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Overview Situation Paper on Flood Management Practices

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1. INTRODUCTION

1.1 Background

1. During recent years, records of loss of life and damage caused by floods worldwide show a steady rising trend. Understandably, the response has been to call for increased efforts to protect life and property. Given the density of population and level of investment on flood plains, such protection can only be achieved at great cost. Furthermore, small and medium sized floods can be a vital source of freshwater and do bring other benefits to the community and the environment.

2. At the same time, the sustainable management of water resources demands a holistic approach – linking socio-economic development with the protection of natural ecosystems and appropriate management links between land and water uses. It is recognized that a river basin is a dynamic system, in which there are many interactions between land and water bodies. In the light of this, attempts should be made to improve the functioning of the river basin as a whole rather than simply fixing local problems in an ad-hoc manner.

3. The *Integrated Flood Management* (IFM)[I] is an approach which integrates land and water resources development in a river basin, within the context of Integrated Water Resources Management (IWRM)[II], which is defined by the Global Water Partnership as: "*a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems,"* and is itself a relatively new evolving concept. The aim of IFM is to maximize the efficient use of flood plains and minimize loss to life due to extreme hydrologic events giving due consideration to the negative as well as the positive aspects associated with flood waters and to the valuable resource that is represented by the flood plains that these waters occupy on occasions.

4. The WMO/GWP *Associated Programme on Flood Management* (APFM) was launched in August 2001 with the aim to promote the concept of IFM. As part of the implementation of the APFM an IFM Concept Paper was prepared and published in 2003. In order to assess the current status of flood management practices in different parts of the world, APFM collected a number of case studies. The aim was to obtain information on relevant practices from countries in various regions representing different physical, hydrometeorological and socio-economic conditions. By focusing on the evolution of flood management practices in a given location/environment, the overall goal is to help identify those tools that are required to implement the concept of IFM. The main objectives in collecting these case studies were to:

(i) identify the extent to which flood management has been carried out within the context of IWRM;
(ii) understand shortcomings in current flood management practices worldwide;
(iii) extract good practices for IFM;
(iv) catalogue the policy and legislative requirements in support of IFM; and
(v) identify the institutional setup required to achieve IFM.

5. The present Overview Situation Paper (OSP) is based on material contained in 19 case studies on flood management practices collected under the programme. It provides an overview of flood

I, II, III, … – Reference listed at end
[ ] – List of Case Studies at the end of Chapter 1

management practices being followed around the world, ranging from single sector intervention to an integrated approach. An analysis of these case studies was carried out by six specialists covering following specific subject areas: (i) hazard and risk assessment; (ii) flood forecasting and warning; (iii) ecosystems; (iv) cross-sectoral integration and conflict mitigation; (v) risk management; and (vi) legal and institutional arrangements. Each reviewer prepared comments with regards to the drawbacks and gaps in existing systems vis-à-vis IFM approach; recommended approaches to IFM and issues and concepts identified and proposed to be developed to further support implementation of IFM.

6. Based on the case studies, the OSP provides: an overall synopsis of floods, their nature, type and magnitude of damages caused; an overview of present trends and approaches to flood management such as flood management policies, instruments, and institutional response for flood management; and the lessons from current flood management practices. The findings and recommendations have been consolidated in ***Chapter 5***.

7. The current version of the OSP should at this stage be seen as a first compilation of flood management practices. It will be complemented in the light of additional case studies to be collected so as to improve their geographical coverage and representation.

1.2 Description Of Case Studies[1]

The collection of case studies[2] was initiated in late 2002 and by February 2004 a total of 19 cases had been received. Their geographical coverage is shown in ***Figure 1***.

8. Fourteen of the case studies provide information on flood management practices in a specific basin

Figure 1 – Regional distribution of case studies received

1 For reference and in-depth study, synopses and extended summaries of the case studies, as well the case studies in full are published on the APFM web page: http://www.apfm.info

2 It might be of interest to note that the majority of case study authors are active either in national Government agencies, in technical universities or in water-related research institutions: Some of them, however, come from the diverse fields of ecology, economy and social sciences.

or region (for instance, delta areas, etc.) of the corresponding country. Four referred specifically to the urban areas within a basin, while five of the case studies reported on the overall flood management situation in their respective countries. As such, there is a large variation in the scales of the case study areas, which fluctuate between a minimum of 160 km^2 (Senegal River delta, Mauritania) to a maximum of 360,000 km^2 (Mississippi River, USA), or even to a whole country of the size of China [see ***Table 1***], thereby providing a mixed sample of both macro and micro flood management units.

9. Following points need to be taken into account when considering and interpreting the assessments contained in the OSP. First, as described in the preceding paragraph, there is an enormous variation in scale of the case study areas. Although this provides on one hand good samples of both macro and micro flood management examples, there is a difference in focus and level of detail covered in the studies. Secondly, while the coverage of the case studies collected from Africa, Asia and to a possible extent Europe could at this stage be considered to be, at least to some degree, a reasonably representative sample of the flood management practices of the corresponding region, this is not the case for Central and South America and the South-West Pacific regions.

