organizations**

To be able to respond to emergencies like floods, organizations need to have an effective emergency plan in place. This would help to avoid confusion during a disaster situation as people would know what to do. Such a plan also reduces damage to life and property, and saves crucial time (otherwise spent in chalkling out last-minute plans). Further, an emergency plan is always strongly focused on ensuring maximum safety.

**Flood Training and Evacuation Plans UK**

The Environment Agency in the United Kingdom has developed a handbook for businesses on how to conduct staff training for flood evacuation. The training enables employees to quickly and efficiently take damage-control measures in case of a flood, and to protect themselves and their business. It helps to ensure that the evacuation is done in an
organized and safe manner. Training programs vary from a ready-to-use information checklists to a full evacuation drill.

What goes into developing an effective organizational emergency plan?
- The attitude of the management should be proactive.
- The management must communicate the importance and necessity of the emergency plan to the staff.
- The management must ensure that the plan can be and is actually implemented.
- Policy changes in support of the emergency plan must be made as the need arises.
- An adequate budget must be earmarked for the plan.

**Pollution due to floods**
Flood waters carry with them numerous harmful contaminants, and transport these pollutants across many miles. This poses a great risk to groundwater quality, since a number of underground aquifers that feed all private wells are recharged by surface water (which could be contaminated).

**Flood hazard maps**

**The utilization of flood-hazard maps**
*Japan*
In Japan, flood-hazard maps have proved to be very useful in preparing people to handle disasters like floods. The maps enable people to see an approaching flood and evacuate promptly. The effectiveness of the maps can be judged by the following fact – Over 30% of people that saw the maps evacuated within 6 hours of seeing them. However, this number dropped to 20% among those that did not see the maps.

**Rhine Atlas**
*Rhine river basin*
The ICPR has created flood-hazard maps for people living along the river Rhine. These maps show the different extents to which flooding could occur in different areas, and how high water levels could rise even in unexpected cases. Large-scale flood-hazard maps are designed using computer modeling. Earlier, flood forecasts were made based on
marks or signs left behind from an earlier flood. However, now computer programs help to determine the scope, extent and depth of flooding in a specific area. The programs also provide data on flood velocity and direction for any location at any time.

**EXTENDABLE HAZARD MAPPING SYSTEM**

*The Netherlands*

As part of its national safety policy, the Dutch Government has developed a Flood Management System that helps to assess the possibility of a flood to occur at a given place and the damage it could cause. The system also provides information on what action can be taken to minimize risks; thereby helping in drawing up evacuation plans, designating overflow areas and for spatial planning. The system has been designed as a set of modules, making it flexible and easy to develop as it can be expanded by attaching new modules.

**REAL-TIME HAZARD MAPS**

*Seine-Normandy Basin, France*

People living in the Seine-Normandy Basin area are aware of the flood risks it poses. As an effective flood preparedness measure, the Government of France operates a website that hosts real-time hazard maps of the basin. On the website, people can zoom in on specific areas of the river basin to get real-time information on weather conditions, water levels and the possibility of floods in that area.

**RISK CLASSIFICATION**

*Germany*

In order to have a logical and fair basis for claiming flood insurance, a zoning system has been developed in Germany that specifies the threat different areas in the country face from floods. Data regarding discharge velocities of water (in case of flooding) was used to compute corresponding water levels at any given point along chosen water courses. Then, based on these computations, each area was divided into one of four zones based on the risk assessment for that area.

**FLOOD RESILIENCE**

Resilience is a new concept in flood management that is used to predict the strength and effectiveness of a certain system of measures. Studying the resilience of a flood risk management system, for instance a polder surrounded by dikes, gives an idea of how it will react to flooding. The final objective of any flood resilience strategy is to minimize flood impact and hasten recovery. This is in contrast with the concept of flood resistance, which aims to prevent floods entirely.

**CALCULATING FLOOD RISK**

Flood risk can be estimated for alternative measures by:

1. Calculate the maximum water level with a hydrodynamic model and the extent of flooded area (Digital Terrain Model) for floods with different return periods (T=10, T=20, T=50, T=100 etc.);
2. Estimate the damage for each return period with GIS by projecting the flooded area on land use types and multiplying it with pre-defined damage figures; and
3. Multiply the return periods with the estimated damage and add these up to obtain the capitalized risk.

**EC guidelines for flood risk maps**

The purpose of a flood risk map is to increase public awareness of the areas at risk of flooding and then categorizing them into flood risk zones. This maps serve as a basis for spatial planning and in prioritizing, justifying and targeting investments in order to manage and reduce the risk to people, property and the environment.

According to EU guidelines, flood risk maps should:
- be developed through co-ordination at river basin level;
- include both fluvial and flash floods and, if appropriate, coastal floods;
- provide reliable, sufficient and easily understandable information;
- as a minimum, distinguish three levels of risk:
  - areas that face frequent floods,
  - areas that face less-frequent floods, and
  - areas that face very rare floods (including, where appropriate, dike failures);
- address both the water/flood depth and the potential damage;
- address both the current situation and scenarios for future flood risk; and
- take other objectives in the river basin into account.

**Early warning systems**

**Hydrological monitoring system**

*Romania*

The DESWAT program was initiated by Romania’s Ministry for Environment and Water Management to improve the flood forecasting capabilities of the Romanian National Meteorological Administration. The program resulted in a significant upgradation of Romania’s hydrological monitoring system, enabling real-time monitoring and rapid response.

In addition, flood modeling and flood forecasting capabilities have also improved. The DESWAT program will be integrated with the country’s new meteorological system (SIMIN).

**Flood prediction using satellites**

Floods can be predicted with the help of satellite remote sensing. Satellites are able to detect high water levels as well as extremely low flows. With a growing amount of reli-
able data at the disposal of experts, it is becoming increasingly possible to predict where and when major flooding will occur, and to analyze trends over time.

Manual for flood warning systems

Australia

The Australian Emergency Manual identifies the following six components as important in an effective flood warning system:
- Prediction: Detecting changes in the environment that lead to flooding and predicting river levels during the flood;
- Interpretation: Identifying, in advance, the impacts of the predicted flood levels on communities at risk;
- Message construction: Producing the content of the message which will warn the people;
- Communication: Distributing warning information in an appropriate way to people and organizations that are likely to be affected by the flood;
- Response: Generating appropriate actions from the threatened community and from agencies involved; and
- Review: Examining the various aspects of the system to improve its performance.

(Source: EMA, Australian Emergency Manual Series)

Integrating flood warning systems

Europe

After the disastrous floods in the Elbe and Danube river basins in 2002, the European Commission announced the development of a European Flood Alert System (EFAS). This alert system will be able to provide medium-range flood simulations across Europe with a lead-time ranging between 3 to 10 days. The system offers two advantages. First, it provides the European Commission with useful information for the preparation and management of aid during a flood crisis. Second, national water authorities would be able to use the information to increase their preparedness in case of an impending flood. EFAS is aimed at complementing national flood forecasting systems, not at replacing them.

Low-cost warning systems

Thailand

To reduce the risk of flooding, simple rain gauges and manual warning sirens have been installed in the village of Mae Kampong. This equipment is used for observing local flood conditions and issuing forecasts and warnings to villagers. The rain gauge comes very cheap and is simple to use. Village volunteers are trained to measure, record and read the daily amount of rainfall. When the amount of rainfall exceeds the predefined normal level, the volunteer in charge of observations will issue a warning by using the manual siren. The village headman will then spread the warning through the village news broadcasting tower. (ADRC)

Communication

Warning sirens

The Netherlands

Communities in the Netherlands have emergency sirens installed which are tested once every month. These sirens are sounded to warn people of impending disasters, and since
local authorities operate them, warnings can be issued at the slightest hint of danger or disaster. Although these sirens can be tested with the sound switched off, that is not done just so that people are aware of their existence.

[picture sirene, "warning siren in the Netherlands]

**South Africa**

Johannesburg’s Alexandra Township, which is situated near the Jukskei River, has a rainfall and upstream water-level monitoring system. Advance warnings of possible floods are sounded through sirens which start blowing about 30 minutes before the river starts overflowing. Though people generally don’t immediately evacuate, they are in a state of preparation to do so should the floods intensify.

**CONTENT OF WARNING MESSAGES**

A warning message provides advice on what is happening and where it is happening, what the flood prediction means to the target audience, and what they should do. Warning messages are the critical link in communicating information on expected flooding. They provide the signal for those at risk to take action before the flood arrives or reaches particular levels. Message construction should be based on the needs of those at risk and should be in language familiar to those expected to take action.

**WARNING SIGNALS**

**Bangladesh**

To protect people in Bangladesh from cyclones and accompanying floods, the International Federation of Red Cross has launched the Cyclone Protection Program. As part of the Program, cyclone warnings have to be issued to the public when a threat is detected. Also, when a cyclone strikes, people have to be provided assistance in receiving protection and shelter. The Program also includes the rescue and administration of first aid to distressed people.

**WARNING CONFIRMATION**

When warnings are issued, the target recipients must be able to confirm the validity of these warning messages. This is something people will frequently seek to do. Confirmation should be facilitated, as people may delay appropriate response until they have satisfied themselves that the message is real and applies to them.

**INFORMATION DISSEMINATION THROUGH SPEAKERS**

**Bangladesh**

Over the last couple of years, radios have been distributed among flood preparedness committees in Bangladesh. News about oncoming floods can be heard on a particular channel, which enables the committees to warn villages and put the preparedness plans into action. These warnings can also be broadcast through public address systems of mosques. Each radio can cover 4 to 5 villages, which means information through each radio can reach around 300 households.
PRE-FLOOD MITIGATION

POOR COMMUNICATION

Mozambique

Before the floods of 2000 in Mozambique, flood warnings were either not issued in time or were not clear. This was mainly due to three reasons. First, the administration was too centralized. With ministers and national directors being the main decision makers in cases of emergency, there was little involvement of technical experts in the decision-making process. The authorities were not technically competent enough to deal with floods. Second, the warnings issued were not clear enough and failed to address the people properly. Though warnings were issued over the radio, they said nothing about the scope and extent of floods, and what emergency action had to be taken. Third, the authorities were over-cautious in issuing warnings since a false prediction of an El Nino drought in the past had damaged the reputation of the meteorological office. The authorities were never sure of the flood predictions made by their technical staff, and did not want to risk issuing another false prediction.

MESSAGES BY TELEPHONE

Modern telephone technology allows automated dialing of large numbers of telephones at the same time and the capacity to warn by voice mail. This technology is particularly useful if the number of premises to be contacted is large relative to the time available.

DOOR KNOCKING

Door knocking should be carried out if radical action, including evacuation, is expected to be necessary, provided time permits and it is safe for door knockers to operate. Door knockers should, ideally, deliver printed material giving advice on how to prepare for and respond to the coming flood. The message may include information on evacuation routes and evacuation centers, and should specify what people should do before leaving home and what they should take with them.

USE OF MEDIA

Both the broadcast and print media offer an opportunity for raising the awareness of those at risk, which can be considerably more effective than pamphlets alone. For example, newspapers could publish flood action guides provided time is available. Broadcasting media offer the possibility to achieve rapid message dissemination to large and diverse audiences.

Flood warning on television
Shelters

What to Bring to a Shelter

Monroe County in the United States has made a list of what each person must bring to a shelter when a hurricane is predicted. Although hurricanes do not pose the same threat as floods, the measures that should be taken are more or less the same. That is why the following list can be used for flood shelters as well:

- Water – one gallon per person per day;
- Food – high-energy food is preferable – must be non perishable, needing little or no cooking. If required, people must also bring their special dietary foods;
- Eating and drinking utensils are very useful, as well as ice for cooling;
- One complete change of clothing;
- A sleeping bag, blanket and pillow;
- Rain gear and sturdy shoes;
- Personal items – a washcloth, towel, soap, toothpaste, tampons etc;
- Medication – clearly marked with a name, dosage, type of medication and the prescribing physician;
- A first-aid kit in a waterproof box. If needed, baby supplies must be brought, such as diapers, formula, food etc;
- Identification and other valuable papers. People also need to bring names and addresses of doctors and nearest relative not living in the area; and
- Various other items are also useful – games, cards and toys, radios, flashlights and batteries. People are advised to take a bath and eat before they leave their homes.

(Source: http://www.co.monroe.fl.us)

Churches as Emergency Shelters

Texas, USA

During the tropical storm Allison in 2001, churches in Louisiana offered shelter to flood victims. In Houston, two churches became emergency shelters to not only some of the city’s hurricane victims but also to those from southeastern Texas.

Local Initiatives for Shelters

The Netherlands

In 1995, water levels in the Rhine and Meuse rivers rose alarmingly. There was a real, imminent threat that dikes along the rivers would collapse. This lead to the evacuation of about 200,000 people from the risk areas who were then accommodated in places such as churches, holiday parks and camping sites.

Construction of Flood Shelters

Assam, India

Following heavy rains in 2004 in the state of Assam, it was decided that four large flood shelters should be constructed for future emergencies. The shelters are to be single-storied, two-room structures raised on stilts so as to keep them above the maximum flood level. Depending upon the situation, the shelters could be used as schools, community centers, festival halls, meeting halls etc. Disaster mitigation task-force meetings could also be held at these shelters and disaster management training equipment and materials could be stored as well.

Pre-flood mitigation
Pre-flood mitigation

Temporary shelters

Romania

Following floods in Romania, people were accommodated in temporary shelters. These shelters could protect them from rain and wind, but not from the cold. It was only after other arrangements for shelter were made that these people could be moved into schools or houses of culture.

Shelter during Hurricane Katrina

USA

When Hurricane Katrina hit New Orleans, one of the ‘refuges of last resort’ for citizens who could not leave the city was the Louisiana Superdome. When Katrina came ashore, about 9,000 people sought shelter in the stadium. After the storm had passed, the total number of people in the Superdome had risen to as much as 60,000 people, remaining in increasingly difficult circumstances. Officials later said that the flood damage, debris, human waste and bodily fluids in the Superdome were a potential biohazard. The Superdome episode holds important lessons for mega-shelter management in urban areas.

Financial preparedness

National insurance

USA

In 1968, Congress created the National Flood Insurance Program (NFIP) in response to the rising cost of taxpayer-funded disaster relief for flood victims and the increasing amount of damage caused by floods. Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters and business owners in these communities. The NFIP is self-supporting for the average historical loss year, which means that expenses and flood insurance claims are not paid for by the taxpayer, but through premiums collected for flood insurance policies. When losses are heavy, the program is able to borrow money from the U.S. Treasury. These loans must be paid back with interest. People that want to buy, build or improve structures in Special Flood Hazard Areas, they will be required to purchase flood insurance.
Germany
In order to have a logical and fair basis for claiming flood insurance, a zoning system has been developed in Germany that specifies the threat different areas in the country face from floods. Data regarding discharge velocities of water (in case of flooding) was used to compute corresponding water levels at any given point along chosen water courses. Then, based on these computations, each area was allocated to one of four flood risk categories based on the risk assessment for that area.

Mandatory Natural Disaster Insurance
France
France has a functional system of insurance protection against natural disasters. Under the system, it is mandatory for citizens to purchase insurance against natural disaster damage together with standard property insurance. The re-insurance on risks is provided by financial institutions with governmental warranty. In order to make use of the insurance, the state must officially declare that there has been a disaster.

Special Fund for Natural Disasters
European Union
Following the 2002 floods in central Europe, the European Union set up the European Union Solidarity Fund (EUSF) as a financial instrument to disburse rapid financial assistance to victims in the event of a major disaster. The Fund will help affected areas/communities return to living conditions and will be used only for emergency operations. The EUSF was not set up to cover all the costs linked to natural disasters nor was it meant to compensate for private losses or damage covered by insurance.
Pre-flood mitigation
5. **Post-flood mitigation**

After a flood has occurred, there are several relief measures that have to be undertaken, all at the same time, to reduce human misery and restore livelihoods. It is important that such post-flood mitigation measures are clearly thought through and that relief teams are familiar with them. These post-flood mitigation measures include evacuation plans, robust communication systems, first-aid relief, emergency repairs, disease prevention, restoring water supply. This chapter discusses in detail with several of these measures.
5.1 Evacuation

What to do when a flood is imminent

1. Be aware of flood-warning procedures;
2. Plan escape routes to higher ground;
3. During times of heavy rainfall, monitor the level of water in domestic drains. Stay tuned to radio or TV for possible flood warnings;
4. Evacuate the flood-hazard area in times of impending flood or when advised to do so by the police-, fire- or city-emergency personnel;
5. Do not attempt to cross a flooding stream on foot or by car;
6. If your car stalls in high water, abandon it immediately and seek higher ground;
7. Keep children away from flood waters, ditches, culverts and storm drains;
8. Be especially cautious at night; and
9. Stay away from power lines and electrical wires; be aware of possible gas leaks (turn off gas and electricity).

(Source: City of St. George – www.sgcity.org)

Essential evacuation activities

To secure the safety of the people in an evacuation area, some initial actions are essential:

- A decision must be made at the outset as to whether or not evacuees will be permitted to use their own mean of transport. Self-evacuation is harder to control than an evacuation for which all transport is provided, but it is economical, in terms of outside transport resources which, in any case, may not be available in time;
- If some or all of the evacuees have to be moved out of a danger area by mass transport means, such as buses or trains, it will be necessary to identify pick-up and assembly areas;
- Once assembly areas have been identified, it is possible to begin moving people. The best means of initiating movement is by door knocking, although
Almost always, there will be those who will refuse to leave, so areas which have been evacuated must be checked. It is wise to arrange for police assistance to be on hand for this purpose.

**Motorway lane reversal**

On some freeways in the USA, traffic direction can be reversed. This way, both lanes of the motorway can be used during a large-scale evacuation. However, a drawback of this system became apparent when it was applied in Louisiana State during Hurricane Ivan – bottlenecks developed at the end of the motorway where all the lanes converged.

**Controlled evacuation**

Traffic congestion is a major problem during large-scale evacuations because of the limited capacity of roads. To prevent congestion, it is useful to evacuate the various areas of a city in different stages and directions. This way, the entire traffic is manageably spread out over time and in different directions.

**Evacuee registration**

When arriving at evacuation or registration centres (or hospitals in the case of casualties), evacuees must be registered as soon as possible. If registration is not accomplished quickly, victims will drift away. Countries should have a standard format for registering evacuees. If this is not available, then these are the details that should be recorded:
- Surname and initials;
- Date of birth;
- Home address;
- Destination;
- Contact phone number;
- Permission to release information.

**Using boats for evacuation**

**India**

Transport is a critical problem during floods. To reach marooned people, boats are essential – but they are rarely available in sufficient numbers. Therefore, villagers can pitch in efforts and resources to construct boats if they have advance warning of impending floods. A number of local techniques have been developed to make boats from locally available material. These include:
1. Cot boats – cots are converted into boats for moving light materials.
2. ‘Karahi’ boats – large pots (or karahis) are used for mobility during floods.
they are best used in calm floods.

3. Inner tube boats – tractor tyre tubes are used to make rafts. These too are best used in calm waters.

4. Pitcher boats – large pitchers are tied together along with bamboo poles. Again for use in calm waters.

5.2 Post-disaster communication

Communication during relief operations
During relief operations, communication facilities must be available for tracing victims and for coordinating relief. The communication system itself should be robust and not fail at its most critical time. Whenever possible, the public telephone network should be used to keep radio networks free for urgent operational traffic.

Tracing by mobile phones
The tsunami of 2004 washed away the existing fixed and wireless communications infrastructure along with everything else. Once communication was re-established, the network was used to locate potential survivors by tracing their mobile phones signals.

Using satellites for post disaster information
USA
NASA systems and Earth-orbiting satellites provided detailed imagery and data of the environmental devastation and extent of flooding caused by Hurricane Katrina. The satellites also provided information about damage to homes, businesses and infrastructure, and the hazards caused by the storm.

Providing communication means in shelters
USA
Soon after Hurricane Katrina’s devastation, Red Cross teams restored communications to 300 shelters in the region. The teams set up phone banks and internet kiosks so survivors could let their loved ones know that they were alive. The communications equipment also helped the shelters coordinate activities.