Table 1 – Size of case study areas

Size of case study area (km^2)	**No. of case studies**	**Basins/Regions**
Less than 1000	3	Senegal River Delta (Mauritania), Lai Nullah Basin (Pakistan), Tokay (Japan)
1,000 to 10,000	5	Curitiba (Brazil), Rewa River (Fiji), Chenab River (Pakistan), Parrett Catchment (United Kingdom), Zambezi Basin (Zimbabwe)
10,000 to 50,000	3	Damodar River Basin (India); Piemonte Region (Italy), North Western Black Sea Region (Turkey)
50,000 to 100,000	1	Inner Niger Delta (Mali)
100,000 to 200,000	1	Red River Basin (Canada)
More than 200,000	1	Mississippi River Basin (USA)
Size of country (km^2)	**No. of case studies**	**Countries**
130,170	1	Bangladesh
465,400	1	Cameroon
1 000,000	1	Ethiopia
9 158,960	1	USA (NAI)
9 327,420	1	China

10. The case studies have highlighted a number of important ***issues*** related to flood management. The *Bangladesh* study [1] is an example of an approach taken when a significant portion of the country and its development are exposed to annual flooding. The *Fiji* study [7] provides an example of what might be a preliminary needs analysis for design of IFM strategy within wider IWRM policies. The *Pakistan (Chenab River)* case [13] illustrates the problems associated with changing water policy and the transitional institutional structures. The *India* case [8] represents a conscious but slow move which shows a trend towards IWRM/IFM principles where flood issues are attempted to be examined in an integrated fashion. The *Ethiopia* study [6] shows the changes in water policy in a developing country. The *Zimbabwe* case [19] describes a good case of evolving IFM in Africa.

11. The *Brazil* paper [2] focuses on local-level (metropolitan area and county) as scale of analysis, together with upstream-downstream relationships. The *Mali* study [11] provides an example of the role of natural flood plain wetlands in reducing flood risk downstream by acting as natural storage areas. The *Mauritania* paper [12] stresses the positive role of floods in maintaining ecosystem and providing natural resources and income to local communities. The *Cameroon* study [3] is an attempt at integration of flood management and ecosystem conservation and restoration.

12. The *Italy* study [9] features a situation with multi-purpose water management and flood control structures planned at the river basin level. The *China* case study [5] illustrates the efforts to develop an integrated approach to flood management, based on a coordinated set of structural and non-structural measures and showcases the process of developing a combination of legal and economic instruments. The *Turkey* case study [15] also represents a good example of transition from a narrowly focused flood control strategy to a broader IFM strategy and the kinds of opportunities, issues and problems that need to be addressed in this transition. The *Pakistan (Lai Nullah)* case [14] describes how a major flood event appears to have played a key role in triggering improved disaster management response from the authorities.

13. The *United Kingdom* study [16] illustrates the steps required for creating a sustainable approach towards flood management in an existing system with a long history of flood management. The key item highlighted in the *USA (Mississippi River)* [17] is that despite the integration of flood management measures over many decades, in real terms the annual flood damage is nevertheless increasing. The case study of *Canada* [4] describes an integrative approach that has steadily developed over the years, with learning from failure and progressively moving from structural measures to non-structural measures. The paper describing the situation in *Japan* [10] witnesses a shift from flood control to minimisation of flood loss, and provides details on the establishment of a river administration framework for flood control.

List of case studies

Serial number	Country	Title
[1]	Bangladesh	Flood Management
[2]	Brazil	Flood Management in Curitiba Metropolitan Area
[3]	Cameroon	Integrated Flood Management in River Logone Flood-Plain
[4]	Canada	Flood Management in the Red River Basin, Manitoba
[5]	China	Flood Management
[6]	Ethiopia	Integrated Flood Management
[7]	Fiji Islands	Flood Management – Rewa River Basin
[8]	India	Flood Management – Damodar River Basin
[9]	Italy	Piemonte Region Meteo-Hydrological Alert and Real-Time Flood Forecasting System
[10]	Japan	Tokai Heavy Rain (September 2000)
[11]	Mali	Flood Management – Niger River Inland Delta
[12]	Mauritania	Managed Flood Releases and Livelihoods - Lower Delta Senegal River
[13]	Pakistan	Flood Management - River Chenab from Marala to Khanki
[14]	Pakistan	Lai Nullah Basin Flood Problem Islamabad – Rawalpindi Cities
[15]	Turkey	Recent Flood Disasters in Northwestern Black Sea Region
[16]	United Kingdom	Parrett Catchment Project
[17]	USA	Flood Management – Mississippi River
[18]	USA	No Adverse Impact - A New Direction in FloodPlain Management Strategy
[19]	Zimbabwe	Flood Management Practices- Selected Flood Prone Areas Zambezi Basin

2. FLOODS AND THEIR IMPACT

14. Rivers and freshwater lakes, being sources of water for the survival of all forms of life, have attracted humankind and played an important role in their transforming from a nomadic behaviour towards a settled way of life. River valleys have served as cradle of human civilisations. River banks along with the adjoining flood plains, due to ease in communication, fertile lands and relatively less hostile surroundings, provided attractive locations for settlements and livelihood. Over the years, these settlements developed into towns and fuelled by development progress grew into cities. The Mississippi River was a major highway for early explorations of Mid-west United States and settlements in associated flood plains [17]. Barely ten per cent of the plain areas in Japan that is formed by the flood plains in otherwise earthquake prone mountainous terrain provide the only “safe” place for the development activities [10].