Radios to recover from trauma
Sri Lanka
Victims of the December 2004 tsunami in Sri Lanka received 10,000 radio sets sent by Australia. Not only did the radio sets provide relief through entertainment programs, but victims also received news updates and information of happenings around them.
5.3 EMERGENCY RELIEF

DIRECT RELIEF AFTER A FLOOD
After providing emergency relief, it is important to undertake post-disaster relief activities to quickly restart the local economy and resume basic social services. This means that clean water, or means to obtain clean water, must be provided. In addition, food, medical sets and sanitation material have to be supplied. Following this, shelter and clothing must be provided to prevent post-flood casualties. Examples of indirect needs include providing farmers with seeds and fertilizers, and constructing schools for educational needs.

DEPLOYING BOATS AND HELICOPTERS
Mozambique
After the floods of 2000 in Mozambique, many countries came forward to assist in the rescue of as many people as possible. The military was sent out into the countryside on aeroplanes, helicopters and boats to retrieve people from flooded areas. The boats proved to be very useful in reaching isolated communities that required aid.

USING EXISTING CHANNELS
Bangladesh
In the aftermath of floods in Bangladesh, agricultural service providers were engaged to implement the government-led agricultural rehabilitation program. The service providers collected seeds from the government and distributed them amongst poor farmers.

REPLACEMENT SEEDS
Somalia
In 1997, torrential rains flooded many of the traditional underground storage pits (bakars) which Somalis use to preserve their grains and seeds. After sending emergency relief to the flood victims, the International Committee of the Red Cross decided to provide farmers with replacement seeds which could be planted in time for the sowing season. Since there was also a direct food shortage, steps had to be taken to avoid the immediate consumption of the seeds. Therefore, each family was also given 45 kilograms of food in addition to a vegetable seed kit.

ENSURING BASIC FOOD QUALITY STANDARDS
Food distribution should be done under extremely sanitary conditions to prevent spread of infection and disease. Food quality must be ensured before distribution and all food donations must be accepted by the distribution committee to prevent unauthorized food distributions.

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Evacuation using boats after the floods of 1953 in The Netherlands

DIRECT RELIEF AFTER A FLOOD

After providing emergency relief, it is important to undertake post-disaster relief activities to quickly restart the local economy and resume basic social services. This means that clean water, or means to obtain clean the water, must be provided. In addition, food, medical sets and sanitation material have to be supplied. Following this, shelter and clothing must be provided to prevent post-flood casualties. Examples of indirect needs include providing farmers with seeds and fertilizers, and constructing schools for educational needs.

DRINKING WATER QUALITY

METHODS TO CLEAN WATER

Pollution of drinking water is always a major problem in flooded areas. Shallow wells are immediately contaminated, hand pumps get submerged and the flood water itself is highly polluted. In such a scenario, clean water can be obtained by following the following common practices:
1. Boiling water;
2. Cleaning/purifying water with alum;
3. Cleaning/purifying water with bleaching powder;
4. Raising the height of hand pumps; and
5. Filtering water.

TESTING KIT

Sri Lanka

The Industrial Technology Institute tested drinking water in densely populated areas that were hit by the tsunami in Sri Lanka. The Institute used a testing kit that provided results very quickly.

WATER-PURIFYING PACKAGE

Tsunami-hit areas

Greenstar Social Marketing in Pakistan had a stock of nine million packets of PUR Purifier of Water donated by Proctor & Gamble – enough stock to sanitize 90 million litres of water. The Greenstar staff worked with local government agencies to organize the logistics of moving 8.8 millions sachets to needy regions. PUR sachets were shipped by the International Federation of the Red Cross from Greenstar warehouses in Pakistan to Indonesia, Sri Lanka and other aid organizations. PUR was given free to survivors.

EDUCATION ON SAFE WATER AFTER EMERGENCY

India

Population Services International (PSI), an Indian non-profit organization, made staff available in tsunami-hit areas to train and educate affected populations about the importance of treating water before consumption and use. The idea was to avoid the spread of water-borne diseases and support oral-rehydration therapy initiatives being undertaken to treat diarrhoea-induced dehydration.

SOLAR WATER DISINFECTION

Solar Water Disinfection (SODIS) is a simple method that
uses solar radiation to improve the microbiological quality of drinking water. A study showed that regular consumption of SODIS-treated water has a significant impact on health – cases of diarrhoea in children that consumed the water were 35% less.

**CERAMIC FILTERS**

The Silver Ceramic System (SCS) pottery purifier offers an easy, inexpensive way of purifying water. The ceramic filter is made of a mixture of clay and sawdust, which is heated and then treated with colloidal silver. The SCS removes both impure particles and bacteria.

**DE Salination of Water Wells**

*South East Asia*

The tsunami of December 2004 submerged coastal areas under several meters of sea water for many hours. This caused salt water to seep into underlying fresh-water aquifers, resulting in the contamination of water wells used by people in several areas. There are ways to rectify such a situation. The first approach, though a passive one, is to let the aquifer naturally flush out the saline water as it would do in the normal course. This however requires a long recovery time and alternative drinking water arrangements must be made in the meantime.

The second option is well-purging. Salt water is removed immediately by pumping the well for a period of time until saline concentration becomes negligible. The final option is to limit the contamination to shallow aquifers. Confining units are used to isolate deep aquifers from shallow contaminated ones, thereby ensuring good water quality in the former.

**Disease Prevention**

**Preventing Diseases from Spreading**

The WHO has drawn up the following list of immediate measures that need to be taken after a flood to prevent communicable diseases:

1. Emergency medical care – providing medical and surgical care and psychosocial support is a first priority;
2. Water and sanitation – to prevent water-borne diseases, provision of safe drinking water is necessary. Chlorine can be provided to disinfect water. Also, adequate sanitation must be provided in the form of latrines or designated defecation areas;
MANAGING HEALTH CARE IN FLOOD SHELTERS

CARE has come up with a checklist of activities that need to be considered while providing health services to disaster victims in flood shelters:

- Meet community leaders and discuss plans;
- Check general ration supply;
- Ensure appropriate, adequate and un-crowded shelters;
- Discuss sanitation with the community;
- Protect the water supply from pollution;
- Integrate nutrition screening, Vitamin A/Measles/Polio vaccination for children below recommended age;
- Set up supplementary, intensive feeding for undernourished children and lactating, pregnant mothers;
- Assess major current disease problems;
- Plan for message dissemination on health and hygiene among the camp population and seek voluntary support from the camp community; and
- Set up an integrated clinic and health-scout program to provide curative services for major diseases.


DISEASE TRACKING
Aceh, Indonesia

The setting up of a disease-tracking/disease-surveillance system on the ground by the WHO and the Indonesian health authorities helped prevent any major disease outbreak following the 2004 tsunami. The Outbreak & Alert Response Team would get messages via telephone, SMS or fax from distant areas about possibly infected patients. Team members would then quickly reach the location and collect patient samples that were immediately analyzed. Based on
the analysis, remedial actions were then taken – which meant either treating the patient or vaccinating the population in the vicinity to prevent the spread of the disease.

**POST-DISASTER HEALTH STRATEGY**

CARE Bangladesh advises that a public health physician should supervise the overall activity of a camp health centre. Similarly, a logistics manager should be responsible for support to all centre personnel. In addition, two or three paramedics should be employed to help with clinical services. Critical or complicated patients should be referred to the supervising physician for further evaluation.

**TRAUMA CARE**

Disasters cause major environmental, societal and personal disturbances. When these disturbances are not treated, patients may develop trauma. That is why, during and after a disaster, people need to be assessed on their psychological status. Next to the victims, relief workers should also be assessed, as well as the assessors themselves – as their assessments may be distorted in traumatic situations.

**USE OF VOLUNTEERS**

Volunteers should be appointed in health camps to obtain information about outbreaks of diseases and to provide health information to those around them. To prevent negative impacts in the camp, complicated cases should be treated outside. It is best to establish referral linkages with local clinics and hospitals so that complicated cases that need hospital care can be sent there. Only common cases treatable with drugs and minor injuries should be treated at the camp health centre itself.

**CHILD CARE**

**SCHOOLS IN A BOX**

In response to Hurricane Katrina, UNICEF has set up schools in camps where people displaced by the disaster have been living.

The so-called ‘School-in-a-Box’ kit contains supplies for one teacher and up to 40 students. It contains books, pencils, erasers, scissors, a teaching clock, plastic cubes for counting and a set of laminated posters. Teachers can establish makeshift classrooms by using a locally developed teaching guide and curriculum. In addition, UNICEF is also providing children with a recreation kit that includes balls, coloured tunics, chalk, a measuring tape for marking play areas, a whistle and a scoring slate.
**SUGGESTIONS FOR CHILD CARE**

Plan USA, an organization working for children’s welfare, has developed some practical rules to ensure the rehabilitation of children in disaster-struck areas:
- Children in potential disaster areas must know where to go in case of an emergency. This information has to be provided in recognizable and clear ways;
- Communities must develop contingency plans and children must be involved in this process;
- Aid organizations must train their employees in child protection, child healthcare and child participation;
- Protection of children must be guaranteed not only directly after a disaster, but also on a longer term. Nurseries and day-care centres may contribute to this;
- Teachers, physicians, and relief workers must be trained to recognize symptoms of psychological trauma in children;
- Children can contribute to the rehabilitation by assisting other children who are alone by sharing food and water or by helping with recreational activities;
- Schools offer a stable and safe environment that can be used for trauma handling. Daily routine will bring peace into the lives of children; and
- Children must be taken care of in their own community as much as possible.

**REBUILDING SCHOOLS TO ENSURE STABILITY**

*Tsunami-hit areas*

For children it is very important that they can go back to school. This way children are provided with a daily structure and a safe environment to live in.

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**5.4 RESTORING LIVELIHOODS**

**FINANCIAL ASSISTANCE**

**LOANS FOR ENTREPRENEURS**

*Poland*

In Poland, subsidized loans were offered to groups of affected micro-entrepreneurs who were struck by floods in 1997. The loans were offered for a term of 24 months at an interest rate three times lower than the average rate in the country. For a majority of the borrowers, the disaster loan was the only disaster assistance that they received.

**LOW INTEREST HOUSING LOAN**

*Bangladesh*

The Bank of Bangladesh has provided loans through micro-finance institutions in Bangladesh. The bank provided 10-year term home construction loans, to build flood-resistant homes using cement and tin, at an annual interest rate of 1%.
Re-housing People

**Maldives**

Housing units that were set up in the Maldives are now to be given to people that were left homeless after the tsunami of December 2004. This way, people can resettle in spacious islands which also have more economic prospects.

**Needs of Farmers and Fishermen**

**Thailand**

- Replacement of materials, seeds, bait etc;
- Communication equipment for fishing operations;
- The rebuilding of infrastructure and facilities;
- Repair and rebuilding of houses; and

(Source: FAO – http://www.fao.org)

**Simplifying Loan Procedures**

**Sri Lanka**

The Government of Sri Lanka is offering all families that were affected by the tsunami a sum of Rs. 5000 as an immediate start-up allowance to commence their daily life. People can open a savings account with the nearest branch of the People’s Bank where the application procedure has been simplified and made free of cost. The Rs. 5000 will then be deposited into this account and people can use this money to bring their lives to normal as soon as possible.

**Income Generating Activities**

**Thailand**

The FAO has proposed the following new interventions to help families generate income in the aftermath of the tsunami. These include:

- Growing vegetables in net houses. The purpose of this technique is to support affected groups of farmers in the Ranong Province to produce chemical-free vegetables through the use of organic fertilizers for the local market as an additional and alternative source of income and for their own consumption.
- Growing hydroponic vegetables. The purpose of this technique is to support affected groups of farmers in the Krabi Province to produce vegetables where the soil was badly affected by salt water. Training of farmers and availability of appropriate tools, materials and facilities are an important prerequisite for successful implementation of this intervention.

**Restoration of Infrastructure and Homes**

Restoration work must begin after a flood has struck. Breaches in dikes must first be repaired. Once this is done, land restoration work can begin.

**Strengthening River Beds and Banks**

A new technique to strengthen river beds and river banks is to pave them with mats made of a mixture of bitumen and sand or gravel. A number of these mats can be fused together either on riverbed floors or on river banks so that...
they form a layer. The mats can be made in various sizes, strengths and compositions. The advantage of the ‘mat’ system is that rocks and foils are no longer needed and that the mats, in case of an emergency, can be installed very quickly.

**Sand-filled synthetics**

A technique to restore breaches in embankments has been developed by Van den Herik. Geotextile containers, which are mainly classified into geotubes and geocontainers, filled with sand can be used for emergency repairs of embankments. Geotubes can be used on land or in shallow waters as protection against erosion and can be made as large as necessary. Geocontainers are more or less identical to geotubes but smaller in size and length. They are best used in deeper waters to serve as groynes and dams, but can also be used to fill breaches in embankments and scour holes in riverbeds.

**Repairing dike breaches**

*The Netherlands*

After a dike of the Rotte River near the village of Wilnis breached, the spilling water was blocked with a temporary waterproof sheet pile wall and the dike was strengthened with sand. After this was done, the local Water Board prepared plans for reinforcement and permanent restoration of the dike along 1.5 km.

**Restoration of services**

*Czech Republic*

After the Vltava, a tributary of the Elbe River, flooded parts of Prague in August 2002, it took time to restore all essential services in the city. Gas service to central Prague was stopped while workers repaired the damaged equipment and pipes. Electricity was restored to most areas only in mid-September, gas in October, and telephone services in November. In the meantime, the use of portable dehumidifiers and heaters increased business interruption expenses.

**Supply heavy equipment**

*Sri Lanka*

After the post-tsunami emergency relief phase was over in Sri Lanka, many projects to repair key infrastructure such as roads, bridges, schools and health centres have begun. In addition, about 100,000 new houses have to be built. Several government provided Sri Lanka with...
heavy machinery and equipment to rebuild the country, apart from financial aid.

**Rebuilding better houses**

*Sri Lanka*

In several rebuilding programs in Sri Lanka, affected families are being involved in the rehabilitation process to take their preferences into account. The houses being built will be child friendly and communities are being provided with all necessities such as drinking-water systems, sanitary fittings and shops.

**Appropriate housing techniques**

*Mozambique*

The floods of 2000 showed that houses built of reed were not strong enough to withstand the force of flowing waters and were hence washed away. On the other hand, wattle and daub houses with corrugated steel roofing sheets survived the onslaught. Therefore, as part of the post-flood rehabilitation program, people who had lost their homes were provided with the material and funds required to build relatively stronger houses.
POST-FLOOD MITIGATION
6. BENEFITS OF FLOODWATERS AND FLOODPLAINS

Though floods are often associated with damage and misery, they also have several beneficial uses. In some of the poorest parts of the world, floodwater is often used for irrigation while in other areas, temporarily flooded land is utilized for cultivation. Generally speaking, floodplains represent important production systems. Floods sustain fisheries and many native plant species. In Europe, North America and elsewhere, there are many instances where floodwater is being used for groundwater recharge. Furthermore, the floodplains traditionally mark migration routes for many wetland bird species. These birds rely on the presence of regular stopover sites in which they can rest and refuel. This chapter discusses several such examples. There are many positive aspects to floods and floodplains which need to be incorporated into area planning and flood management.
6.1 Using Floodwater for Irrigation

Spate-water Irrigation
In many arid or semi-arid regions, spate irrigation is used to supply agricultural land with water. Spate irrigation is a type of river management where floodwater is diverted from normally dry river beds (when floodwaters overflow) to agricultural lands by the use of spurs or bunds and flow channels. Spate systems are very risk-prone because of the unpredictable nature of floods and the frequent changes in the river beds, which occurs due to sediment shifts, from which the water is diverted. Normally, spate systems are designed to keep away very high floods from irrigation areas. If not, heavy floodwaters would not only damage lands and flood diversion channels, but also cause rivers to shift. That is why the main diversion structures in traditional spate systems, like spurs and bunds, are designed to break when the floods are too big. This way, the vulnerable diversion system is protected and land owners downstream maintain their floodwater entitlements.

Senegal
The construction of the Manantali Dam in Senegal, according to an earlier design, would have meant the end of the natural seasonal inundation of the floodplains downstream. To overcome this problem, even as the dam’s construction was going on, controlled flood releases were made to serve 100,000 hectares of land dependent on inundation for agriculture, fishing and grazing. The World Bank agreed to help finance the dam’s completion in 2001 provided the principle of ‘managed floods’ would be recognized as a long-term strategy.

Kenya
To meet the increasing demand for electricity in Kenya, there is a proposal underway to dam the Tana River. Since the Tana has an extensive floodplain and delta that supports the livelihoods of over half a million people through agriculture, fishing, livestock rearing and horticulture, planners and developers have agreed that the floods that used to take place seasonally must continue. As a result, the dam is being designed to store enough water to produce
a flood downstream through short-term high-flow releases, as well as produce the necessary hydro-electricity. Because silt is recognized as very important, the designers will try to release silt together with the floodwater.

**Flood agriculture**

**Ton Le Sap Lake, Cambodia**
The Ton Le Sap Lake in Cambodia is connected to the Mekong River and acts as a retention area for the river during floods to reduce damage downstream. Ever year, around May, water from the Mekong flows into the lake and the water levels rise up to 9m. In October, the flow reverses direction and flows out to the Mekong again. This variation in water levels allows for an unusual recession cropping system. During the flood, water can be stored at the edge of the floodplain. After the floodwater has receded, rice cultivation starts. The stored water can then be used to irrigate the land that is uncovered by the receding flood. The filling of the storage and the actual irrigation can often be achieved by gravity alone, without the need of a pump.

(Source: Masumoto, T. et al., Future basin-wide flood management by using the roles of paddies in Monsoon Asia)

**Benefits of floodwaters and floodplains**

**Floodplain agriculture**

**Australia**
Floodplains are generally the more fertile agricultural areas in Australia. A significant proportion of Australia’s agricultural output is produced on floodplains, which are hubs for extensive and intensive agriculture, including irrigated agriculture. Regular flooding of these areas improves soil fertility and agriculture by increasing soil moisture, recharging groundwater tables and depositing fertile silt.

**Multifunctional paddies**

**Mekong River Delta**
In the Mekong River Delta, paddy fields are used as retention basins when floods occur. The water that is stored in these paddies acts as a nursery ground for fish cultivation and/or allows fishermen to obtain fish for their own consumption. This way, the paddy fields can be used for integrated agri-/fish-farming and therefore bestow larger economic benefit.

**The Nilometer**

**Egypt**
The ancient Egyptians are considered among the first people to have recorded water levels of their river, the Nile. In support of the flood based agriculture, the Egyptians used a specially developed mechanism, the Nilometer, which was a large stilling well with a marble octagonal column at its center. The column was graded to measure water levels and indicated the extent of the flooding of the Nile. Knowing how high the Nile had risen was extremely important to the survival of the Egyptians. A low flood could mean crop failures, drought and famine and a high flood would destroy...
Nilometer at Aswan, Egypt

**Benefits of floodwaters and floodplains**

Because the ancient Egyptians traded in crops, the Nilometer was used to compute the levy of taxes for the coming year.

**Floodwater spreading for land management**

*Iran*

Floodwater spreading is a method of harnessing the rich sediments and nutrients present in floodwaters for a number of important uses. These include:

- Meeting the water requirements of annual and perennial crops and vegetation, either immediately or over time by using surface reservoirs and aquifers;
- Recharging aquifers to prevent the intrusion of salt water into water-bearing layers;
- Stabilization of drifting sands through precipitation of the suspended load;
- Grading land on sloping and eroded surfaces;
- Reducing gully erosion and controlling downstream flooding; and
- Leaching saline soils.

**Adapting farming systems**

*Vietnam*

Farmers in Vietnam plant their crops early to avoid floods. They have developed new techniques of shrimp and fish breeding suitable for flooded areas. The shrimp and fish enter the area during floods and are harvested with the rice.

**Mekong delta**

In the Mekong delta, people use floodwaters for paddy cultivation using a technique called 'colmatage'. This technique involves digging out natural levees that channel rising water from the river to the areas behind the levees. A part of the water stored this way remains in the area even after the water levels in the river have decreased and is used for rice production during the dry season.

### 6.2 Floods and fisheries

**Floodplain fisheries**

When farmlands are flooded, normal agricultural activities have to be stopped. At such times, farmers can switch to fish cultivation using boats, nets and/or using fishing lines in agricultural fields. The fish thus cultivated is not only a
Floodplains can be pumped dry to extract the last remaining fish. Several fish species require seasonal floods to breed.