15. The flood plain soils are rich due to deposition of fine sediments and exchange of nutrients and different carbon rich organisms between the river and its flood plain. They maintain morphological and biological diversity. Deltas particularly benefit from this intermittent exchange of nutrients and freshwater supplied mainly during flood events, maintaining mangroves and associated fisheries in the coastal zones. In the Niger River Inland Delta in ***Mali*** the floodwater plays a determinant role in regeneration of the Delta’s natural resources, which form natural resource base for a variety of biological systems including human beings [11].

16. In developing countries, the poorest people live off natural resources such as fisheries, fuel wood, herbs, medicines, etc., that are provided by rivers and associated wetlands whose ecosystems are maintained partly by floods. Many species of fish breed on flood plains during inundation. Floods often trigger migration of fish. Recharge of aquifers during flooding provide water storage for use the year round.

17. During earlier times the human settlements and related economic activities were confined to higher grounds within, or in the vicinity of the flood plains, in accordance with the geographical location, topography and meteorological conditions and were largely unaffected by extreme flood events. Occupation of flood plains puts human lives and related economic activities at risk. With the growing population pressures, however, the society is inclined to take greater risks that are associated with inundation due to extreme flood situations, despite the fact that many civilisations in the past are believed to have been wiped out by such extreme events

2.1 Type of floods

18. Meteorological events such as: tropical cyclones, accompanied with strong winds; monsoons; inter-tropical convergence low pressure systems; summer storm rainfalls with large areal coverage; heavy localized storms with favourable antecedent conditions; combined effects of a summer or autumn front and a typhoon; high temperatures resulting in snow-melt (in cases combined with rain); deep frost prior to snow-fall and late and sudden spring thaws, combined with topographical characteristics, generate low, medium or high floods in streams and rivers.

19.

Floods generated by these events have different characteristics. Those resulting from widespread rainfall over large areas are slow rising and extend for days or weeks. Flash floods are a result of heavy intense rainfall falling over a small and relatively steep catchment, largely at the foothills of mountains. They have a concentration time of few hours and have a short duration. Urban flooding can be associated with any combination of the earlier two situations, which is accentuated due to drainage

congestion. Although urban floodings are local in nature, they are also impacted by major flood events on larger streams or lakes that do not originate from within the urban zone. Storm surges and tsunamis, associated with high sea waves generated as a result of cyclonic conditions at the sea or earthquakes with epicentres in or near the sea cause flooding in coastal areas. They can worsen the flood situation in lower reaches of rivers. Flooding characteristics like duration, depth and its consequential impact is governed by the location, geology, topography and complexity of the hydrological regime of the respective drainage basin(s). Quiet often flooding is induced by human activities like breaching of the dikes, dams and operation failures of floodgates. A summary of the meteorological events and associated types of floods generated as a consequence in the case study areas is provided in ***Annex I***. In the following ***Box 1*** flood characteristics in selected case study areas are briefly described.

2.2 Frequency of floods

20. Frequency of flood disasters recorded is on the rise thereby increasing the associated economic damages, some of which are attributed to increased flood frequency driven by climate change . In some countries information on historical flood records goes back as far as year 206 BC (China), 623 AD (Japan), 1800 (Italy), 1826 (Canada), 1849 (USA) and 1863 (India). Some case studies report that the incidence of floods has been increasing during recent years and cited this as one of the reasons for the increase in the associated damages. An analysis of the limited information presented in the case studies shows that the case study areas have been affected by flood events with varying periodicity, which ranges from one occurrence every two years in three countries (China, Italy's Piemonte Region and Pakistan's Chenab River Basin), to once every 14 years in the USA (Mississippi). ***Annex I*** also presents a statistical summary on the number of flood events (in general since the second half of the last century). However, there is no conclusive evidence of changes in flood frequencies due to climate changes.

21. Urbanization in the upstream catchment and/or insufficient drainage waterways due to infrastructure downstream have definitely increased the flood magnitudes and frequency of flooding in certain areas. It is recognized that urbanization of catchments is a major source of increased run-off, generating floods with higher flows and shorter peak times especially in rivers with smaller catchments. For example, floods in the metropolitan area of Curitiba in Brazil are reported to have increased by as much as six times during the last 20 years [2]. Similarly, in Japan, rapid urbanization in the catchments, because of continuous population growth, has resulted in higher flood peaks in the downstream areas [10]. As such, in many cases the increase in flooding incidences and damages due to floods can be associated with urbanization and intensive economic utilisation of flood plains and not necessarily due to increase in flood frequency *per se*. The perception of increased frequency of flood disasters can also be attributed to better communication and reporting of such events in the media.

2.3 Severe flood events and their impact

22. While being beneficial to the flood plains and their productivity, floods do have great damage potential and affect ever-increasing number of people. On a global scale, there is evidence that the number of people affected and economic damages resulting from flooding are on the rise[III]. Flood losses reduce the asset base of households, communities and societies by destroying standing crops, dwellings and infrastructure. In some cases the effect of flooding can be dramatic, not only at the household level but also at national level. This situation is clearly reflected in the case studies, providing a vivid picture of the types of floods and types of damages they can produce or cause. Flood disaster events of the last decade have shown that impacts of flooding due to extreme events is not limited to the least developed nations, but can also devastate and ravage the most economically advanced and industrialised nations. It should be noted, however, that in developed-industrial nations,

although the annual average flood losses are rising[3], thanks to the resilient society and preparedness measures, the average annual loss of life is falling. However, elsewhere in the developing regions of the world, average annual flood losses as well as average annual loss of life appear to be rising. Flood disasters in less developed nations can effectively wipe out decades of investments and infrastructure, seriously cripple economic progress, and result in spread of epidemics, deaths and destitution. Majority of the deaths associated with flood events take place within the most vulnerable sectors of society, namely elderly people, women, children and disabled persons.