**Improving Flood Plain Fisheries**  
**Bangladesh**

About 34% of Bangladesh’s land area is under water almost six months a year providing an ideal, rich and natural setting for fish cultivation. Even the cost of fish feed can be avoided as naturally growing vegetation in the floodplains is a rich source of food for the fish. However, in spite of this natural wealth, fish cultivation in the floodplains has been dropping for some years. In order to turn the situation around, the government initiated the Third Fisheries Project, which has resulted in an increase in fish and shrimp production for domestic consumption and export. Production of stocked species increased by 700% while that of non-stocked species was either maintained or showed marginal increase. The Project has also resulted in improved management of the floodplains through private-sector and community participation.

**Managed Floods and Fish Stock**  
**USA**

In 1996, a managed flood was conducted on the Colorado River in Arizona which gave scientists a rare opportunity to intensively study a strong flood. Follow-up research showed that the flood increased sand bars and improved backwater areas which provide important habitat for young fish. Additionally, the managed flood cut down the number of non-native fish.

**Small Pulses of Floodwater**

In some ecosystems, water needs to be present or absent at the right times of the year. Many organisms are adapted to expect a series of small floods at the beginning of the rainy season which signals to them that it is time to breed, before the bigger mid-season floods arrive. Some species need small pulses of freshwater to signal the start of migration and to provide direction.

**Providing Debris for Breeding**

Many fish species depend on normal flooding to wash wood debris into the water, which they then use for shelter.

**6.3 Using Floodwaters for Groundwater Recharge and Water Buffers**

**Groundwater Recharging**

When floods occur, wetlands and floodplains can store water. Slowing down the runoff allows additional time for the water to infiltrate and recharge available groundwater aquifers, when there is unused storage capacity.

**USA**

In the Mojave Desert, the only source of water is the Mojave River. However, the river itself is unreliable for direct water supply because its river bed is dry, except for a short period of returning flow and periods of flow after intense storms.
**Benefits of floodwaters and floodplains**

Therefore, the residents of the basin rely almost entirely on groundwater reserves, which are recharged by floods.

*Nigeria*

The population around the wetlands of the Hadejia-Jama’are floodplain depend heavily on groundwater for drinking and other household uses. The aquifer is recharged by the regular flooding of the wetlands.

**Using water in floodplains as drinking-water sources**

*The Netherlands*

To create new sources of drinking water, there are proposals to create water-collection basins and infiltration facilities in the floodplains of rivers. These proposals are part of the government’s current strategy to process drinking water from surface-water sources. This way the decline in groundwater tables can be reduced.

**Controlling negative effects of sand mining**

The capacity of a river to ‘store’ floods and recharge surrounding aquifers is often negatively affected by sand mining. Rather than being absorbed in the river bed, the floods flow downstream. Controlling sand mining is important to mitigate flood peaks and to improve groundwater recharge.
ANNEX 1: REFERENCE SOURCES

This annex provides a list of reference sources including the names of organizations, a short description of their activities and their contact details. The organizations can be contacted either through their websites or with the help of contact details listed here. This annex has been compiled by the authors from searches made during the preparation of this book and does not pretend to be exhaustive. The references are arranged in alphabetical order under the following topics:
1. Flood Management;
2. Disaster Management and Relief;
3. Trans-boundary Initiatives; and
4. General Information Sources.
1. Flood management

Flood organizations

WMO, Associated Program on Flood Management (APFM)
The APFM is a joint initiative of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP). It promotes the concept of Integrated Flood Management (IFM) as a new approach to managing floods. The principal goal of the APFM is to maximize the productivity of the floodplains while minimizing loss to life and property. Thus, an increase in occasional losses from floods can be consistent with a long-term increase in the efficient use of flood-prone land.
E-mail: apfm@wmo.int
Internet: http://www.apfm.info

Global Water Partnership (GWP): Integrated Water Resources Management (IWRM) Toolbox
The GWP has developed a web-based Toolbox on IWRM. It is a reference site that provides water management professionals with examples of good and bad practices and lessons learnt from real-life experiences of implementing IWRM. Information is organized into four main parts – policy guidance; operational tools; case studies and references; and organizations and websites. The Toolbox would be useful to water-resource management professionals such as water-resource planners, policy makers, river-basin managers and political advisors, as well as the general public.
E-mail: gwp@gwpforum.org

National Flood Insurance Program (NFIP)
The NFIP has been developed in response to the rising costs of taxpayer-funded disaster relief for flood victims and the increasing amount of damage caused by floods. The website contains information on the requirements of the insurance program and how to join it. It also hosts a library on flood insurance and information on oncoming hurricanes. The program is managed by a division of the Federal Emergency Management Agency.

Internet: www.gwpforum.org

International Flood Network (IFNet)
The objective of the IFNet is to facilitate international cooperation in flood management. The Network aims to reduce the damage and loss to life caused by floods. It also intends to promote policies and practices that can break the vicious circle of poverty and environmental degradation thereby leading to a safe and sustainable future. IFNet believes that there must be a shift in emphasis from reactive to proactive action by authorities and that flooding is often a very local problem that can benefit from national and international assistance. IFNet provides a framework within which all those who work in flood management can exchange information and seek partnerships to improve the effectiveness of their work.
IF-net, c/o Infrastructure Development Institute (IDI), 5-3-23, Kojimachi, Chiyoda-ku, Tokyo, 102-0083, JAPAN
Fax: +81 3 3230 4030
E-mail: info@internationalfloodnetwork.org
Internet: http://internationalfloodnetwork.org/
Management Agency (FEMA).
E-mail: nfip@dhs.gov
Internet: http://www.fema.gov/nfip

**Tsunami Reconstruction**

Tsunami Reconstruction is a web portal opened by the Food and Agricultural Organization to help and support the reconstruction of countries that were hit by the Indian Ocean tsunami of December 2004. The site provides news updates about recovery initiatives in the area, listing needs assessment, and country-wise and sector-wise overviews on progress in relief measures and developments.
E-mail: tsunami@fao.org
Internet: http://www.fao.org/tsunami/
Information on beneficial use of floodwater and floodplains

**AQUASTAT**

AQUASTAT is the Food and Agricultural Organization ‘s global information system of water and agriculture developed by the Land and Water Development Division of FAO. The objective of AQUASTAT is to provide users with comprehensive information on the state of agricultural water management across the world, with emphasis on developing countries and countries in transition. It provides among other things, information on how to use floodwaters for agriculture.
E-mail: aquastat@fao.org

**Ecoflood**

Ecoflood is a research project supported by the European Commission. Their long-term objective is to stimulate creation of floodplains that both protect the environment against floods and provide opportunities for restoration and development of highly valuable ecosystems. Ecoflood has identified a knowledge gap between research fields, and feel that scientific output is often not appropriate for stakeholders. EcoFlood results are comprehensive guidelines for creation of natural flood defenses based on the present information.
Grontmij Advies en Techniek - Adviesgroep Water,
Evalyne de Swart
P. O. Box 119, 3990 DC Houten, The Netherlands
Tel: +31 (0)30 634 48 65, Fax: +31 (0)30 638 14 29
Internet: http://levis.sggw.waw.pl/ecoflood/

**The Ramsar Convention on Wetlands**

The Convention on Wetlands is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. It was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975, and it is the only global environmental treaty that deals with a particular ecosystem. The Convention’s member countries cover all geographic regions of the planet.
The handbook for wise use of wetlands that was created comprise a set of nine handbooks containing guidelines, supporting background documents, photographs, case studies and cross-references.
Ramsar Convention Secretariat,
Rue Mauverney 28, CH-1196, Gland, Switzerland.
Tel: +41 22 999 0170, Fax: +41 22 999 0169

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Tel: +41 22 999 0170, Fax: +41 22 999 0169
Annex 1: Reference sources

E-mail: ramsar@ramsar.org
Internet: www.ramsar.org

Spate Irrigation
The Spate Irrigation Network aims to spread information and facilitate exchange of knowledge on spate irrigation. Spate irrigation is a type of water management found in arid areas in Pakistan, Yemen, North Africa and the Horn of Africa, where floodwater from mountainous catchments is diverted to agricultural areas for irrigation. The website contains guidelines and a library on spate irrigation.
E-mail: info@metameta.nl
Internet: http://www.spate-irrigation.org

World Commission on Dams (WCD)
The WCD website provides useful documents regarding the benefits of floods that are related to (the absence of) dams. It provides information on floods and agriculture, groundwater recharge, managed flood releases and other related issues.
Internet: http://www.dams.org

Flood warning and flood monitoring

Dartmouth Flood Observatory
The Observatory detects, maps, measures and analyzes major flood events world-wide using satellite remote sensing. It uses microwave and optical satellite imaging of selected river reaches to detect over-bank flood and extreme low flow conditions. Also provided are yearly catalogues, large-scale maps, and images of river floods, from 1985 to the present. Dartmouth Flood Observatory, Dartmouth College, Hanover, New Hampshire USA 03755
Fax: (603) 646-1601
Internet: http://www.dartmouth.edu/~floods/

European Flood Alert System (EFAS)
The EFAS is being developed by the Joint Research Centre of the European Union and will be capable of providing medium-range flood simulations across Europe with a lead-time between 3 to 10 days. This site provides news and information on the development process of the system.
E-mail: jutta.thielen@jrc.it
Internet: http://efas.jrc.it

Flood Forecasting Warning of the Mekong River
The Mekong River Commission website has a section devoted to river monitoring and early flood warning. This section, which is still in the development stage, provides information about current or/and forecasted hydrological conditions in the Mekong River Basin.
E-mail: floodinfo@mrcmekong.org
Internet: http://ffw.mrcmekong.org/

Flood Relief
Flood Relief is a real-time decision support system integrating hydrological, meteorological and radar technologies. The project aims to develop and demonstrate a new generation of flood forecasting methodologies which will advance present capabilities and accuracies. It also intends to make the results more readily accessible both to flood managers and those threatened by floods.
E-mail: mib@dhi.dk
Internet: http://projects.dhi.dk/floodrelief
2. DISASTER MANAGEMENT AND RELIEF

DISASTER RELIEF

The Disaster Assistance Process for Individuals and Families
Disaster Assistance is a part of the FEMA site where people can apply online for assistance after a disaster. Disaster Assistance lends financial support and/or direct assistance to individuals, families and businesses in areas where property has been damaged or destroyed and whose losses are not covered by insurance. It is meant to help people with critical expenses that cannot be covered in other ways.
Internet: http://www.fema.gov/about/process/

ReliefWeb
ReliefWeb is an online gateway to information (documents and maps) on humanitarian emergencies and disasters. It is designed specifically to assist the international humanitarian community in effective delivery of emergency assistance. It provides timely, reliable and relevant information as events unfold, while emphasizing the coverage of “forgotten emergencies” at the same time.
Internet: http://www.reliefweb.int

International Labour Organization (ILO) Publications
The ILO publications program provides relevant research findings and practical solutions to workplace problems for workers and employers in developing, transition and industrial economies. As a part of this program, it has published a range of research studies, strategies and reports on how to approach and tackle the many aspects of crisis- and recon-
struction (in combination with labour issues) situations.
ILO Bureau of Publications,
Fax: +41.22.799.6938
E-mail: pubvente@ilo.org
Internet: http://www.ilo.org/public/english/support/publ/xtextrci.htm

MICRO-FINANCE

Asian Development Bank (ADB)
The ADB, through its Micro-finance Development Strategy, aims to ensure permanent access to institutional financial services for the region’s poor and their small businesses. By providing poor people with improved savings, credit and insurance facilities, the Strategy helps them manage risk, build assets, increase income, and enjoy a better life.
Internet: http://www.adb.org/Microfinance/

BRAC Bangladesh
BRAC works for the alleviation of poverty and empowerment of the poor in Bangladesh. In addition to multifaceted development interventions, BRAC offers financial services designed according to the needs of different people living at different levels of the poverty ladder (extreme poor, moderate poor and vulnerable non-poor). BRAC is also active in post-disaster management programs, where it supports various income-generating enterprises.
BRAC Centre,
75 Mohakhali, Dhaka 1212, Bangladesh
Tel: (880 2) 9881265 72, Fax: (880 2) 8823542, 8823614
Internet: http://www.brac.net/index_2.htm

Fundusz Mikro
Fundusz Mikro is a non-profit micro-finance institution that was established to promote the development of micro-enterprises in Poland. Following the floods of 1997 and 2001, Fundusz Mikro provided micro-aid to several small entrepreneurs that were affected and badly needed assistance to restart their businesses.

Fundusz Mikro Ltd.,
ul. Solec 38, 00-394 Warsaw, POLAND
Tel. (48 22) 458 22 60, fax (48 22) 458 22 68
E-mail: fm@funduszmikro.pl
Internet: http://www.funduszmikro.com.pl/

**microLiNKS**

microLiNKS is a dynamic knowledge-sharing website designed to improve the impact of USAID-funded micro-enterprise programs and activities. microLiNKS serves as a meeting place that allows for the sharing of cutting-edge research between practitioners of micro-enterprise development and financial services, USAID Mission staff, and other interested individuals and organizations. One section of the website focuses on the challenges micro-enterprise development in post-disaster settings and how micro-enterprises can alleviate insecurity in these environments.

E-mail: microlinks@qedgroupllc.com
Internet: http://www.microlinks.org/disaster

**POST-FLOOD REHABILITATION**

**Solar Water Disinfection**

Solar Water Disinfection or SODIS is a water-treatment method that improves the microbiological quality of drinking water by using solar UV-A radiation and temperature to inactivate diarrhoea-causing pathogens.

EAWAG/SANDEC,
Martin Wegelin, Ueberlandstrasse 133, CH-8600 Duebendorf, Switzerland
Tel: +41 1 823 50 19, Fax +41 1 823 53 99
E-mail: wegelin@eawag.ch
Internet: http://www.sodis.ch/

**Food and Agricultural Organization (FAO) of the United Nations**

The FAO’s mandate is to achieve food security for all; that is to make sure people have regular access to enough high-quality food to lead active, healthy lives. The FAO desires to raise levels of nutrition, improve agricultural productivity, better the lives of rural populations and contribute to the growth of the world economy. The FAO site provides information on how to react to disasters such as large floods and how to provide relief to people in the area.

E-mail: FAO-HQ@fao.org
Internet: http://www.fao.org/

**International Food Policy Research Institute (IFPRI)**

The International Food Policy Research Institute’s mission is to provide policy solutions that cut hunger and malnutrition. Two key principles underlie this mission. First, sound and appropriate local, national, and international public policies are essential to achieving sustainable food security and nutritional improvement. Second, research and dissemination of its results are critical inputs into the process of raising the quality of the debate and formulating sound and appropriate food policies. The IFPRI’s mission lays a strong...
emphasis on research priorities and qualities that facilitate change

IFPRI,
2033 K Street, NW, Washington, DC 20006-1002, USA
Tel: +1 202 862 5600, Fax +1 202 467 4439
E-mail: ifpri@cgiar.org
Internet: http://www.ifpri.org

World Health Organization (WHO) – Health Action in Crisis (HAC)Department
The principal objective of the WHO Health Action in Crisis Department is to reduce avoidable loss of life, burden of disease and disability in crises in the indicative list of crisis-prone and crisis-affected countries. The website contains technical guidelines and information related to HAC activities.
E-mail: info@who.int
Internet http://www.who.int/hac/en/

WHO – Household Water Treatment and Safe Storage (HWTS)
HWTS can lead to dramatic improvements in drinking water quality and reductions in diarrhoeal disease, which makes an immediate difference to the lives of those who rely on water from polluted sources.
http://www.who.int/household_water/en/
General information on disaster preparedness and management
Asian Disaster Preparedness Center (ADPC)
The ADPC is a non-profit organization supporting the advancement of safer communities and sustainable development, through implementing programs and projects that reduce the impact of disasters upon countries and communities in Asia and the Pacific.
ADPC,
PO. Box 4, Klong Luang Pathumthani 12120, Thailand
Tel (66 2) 516 5900 - 10, Fax (66 2) 524 5360
E-mail: adpc@adpc.net
Internet: http://www.adpc.net

Asian Disaster Reduction Center (ADRC)
The ADRC aims to promote multilateral disaster-reduction cooperation through exchange of disaster-reduction experts between countries and concerned bodies, compiling and disseminating disaster-reduction information, and carrying out research on multilateral disaster-reduction cooperation.
E-mail: rep@adrc.or.jp
Internet: http://www.adrc.or.jp

Center for International Disaster Information (CIDI)
CIDI uses its information-management resources to implement various targeted public awareness activities. These activities address the issues of appropriate donations and volunteer practice for disasters in order to reduce the burden they cause for relief organizations, host governments and disaster victims. They will also lessen the frustration experienced by the public donor community. The Center encourages public participation in international affairs and provides guidance in promoting activities that would be most useful and beneficial for the ultimate recipients – the disaster victims themselves.
E-mail: cidi@cidi.org
Annex 1: Reference Sources

Internet: http://www.cidi.org

**UNDP – Bureau for Crisis Prevention and Recovery (BCPR)**
The BCPR’s mission is to enhance the UNDP’s efforts for sustainable development, working with partners to reduce the incidence and impact of disasters and violent conflicts, and to establish solid foundations for peace and recovery from crises. The BCPR strives to ensure that the UNDP plays a pivotal role in transitions between relief and development, promotes linkages between UN peace and security and development objectives, and enhances governments’ responsibilities and technical and national capacities to manage crises and post-conflict situations.

BCPR New York,
UNDP — One U.N. Plaza, New York, NY 10017, USA
Tel: (212) 906 5194, Fax: (212) 906 5379
E-mail: bcpr@undp.org
Internet: http://www.undp.org/bcpr/

**UNDP/BCPR – Disaster Reduction Unit (DRU)**
The goal of the DRU is to reduce risk of disasters in countries that take part in the program. The DRU works to achieve a sustainable reduction in disaster risk and sustainable recovery from disaster, by strengthening national and regional capacities. This involves ensuring that disaster risk considerations are factored into all new development projects, that disaster impact is mitigated and that development gains protected. It also entails that risk reduction is factored into rapid disaster recovery.

E-mail: bcpr.disasters@undp.org
Internet: http://www.undp.org/bcpr/disred/

**Emergency Management Australia (EMA)**
EMA assists states and territories in Australia to develop their emergency management capabilities. During major disasters, EMA also coordinates Australian Government physical assistance to states and territories upon request. EMA also promotes a national approach to emergency management in Australia through comprehensive measures that embrace prevention, preparedness, response and recovery activities. EMA has developed the Australian Emergency Manual Series, which provides information on the most important issues in emergency management.

EMA,
PO Box 1020 Dickson, Australian Capital Territory 2602, Australia
Tel: + 61 (0) 2 6256 4600 Fax: +61 (0) 2 6256 4653
E-mail: ema@ema.gov.au
Internet: http://www.ema.gov.au

**Federal Emergency Management Agency (FEMA)**
FEMA’s mission is to lead the effort to prepare the United States for all hazards and effectively manage federal response and recovery efforts following any national incident. FEMA also initiates proactive mitigation activities, trains first responders, and manages the National Flood Insurance Program (NFIP) and the US Fire Administration.