Box 1 Flood characteristics in selected case study areas

Bangladesh. - Comprising the deltaic area of the two largest rivers of Asia, this country generally experiences four types of floods. *Flash floods* occur during mid-April before the on-set of the monsoon mainly in its north-eastern hilly regions. *Rain-fed floods* are generally experienced in the deltas in the southern part and in low-lying urban areas: The situation worsens when these rain- fed floods coincide with *storm surge floods* associated with tropical cyclones. *River floods* are the most common along the rivers during monsoon season, when areas far beyond the riverbanks are inundated. Coastal areas are also subjected to *tidal flooding* from June to September.

Japan. – The country is affected in the summer and autumn by thunderstorms, often as a result of the combined effects of a rain front and a typhoon. During winter snowmelt causes floods in the northern parts of the country. Due to the country's mountainous topography many rivers have steep riverbed gradients, causing torrential and violent flash floods. Furthermore, the riverbeds are higher than the protected lowland. The floods overtopping the embankments cause inundation of the protected lowlands and urban areas. Most of the economic activities are concentrated in the deltaic area in the lower parts of the rivers which are protected by embankments. Any floods which overtop the embankments cause serious economic damages.

Fiji. - Tropical cyclones are the main cause of major floods, and their magnitude is dependent on the associated meteorological system. Rapid runoff from an already saturated catchment results in extensive floods. Storm surges associated with the cyclones exacerbate flood levels on the coastal zones, Back water in the rivers then restrict the overland flows, and riverbanks are often breached.

Canada. - Periodically weather conditions promote widespread flooding in the Red River Basin in Manitoba; the most troublesome ones as a result of a combination of one or more of the events, such as: (i) heavy precipitation in the autumn; (ii) hard and deep frost prior to snowfall; (iii) substantial snowfall; (iv) late and sudden spring thaw; and (v) wet snow/rain during spring break-up of ice.

Italy. - The complex hydrological regime of the Piemonte Region has an impact on the flood response. In the winter, precipitation is stored as snow and in glaciers. In the spring the snow melts, aided by rainfall, which result in the spring floods. Summer rainfall can be stormy and the bare, rocky Alps generate high runoff with a rapid response. Autumn rainfall mainly caused by southwest wind coming from the Mediterranean can also be heavy and prolonged. In addition, many man made structures across and along rivers obstruct the flow and often can produce local but heavy flooding.

Turkey. - In the Western Black Sea Region the drainage areas of the rivers have short main courses, with steep slopes. During floods the flows have high speed and, due to heavy sediment load, are muddy and viscous. A large amount of erosion and debris is dragged by the flows and deposited in the low-lying areas of the less steep flood plains. Devastating flash floods occur most frequently between May and July.

[3] In the USA a conservative estimate of total flood losses at present is well in excess of USD 6 billion annually, which is a four-fold increase since the early 1900s.

23. In ***China***, for example, an average of about 78,000 km^2 area, which accounts for about 7.8 % of the total farmland, was affected annually during the period 1950-1990 [5]. ***Pakistan*** has seen significant flood damages in the Lai Nullah Basin flood in 2001, which inundated Rawalpindi City, with loss of as many as 74 lives, affecting about 400,000 people, and damaging 3,535 houses [14]. Estimates indicate a damage/loss of more than USD 0.25 billion to infrastructure. In ***Fiji*** a major flood in 1993 caused damages amounting to some USD 100 million, 23 lives were lost, and more than 120,000 people (approximately 10% of the population) suffered serious losses thereby, adversely affecting the national GDP and government's development plans and programmes [7]. Resources earmarked for capital development works had to be urgently redirected for relief and rehabilitation.

24. Flood losses can usually be categorised into tangible and intangible, direct and indirect, and primary, secondary and tertiary ones. Tangible damages are usually taken to be those which can be measured in economic terms, although such measurement is hardly ever precise. Unfortunately, assessment of damages due to flooding is generally not carried out scientifically. Mostly, only the tangible and primary losses due to floods are reported. Due to the media and public pressure, the governments and politicians are made to come out with certain figures usually the day the flood event takes place. Such quick assessments are generally very rough and cover only the tangible losses and are often motivated. Unfortunately, these rough figures get stuck in the public memory. They bias any well-meaning post-flood analysis of damages. ***Figure 2*** provides a self-explanatory description of these losses. Further, intangible losses defy monetary assessment. Generally, the intangible as well as tertiary flood losses are hardly or ever reported. Their non-quantification also poses difficulty in benefit-cost study of flood management strategies.

25. A number of case studies have shown that urban development and intensification of land use, as well as increased use of agricultural land and changes of cropping patterns are all driving increased risk and exposure of people, property and infrastructure to floods and, in turn, are a major contributor to the increased flood losses [2], [4], [10], [17]. Economic growth improves the average standards of living in flood plains and exposes it to flood risk. One of the major reasons for rise in flood losses is the increase in the value of ownership and possession of consumer goods. The wealthier a society is, the higher are the economic flood losses. On the whole it is possible for the national or regional economy to sustain higher average annual flood losses if the use of natural resources in flood plains help generate gross national product rise more rapidly than the losses. In certain cases, despite increase in absolute terms, flood losses become a small proportion of GDP over time, as is the case in Japan [10].

26. Almost all the cases have reported that the structural and non-structural flood protection and mitigation measures put in place have successfully averted the possible damages that would have otherwise occurred in the situation prior to their implementation. For example, in ***Canada*** the 1997 flood was the highest recorded during the last century and a true test of the flood control system established in the Red River. Flood control measures taken over the years have helped preventing enormous losses, estimates of which run as high as USD 3.75 billion [4]. The main detention reservoirs comprising the Damodar Valley Scheme in ***India*** have served their purpose by moderating the flood flows, showing a tangible reduction in the losses to the extent of 53 to 80% [8], thereby allowing intensive use of flood plains for agriculture and contributing to poverty alleviation. In ***Italy*** the flood forecasting and early warning system was very useful during a recent flood event and allowed a significant improvement of the emergency operations [9].

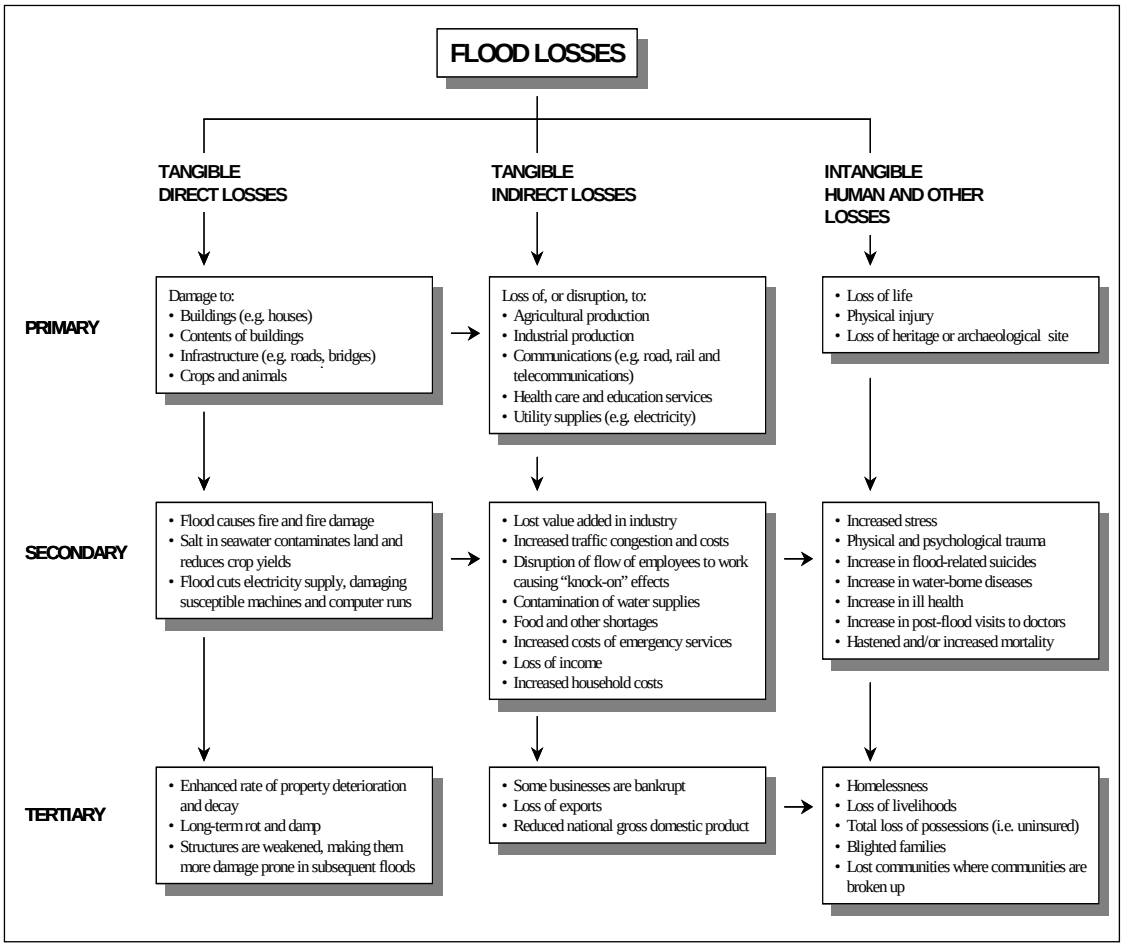


Figure 2 Categorization of flood losses[IV]

2.4 Land use/flood plain development trends

27. By far, the greatest impact of land use change on flood events and hazards is associated with urbanisation itself. The world has become predominantly urban (i.e. 50% or more living in urban areas) for the first time in human history during the past decade. There is a strong association of cities with flood prone locations, such as riverine and coastal positions, because these locations carry important benefits. Because of the considerable economic and other benefits of flood plains and coastal locations, such locations are often likely to be cost effective and thus cannot be avoided. Last 50 years have witnessed a new class of cities - the "mega-city[4]" - become a burgeoning phenomenon. Some two thirds of the world's mega-cities are now located either on the seacoast or in the flood plains and deltas. Most of them are in the developing countries. Growth of large cities appears to be associated with increase in precipitation and convective activity (heat-island effect).