FEMA,
500 C Street S.W., Washington, D.C. 20472, 1-800-621-FEMA
Internet: http://www.fema.gov
International Strategy for Disaster Reduction (ISDR)
The ISDR aims at building disaster-resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters.
United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR),
Palais des Nations, CH 1211 Geneva 10, Switzerland,
Tel: +41 22 9172529 / 762 / 759, Fax: +41 22 9170563
E-mail: isdr@un.org
Internet: http://www.unisdr.org

UN/ISDR – Platform for the Promotion of Early Warning (PPEW)
The PPEW aims to reduce the growing impacts of disasters through the development of more systematic approaches to the use of early warning of the conditions that lead to disasters. The PPEW helps the development of early-warning and preparedness systems by advocating for better early-warning systems (especially in development assistance policy and programs), collecting and disseminating information on best practices, stimulating cooperation among early-warning actors, and the development of new ways to improve early-warning systems.
UN/ISDR Platform for the Promotion of Early Warning,
Görresstrasse 30, D-53113 Bonn, Germany
Tel.: 0049 228 249 88 10, Fax: 0049 228 249 88 88
E-mail: isdr-ppew@un.org
Internet: http://www.unisdr.org/ppew/

WMO – Natural Disaster Prevention and Mitigation (DPM)
The WMO established the DPM program to provide an integrated and coordinated framework by which government authorities and the natural-disaster risk-management community in both the public and private sectors have access to critical scientific and technical information, promptly and effectively. The DPM website will serve as an information hub for all scientific and technical matters related to weather-, climate-, and water-related natural hazards.
WMO Natural Disaster Prevention and Mitigation Office,
7 bis, Avenue de la Paix, PO. Box 2300, CH-1211 Geneva, 2, Switzerland
Tel.: (+41 –22) 730 8006, Fax: (+41 –22) 730 8181
E-mail: disasters@wmo.int
Internet: http://www.wmo.int/disasters/index.htm

Network for Information, Response And Preparedness Activities on Disaster (NIRAPAD)
NIRAPAD’s vision is to empower, enable and equip the people of Bangladesh as much as possible with knowledge, skills, attitude and resources to face any disaster. The Network aims to achieve this by helping its member organizations in increasing their sustainable capacity to cope and prepare themselves and their community to face any disaster.
NIRAPAD,
Pragati RPR Center (13th Floor) 20-21 Kawran Bazar, Dhaka 1215
Tel: 8114207, 9112315 Ext. 179, Fax: 8114183
E-mail: nirapad1@bangla.net
Internet: http://nirapad.org/
Annex 1: Reference sources

ProVention Consortium
The ProVention Consortium is a global partnership of governments, international organizations, academic institutions, the private sector and civil society, dedicated to increasing the safety of vulnerable communities and to reduce the impacts of disasters in developing countries. The Consortium aims to advance disaster risk management in developing countries through forming partnerships and demonstrating innovative approaches to the practice of risk management, and sharing knowledge and resources. ProVention activities fall into three categories – risk identification and analysis, risk reduction, and risk sharing and transfer.

ProVention Consortium,
P.O. Box 372, 17, chemin des Crêts, CH-1211 Geneva 19, Switzerland
E-mail: provention@ifrc.org
Internet: http://www.proventionconsortium.org/

NGOs

CARE
CARE’s projects directly assist survivors of natural disasters through both immediate relief and longer-term community rehabilitation including food, temporary shelter, clean water, sanitation services, medical care, family planning and reproductive health services, and seeds and tools. CARE’s special reports give detailed information about the organization’s emergency work around the world.

CARE International Secretariat,
Chemin de Balexert 7-9, CH 1219 Chatelaine Geneva, Switzerland
Tel: 41 22 795 10 20, Fax: 41 22 795 10 29
Internet: http://www.careinternational.org.uk/cares_work/what/emergency.htm

International Federation of Red Cross and Red Crescent Societies (IFRC)
This website is about disaster preparedness, management and response. It provides information about activities and programs of the IFRC, presents guidelines on how to act before, during and after disasters and offers publications on disaster-related topics. A small section of the website is dedicated to floods and their management and includes documentation on IFRC’s initiatives in this area.

IFRC,
PO Box 372, CH-1211 Geneva 19, Switzerland
E-mail: secretariat@ifrc.org
Internet: http://www.ifrc.org/what/disasters/

Médecins Sans Frontières (MSF)
MSF is an international humanitarian-aid organization that provides emergency medical assistance to populations in danger. MSF works in the rehabilitation of hospitals and dispensaries, vaccination programs, and water and sanitation projects. It is also involved in remote health-care centres and slum areas, and provides training to local personnel – the objective of all these activities being to rebuild health structures to acceptable levels. MSF also seeks to raise awareness of crisis situations.

MSF International Office,
Rue de Lausanne 78, CP 116 – 1211, Geneva 21, Switzerland
Tel: +41 (22) 849.84.84, Fax: +41 (22) 849.84.88
3. Trans-boundary initiatives

**ELBE – LABE (ELLA) Project**
The ELLA Project was set up after the severe flooding of the Elbe River in 2002. The aim of the project is to create a sustainable basis for trans-boundary cooperation in preventive flood management among spatial-planning actors.

Sächsisches Staatsministerium des Innern (Lead Partner), Wilhelm-Buck-Str. 4, D-01095 Dresden, Tel: +49 (0) 351/564 3656 /3652, Fax: +49 (0) 351/564 3659, E-mail: Fachplanung-EU@SMI.Sachsen.de

http://www.ella-interreg.org/

**International Commission for the Protection of the Odra River against Pollution (ICPOAP)**
The ICPOAP oversees the water quality of the Odra River. Apart from pollution reduction, the Commission also aims to undertake precautions against the risk of flood damage and achieve a sustained reduction of flood risk.

ICPOAP, Ul. C. K. Norwida 34, 50-375, Wrocław, Poland, Tel: +48 71/326-74-70, Fax +48 71/328-37-11, E-mail: mkoo@mkoo.pl

Internet: http://www.mkoo.pl

**International Commission for the Protection of the Rhine (ICPR)**
All the countries that share the waters of the Rhine have come together to form the IPCR to jointly deal with issues like water quality and emissions, ecology and floods. The Commission has come up with an action plan for flood management by developing the ‘Rhine Atlas’, which is a tool to create risk awareness. The Rhine Atlas maps the chances of

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**Annex 1: Reference sources**
flooding in the Rhine River Basin so that people are aware of risk prone areas in and around the floodplains.

ICPR,
PO Box 200253, D - 56002 Koblenz
Tel: 0049 (0)261 94252 0, Fax: 0049 (0)261 94252 52
E-mail: sekretariat@iksr.de
Internet: http://www.iksr.org /

*International Commission for Protection of the Danube River (ICPDR)*

The ICPDR is the body in charge of implementing the Danube River Protection Convention. This Convention forms the basis for the efforts of states in the region to achieve sustainable and balanced management of the Danube’s waters, including the protection and effective use of surface-water and groundwater bodies.

The ICPDR has formed the ‘Action Program for Sustainable Flood Protection in the Danube River Basin’. This plan defines a set of general objectives and spells out several categories of measures likely to reduce the risk of flooding.

ICPDR,
Vienna International Center, D0412, P. O. Box 500, A-1400 Vienna / Austria
Tel: +43 1 260 60 5738, Fax: +43 1 260 60 5895
E-mail: icpdr@unvienna.org
Internet: http://www.icpdr.org/

*Floodplain Land Use Optimising Workable Sustainability (FLOWs)*

FLOWs is a trans-national project with participants from Germany, the Netherlands, Norway, Sweden and the United Kingdom. The FLOWs program aims to provide a ‘tool box’ of techniques that planners, water managers and decision makers can use: (1) in decision-support systems for areas facing increased flood risk from climate change, (2) to provide for sustainable development, and (3) to demonstrate practical low-cost measures, including infrastructure for reducing flood damage to property and land.

Internet: http://www.flows.nu/

*FLOODsite*

FLOODsite is an integrated project on flood-risk management that brings together managers, researchers and practitioners from a range of government, commercial and research organizations – all devoted to various, but complementary, aspects of flood risk management.

E-mail: floodsite@hrwallingford.co.uk
Internet: http://www.floodsite.net

*Spatial Quality Enhancement, Alleviation of Flood Damage and Nature Enlargement by Development (SAND)*
The objective of SAND is flood alleviation in northwest Europe by the use of mineral (sand, clay, gravel etc) extraction pits, with a special focus on improving water quality and spatial quality. The project involves several countries in the region that have both small and large rivers.

Directorate-General for Public Works and Water Management, Directorate East-Netherlands, Gildemeestersplein 1, 6826 LL Arnhem
Tel: +31 (0) 26 368 8797, Fax: +31 (0) 26 368 8734
E-mail: h.j.nijand@don.rws.minvenw.nl
Internet: http://www.sandproject.nl/

**Sustainable Development of Floodplains (SDF)**

SDF is a co-operative and interactive project between Germany and the Netherlands that deals with flood prevention and nature conservation along the Rhine River. The main objectives of the program are the reduction of floods and the sustainable development of floodplains for multifunctional use like agriculture, nature development, recreation and as a retention area.

Directorate-General for Public Works and Water Management, Directorate East-Netherlands, Gildemeestersplein 1, 6826 LL Arnhem
Tel: +31 (0) 26 368 8797, Fax: +31 (0) 26 368 8734
E-mail: h.j.nijand@don.rws.minvenw.nl
Internet: http://www.sandproject.nl/

**Room for the River**

The Dutch initiative, Room for the River, is a new approach to the management of water. Instead of the continuing to build dikes, the new strategy looks at possibilities to give the water more room. These include lowering floodplains, dike relocation and creating water-retention areas.

National Bureau Room for the River, PO Box 20903 2500 EX Den Haag, Tel.: +31 (0) 70 - 351 75 77
E-mail: info@ruimtevoorderivier.nl
Internet: http://www.ruimtevoorderivier.nl/index.asp?p_id=420

**Water Framework Directive (WFD) of the EU**

The WFD stipulates several measures that member countries of the EU must undertake as part of their water-management programs. The objective of the WFD is to establish a community framework for the protection of inland surface waters, transitional waters, coastal waters and ground- water – in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts.


Internet consultation on a proposal for a Floods Directive
Internet: http://europa.eu.int/comm/environment/water/flood_risk/consult.htm

**4. General Information Sources**

**Intergovernmental Panel on Climate Change (IPCC)**

The IPCC has been established by the WMO and UNEP to assess on a comprehensive, objective, open and transparent
ANNEX 1: REFERENCE SOURCES

basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.