28. Urban development and intensification of land use generate changes in flood hazard magnitude, exposure and vulnerability. Urbanisation of catchments is now well recognised as a major source of increased runoff and reduced rainfall-runoff lag times. The paving of surfaces significantly reduces infiltration, and waterways are often constricted by the development infrastructure like bridges. These

[4] Mega-cities are defined as urban areas with a population of 8 million or more.

and other interventions like embankments reduce the stream storage and conveyance resulting in higher peaks and shorter flood warning lead times.

29. Subtler changes, which may worsen flood risk, are produced by various other land use changes e.g. de-vegetation and agricultural drainage. Generally, the removal of forest and other natural cover influences infiltration rates and increases sheet erosion. These in turn increase the concentration of solids in the streams and contribute to the river morphological changes such as riverbank erosion, rise in riverbed levels and reservoir sedimentation. Such morphological changes impact the stability of existing embankments and other river training works. Deforestation is believed to have contributed significantly to catastrophic flooding in China [5] and in Central America in 1998. Deforestation and other land use practices can also lead to greater incidences of landslides and mud flows. Storage in wetlands and marshes contributes directly to changes in the timing of runoff, the amount of natural storage in the basin and the vulnerability of river channels to the erosive forces of water. Reclamation of such wetlands for development activities also contributes to increases in the flood magnitudes in downstream areas.

30. At the same time, complex changes are taking place in peoples' *vulnerability* to floods. As standards of living rise for many in the advanced industrial nations, their vulnerability decreases. Growing disaster vulnerability and poverty are unfortunately going hand in hand. Factors such as low income, poor housing and public services, lack of social security and insurance coverage force the poor in many countries to behave in ways that expose them to greater risk. Migrants to cities from poor rural areas frequently find themselves settling in flood prone areas where they are clustered in large numbers of informal settlements within many urban areas and mega-cities. As the impacts of flooding tend to fall disproportionately on the poor, including elderly people, women and children, specific policies and actions are required to tackle the link between poverty and disaster vulnerability. In short, there is need to build *resilience* to floods within the society

31. Similarly there are large changes in *flood exposure.* Economic growth, the accumulation of property and wealth, and urbanisation - which are interrelated - are the principal agents. Although land use planning strategies can slow or somewhat reverse the growth of flood exposure, in most cases as cities develop, so flood exposure grows with them. Sea level rise has already been increasing flood risk. Populated and urbanised coastlines are threatened by further sea level rise induced by global warming. Predictions are that global climate change will increase sea levels and may increase storminess in some parts of the world, and this may increase flood risks. The key issue is therefore how to achieve wise use of flood prone land. The increased exposure of urban populations to coastal flooding hazards is a major challenge to IFM.

3. PRESENT TRENDS AND APPROACHES TO FLOOD MANAGEMENT

32. This Chapter provides an overview, as extracted from the various case studies, of present trends and approaches to flood management practices such as management measures, instruments, institutional response for flood management, and present flood management policies. ***Annex II*** contains a summary of the main approaches to flood management practices reported in each of the case studies. There are a variety of strategies, measures and methods that may be drawn upon to address flood hazards and resulting disasters. Their main goal often translates to reducing flood hazard, exposure and/or vulnerability to the hazards. ***Figure 3*** provides a graphical illustration of how flood risk, flood exposure and flood vulnerability are addressed through flood mitigation measures of the structural and non-structural kind.