IPCC Secretariat,
7bis Avenue de la Paix, C.P. 2300, CH-1211 Geneva 2, Switzerland
Tel: +41 22 730 8208, Fax: +41 22 730 8025
E-mail: IPCC-Sec@wmo.int
Internet: http://www.ipcc.ch

Habiforum
Habiforum is an organization that is an expert network on multiple and innovative land use. Their aim is to find out how the relationship between science, policy, and practice should be structured. Their knowledge is brought about by means of pilot projects and a scientific research programme and education. Their site presents a library with publications on projects they have initiated.
Habiforum,
Büchnerweg 1, Gouda Postbus 420, 2800 AK Gouda
Tel: 0182 540655, Fax: 0182 540656
E-mail: info@habiforum.nl
Internet: http://www.habiforum.nl

SUSTAINABLE DEVELOPMENT

Asian Development Bank (ADB) – Water for All
The Water for All website contains news information about actions undertaken in different countries towards the common goal of providing water for all. The ADB also runs a water-awareness program to help achieve sustainable water resources management and better water services. During disasters, the ADB helps people by providing loans and technical assistance.
Asian Development Bank,
6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel: + 632 632 5317, Fax: + 632 636 2381
E-mail: water@adb.org
Internet: http://www.adb.org/Water/default

Development Gateway
The Development Gateway Foundation is an independent not-for-profit organization that helps to improve people’s lives in developing countries by building partnerships and information systems that provide access to knowledge for development. Also, they exploit powerful and affordable Information and Communication Technologies (ICT), that were previously unavailable, to: (1) increase knowledge sharing, (2) enhance development effectiveness, (3) improve public sector transparency and (4) build local capacity to empower communities. The website has several topics, authored by experts, that contain useful information about floods, water policies and disaster relief.
E-mail: info@developmentgateway.org
Internet: http://www.developmentgateway.org

Environment and Sustainable Development – United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP)
The UNESCAP’s Environment and Sustainable Development Division (ESDD) aims to promote regional and sub-regional cooperation for sustainable development. The Water
Resources Section of the ESDD is the focal point for the co-ordination of natural disaster reduction activities. It promotes and supports sub-regional cooperation to sustain the process of capacity building and works towards strengthening national capacities to reduce impacts of water-related natural disasters.

Water Resources Section, Environment and Sustainable Development Division
United Nations Building, Rajadamnern Avenue, Bangkok 10200, Thailand
E-mail: escap-esdd-wrs@un.org
Internet: http://www.unescap.org/esd/

Mekong River Commission for Sustainable Development
The Mekong River Commission (MRC) was established to promote and coordinate sustainable management and development of water and water-related resources for the mutual benefit of the countries sharing the Mekong River. The MRC’s objective is also to promote people’s well-being by implementing strategic programs and activities, and providing scientific information and policy advice. As part of its ‘Flood Management and Mitigation Program’, the Commission has set up a Regional Flood Centre that provides technical and coordination services to the four countries in the Lower Mekong Basin. The services include flood forecasts, providing flood data, devising technical standards and designing training packages.
Mekong River Commission,
P.O. Box 6101, Unit 18 Ban Sithane Neua, Sikhottabong District, Vientiane 01000, Lao PDR
Tel: (856) 21 263 263, Fax: (856) 21 263 264
E-mail: mrcs@mrcmekong.org
Internet: http://www.mrcmekong.org/programmes/Flood/flood.htm

The Netherlands Water Partnership (NWP)
The NWP is an independent body set up jointly by the Dutch private- and public-sector to act as a national coordination and information point in relation to water activities overseas. The main aims of the NWP are to harmonize the activities and initiatives of the Dutch water sector overseas and to undertake worldwide promotion of Dutch expertise related to water. Their website has a large collection of material about national and international flood initiatives.
E-mail: info@nwp.nl
http://www.nwp.nl

UN Economic Commission for Europe (UNECE)
This part of the UNECE website provides a lot of information about water. The Commission has developed guidelines on sustainable flood prevention which form the basis for the EU report ‘Best Practices on Flood Prevention, Protection and Mitigation’. The UNECE also provides information about recent developments in flood and disaster management.
UN Economic Commission for Europe, Information Service, Palais des Nations, CH - 1211 Geneva 10, Switzerland
Tel: +41 (0) 22 917 12 34, Fax: +41 (0) 22 917 05 05
E-mail: info.ece@unece.org

Annex 1: Reference sources
Annex 1: Reference sources

http://www.unece.org/env/water/

*The World Bank*

The World Bank offers low-interest loans, interest-free credit and grants, as well as technical assistance to developing countries and countries in transition. Water is one of the main areas of focus. The World Bank website contains links to information on dams, retention basins and drainage systems.

Internet: http://www.worldbank.org/water
ANNEX 2: LIST OF RESOURCES
1. **INTRODUCTION**

**Information Sources**
- Alphen, van J., E. van Beek, From flood defence to flood management – prerequisites for sustainable flood management. 2005
- Douben, N., R.M.W. Ratnayake. Characteristic data on river floods and flooding; facts and figures. 2005
- European Union, Best practices on flood prevention, protection and mitigation.
- Commission of the European Communities, Flood risk management. Brussels, 2004

**Internet**
- UNISDR. http://www.UNISDR.org
- HR Wallingford. http://www.hrwallingford.co.uk/
- Webster’s online dictionary. http://www.websters-online-dictionary.org/

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6 Dilley, M. et al.. Natural Disaster Hotspots A: Global Risk Analysis.
8 Rob Pudim. http://www.colorado.edu
9 EU, http://europa.eu.int/ p.19

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**Information Sources**
- Arcadis
- Braakhekke, W. et al., Ruimte voor nieuwe rivieren, Een nieuwe rivier als ruggengraat voor ruimtelijke ontwikkeling en waterbeheer – Een eerste verkenning.
- Heidemij RealisatiePlus, Volume 23
- Nijland, H.J., G. Schaap, SAND: Spatial quality enhancement, flood damage alleviation, and nature enlargement by development or redevelopment of mineral extraction sites. ISFD3, 2005.
- Rijkswaterstaat
- Society for Environmental Communications, Down To Earth. Volume 14, nr. 9. 2005
- The World Bank, Reclaiming Drainage: toward an integrated approach. Cd-rom

**Internet**
- Asian Disaster Reduction Center. http://www.adrc.or.jp
- SARDC. http://www.sardc.net
- White water to blue water partnership. http://www.ww2bw.org

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15 Arcadis
16 Ruimte voor de Rivier. http://www.ruimtevoorde rivier.nl
17 Paul Paris, Amstelveen
19 Arcadis
19 Aanpak flessenhals bij Nijmegen. http://www.dijkteruglegginlent.nl
26 International Sustainable Solutions. http://www.i-sustain.com
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Information Sources
- Arcadis,
- Brinkhuis-Jak, M., et al., Cost benefit analysis and flood damage mitigation in the Netherlands.

Internet
- Asian Disaster Reduction Center. http://www.adrc.or.jp
- InfraSite. http://www.infrasite.nl
- LSU AgCenter , Floods and Hurricanes. www.louisianafloods.org
- Nederland leeft met water. http://www.nederlandleeftmetwater.nl
- Waterforum Online. www.waterforum.net

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Measures and Effectiveness. ICPR, 2002.

36 WMO/GWP, Study Of The Historical Floods From Integrated Flood Management Viewpoint. Country Report – Bulgaria

4. PRE-FLOOD MITIGATION

Information Sources
- Arcadis
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It is often the poor that suffer most from floods. Therefore, effective flood management can be seen as contributing to the reduction / alleviation of poverty. Proper and adequate rehabilitation will also help reduce the population of poor, needy and homeless people.

<table>
<thead>
<tr>
<th>Threat or negative impact</th>
<th>Primary affected persons</th>
<th>Immediate or apparent cause</th>
<th>Other causal factors</th>
<th>Potential solutions</th>
</tr>
</thead>
</table>
| Death or severe injury   | Poor persons living near rivers subject to flash flooding (rural and urban context) | Intense rainfall for sufficient duration to cause local flash flooding, riverbank collapse of buildings washouts of roads and bridges | - Failure of flood control embankments  
- Accidental dam breaks  
- Deformation in the upper catchment, construction of extensive paved areas, loss of vegetative protection  
- Sudden excessive release of water from reservoirs (e.g., to ensure dam safety or for hydroelectric generation)  
- Canalization of riverbed (i.e., hard paving) | - Provision of temporary off-stream storage (e.g., detention basins or runoff capture within urban subdivisions)  
- Provision of flood mitigation reservoirs  
- Provision of strengthened and well designed flood containment embankments  
- Provision of better engineered roads and bridges  
- Provision of flood diversion channels  
- Provision of flood warning and alert systems  
- Program of reservoir safety monitoring and strengthening |
| Poor person living in floodplains (rural context) | Intense local rainfall coinciding with arrival of flood peak in the main channel of the river, leading to unusually deep flood levels and possibly accompanied by embankment failure and collapse of buildings, roads and bridges | - Accidental dam breaks or failure of flood embankments (sometimes both together)  
- Deliberate rupture of flood embankments  
- Rapid flood recession leading to collapse of riverbanks and flood embankments | - Restoration of wetlands and provision of other off-stream flood storage or retention areas within the floodplain.  
- Flood proofing of houses and villages  
- Provision of better engineered roads and bridges  
- Provision of flood mitigation reservoirs and flood diversion channels  
- Provision of flood-proof evacuation roads  
- Provision of flood warning and alert systems  
- Program of reservoir safety monitoring and strengthening |
| Poor persons living in low lying coastal areas (e.g. southern parts of Bangladesh) | Sea level rise and inland movement of waves caused by cyclonic depressions with strong winds | - Clearing of coastal mangroves and other protective vegetation  
- Failure of embankments protecting against storm surge | - Provision of safe havens (e.g., elevated platforms) and flood-proof evacuation roads  
- Provision of well-designed and maintained embankments to protect against storm surge  
- Storm surge warning and alert systems |
| Homelessness and loss of possessions, crops, livestock, means of livelihood | Poor persons living near rivers (rural and urban context) and in floodplains (rural context) Poor persons living in low lying coastal areas | Prolonged or deep flooding (less severe than described above) | - All of the above | - All of the above  
- Provision of flood insurance |
| Increased incidence of water borne diseases | Poor persons living near rivers (rural and urban context) and in floodplains (rural context) Poor persons living in low lying coastal areas | Contamination of wells and other sources of drinking water | - Prolonged presence of contaminated flood water  
- Spillage of flood and animal feed stocks  
- Proliferation of pests and vermin in unsanitary conditions following flooding | - Provision of safe drinking water supplies  
- Provision of food and seed storage facilities above flood level  
- Public education and provision of emergency medical services during and after floods  
- Provision of health insurance |
| Interference with major economic activities | Owners of large commercial interests in floodplain (direct significant impact) Regional and national economy (indirect significant impact) | Large floods causing overtopping of flood embankments and/or damage to buildings, roads, bridges and other infrastructure | - Accidental dam breaks or failure of flood embankments (sometimes both together)  
- Deliberate rupture of flood embankments | - Restoration of wetlands and flood retention basins  
- Implementation of building and land use controls based on flood hazard mapping  
- Compulsory use of flood insurance |

Source: ADB, Floods and the poor