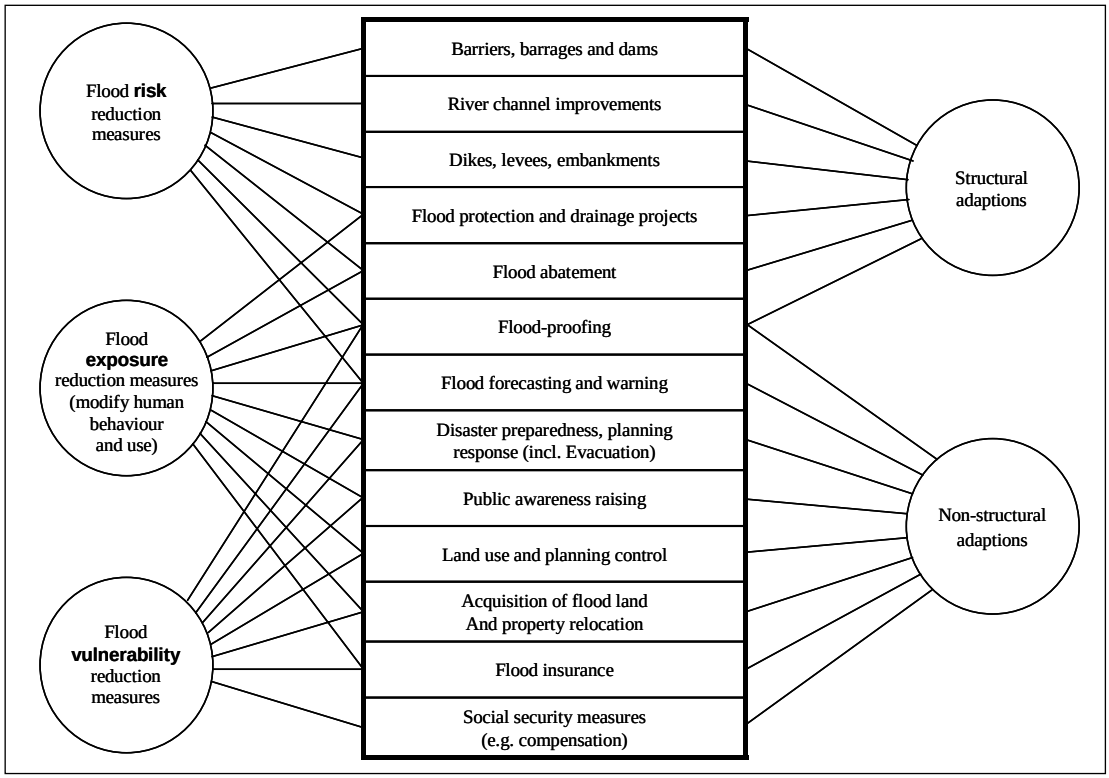


Figure 3 Conventional ranges of options to mitigate inland, fluvial flood hazards and disasters

3.1 Flood management measures

33. Most of the flood mitigation options outlined in ***Figure 3*** are also reflected in the case studies. Flood management practices have largely focused on reducing flooding and the susceptibility to flood damage through a variety of interventions. Invariably, the initial starting point has been the local embankments constructed by the landowners to protect their agricultural lands from frequent flooding. Whether they were the initial settlers of New Orleans on the Mississippi in 1700, or the "*Zamindars*" and landlords during the British Empire in India, or embankments constructed in pre-Meiji era in Japan, they all were local in nature. Long continuous embankments along with drainage sluices followed these, which generally provided protection mainly to agricultural lands from frequent flooding (generally 6 to 20 years frequency). These measures helped in improving agricultural practices and general economic conditions of the farmers, stabilised other economic activities and build resilience in the societies to face extreme events. Embankments were accompanied and followed by by-pass

channels and channel deepening works, drainage channels with pumping systems, out-fall structures and tidal sluices. ***Box 2*** provides some examples of case studies highlighting approaches of implementation and application of the various flood management measures, as well as some of the problems or negative effects encountered as a result of their application. More detailed information relating to all case studies is contained in ***Annex II***.

Box 2 - Approaches of implementation of flood management measures

Brazil. - To solve the flooding problem of the Iguaçu River in the Curitiba Metropolitan Area, the usual approach would have been to carry out construction works to increase the flood carrying capacity of the river. However, because of the fact that flood frequency would then decrease as a result of these works, the population would feel protected and start to occupy the flood plain. To avoid such a future scenario, the conceptual approach was to create a space for flow and storage in the flood plain of the Iguaçu, and to develop a way to control population invasion of the flood plain.

Cameroon. - Dikes and a storage dam constructed on the Logone River to protect population and irrigated areas altered the hydrological system of the flood plain. Reduction of the flooded surfaces and of the retention in the dam of the water loaded with limestone, which plays a very important role for the fertility of plain soils, had certain negative effects on the survival of the population in this region, where the flooded lands are very much used for agriculture, grazing and fishing activities.

India. - The Damodar Valley scheme, comprising a number of reservoirs in the upstream catchment and dikes in the lower reaches, has provided protection from all floods of intensity less than the 25 year flood. In the resulting absence of frequent floods after the scheme, there was extensive encroachment into the flood plains within embankments. However, recognizing the importance of the productive value of the flood plains the land use within embankments is allowed. Therefore, while there are losses in the high flood years, the flood plains are utilised gainfully by the inhabitants during the low flood years. Thus, the approach has been to ”bear the losses” at the time of extreme flood while enjoying the benefits of the land during the normal years.

Italy. - Flood management practices in the Piemonte Region are influenced by the natural peculiarities. Reforestation and structural bio-engineering measures are used in small mountain catchments for mitigation of erosion and landslides. Comprehensive hazard map developed for the region highlights the interaction between river, human activities, and hill slope dynamics. An alert system based on a decision support system for real-time flow forecasting, has also been established.

Japan. - Besides structural protection works, the non-structural measures that are being undertaken are of two types; the first geared to decrease the run-off by means of storage of water in the basin (infiltration of rainwater, storage in each house). The second is related to disaster prevention through local prevention plans, local ordinances (construction regulations, etc.) and the distribution of hazard maps to support emergency evacuation in extreme floods. As regards flood forecasting and warning, a user-friendly information system has been developed available to users and to the public through a web site, cell-phones and Internet.

Zimbabwe. **-** Dams and weirs were put in place to improve water security and serve as flood mitigation structures. However, the country being in a semi-arid region, it is difficult for managers to release water in anticipation of floods because of uncertainties in the occurrence and magnitude of runoff during the coming season. There is also flood forecasting but only providing very short forecasts in an accurate form, which may not allow enough time to respond to the event.

34. In order to operate these structural measures and also to prepare for relief and rescue operations in case of their failure, importance of non-structural measures like flood forecasting were realized. Flood forecasts and warnings now constitute an important flood management tool. Flood forecasting and warning systems have been established, which in general comprise of hydro-meteorological networks, weather radars, telemetric rainfall and runoff stations transmitting data in real or near real-time to a centre, where flood forecasts are prepared using mathematical models. Warnings are issued

for the flood-prone areas, providing real-time flood information with different lead-times, as stipulated on the basis of the requirement. Different variants of such systems are reported to be in place in practically all the case studies. In a number of countries other non-structural measures such as land use regulation and mapping, introduction of controlled flooding and flood insurance followed.

35. In a number of cases although the forecasting systems are relatively well developed and reliable, their further dissemination as flood warnings for the flood prone public to respond effectively in a prompt and efficient manner, are inadequate [1], [13], [15], [19]. Difficulties are reported with flood warning dissemination and communication where effected population is beyond the reach of the existing dissemination systems. Ensuring that all sectors of society are reached requires to be addressed within any sound flood warning strategy. For example, one case reports about young members of a NGO riding on bicycles to assist in the dissemination of cyclone forecasts. Another case reported on the use of *traditional, 'folk' flood forecasting* (qualitative) methods based on local knowledge and biological indicators with scientific and technological ones. Development of *flood-warning manuals* setting out links between flood levels, flood warning and allocation of disaster watch and management duties with active involvement of downstream users is likely to prove a good tool.

36. Flood proofing, evacuation of flood affected population, relief and rehabilitation and post-flood recovery have continued to form an important part of the strategy of living with the floods since time immemorial and continue to play an important role.

3.2 Flood management policies

37. Clear and objective policies for achieving the development goals of the government of a country – supported with appropriate legislations and regulations – are a pre-requisite for the sustainable and integrated development of water resources and flood management. As reflected in the case studies, most of the countries have established national policies relating to, or covering issues of water resources and flood management. Interesting to note is the recent shift of trend in the policies towards IWRM and also, in cases, to IFM, through a change of strategy towards efficient management of flood plains, flood proofing and forecasting, and flood insurance. In ***Box 3*** below some relevant case study examples highlighting national policies related to water and flood management are presented.

38. The statement made in one case study, namely that "*Government and the public came to realize that … floods are a natural phenomenon which cannot be eliminated nor be totally brought under control"* [5] could be considered as an overriding introduction to this Chapter.

39. Of interest are the changes in approaches to flood management practices observed in recent years in a number of countries. There has been a growing realisation that the success of flood management measures in terms of reducing loss of life and minimizing flood losses cannot be achieved through ad hoc reactive policies. That absolute safely from flooding is a myth and that the adjustments with floods are necessary to reap the benefits of floods and flood plains and keep their adverse impacts to a minimum. Universal acceptance of IWRM process for the sustainable development and move towards its objectives has also contributed to a change in approach towards flood issues.

3.3 Flood management institutions

40. A number of case studies report that ***flood management responsibilities*** have long been scattered among several ministries, (e.g. water resources, irrigation, agriculture, energy, forestry, infrastructure and environment), sometimes with little or no cross-institutional coordination and often, perceived conflicting interests. In particular, countries with decentralised flood management

responsibilities have created different institutional arrangements for different phases of the flood management.

41. In a particular case ***one institution*** is in charge of managing all flood-related activities (before, during and after the disaster across the water cycle from flood, to drought. This is however the exception rather than the rule. One case reports on decreasing Government attention given to water resources management with a view to reduce governmental role in this sector, and transferring water resources development by creation of a semi-autonomous river basin agencies. Such structural adjustments can temporarily paralyse the functioning and increase flood risks and needs to be guarded against.

42. There is an increasing shift in decision-making process towards greater involvement of the community and realisation towards need for sustainable development by incorporating the ecological concerns for all development actions. These factors have contributed to various kinds of changes in flood management policies in different countries depending on the physical economic and social conditions and the level of flood protection already provided. In one case study, local stakeholders also assist in defining the integrated flood management policy and participate in decision-making, through involvement of village elders and of elected members of the rural communities. Another case study reports that public consultation is legally made compulsory for any flood management project. One case study reports on the concept of "river administrator", which functions like a decentralised *"dialogue tool" for decision-making* for water and river uses. It both maintains Government coordination and also brings the decision closer to the people. This administrator also serves as facilitator in discussions between stakeholders, or with State services. In another case, a "provincial crisis table" for emergency management is mentioned as an example; it involves a three-level institutional framework (executive, operations and users).

43. In ***Bangladesh,*** emphasis is now put on non-structural means such as flood forecasting, regulated development in flood plains and wetlands and in particular by adopting a policy of involving communities in flood management. A new concept of controlled flooding in consultations with the stakeholders is being introduced [1]. In ***China,*** after a review in the 1990s of flood management strategies, it was realised that flood management has to be closely integrated with the land use plans, taking full account of the population pressures in the flood-prone area [5]. Furthermore, that floods are a natural phenomenon, which cannot be eliminated nor be totally brought under control, has also been recognised in its Flood Control Law of 1997 and Water Law of 1998. In ***Japan,*** in recent years relevance of non-structural measures has become greater for urban flood protection, since skyrocketing land prices and the need of displacement of existing buildings and houses have made structural measures more difficult to implement [10]. This has resulted in a call for judicious combination of various approaches, ensuring participatory processes and preserving river and water ecosystems.

44. In ***Turkey*** an integrative programme of flood management was initiated in 1998 [15]. Besides new structural protection works and flood forecasting, other non-structural measures now comprise flood proofing, land use changes, building public awareness, change in urban planning concept to keep the settlements, as far as possible, away from the flood plains, obligatory natural disaster (including floods) insurance and greater public awareness of the flood issues through education of the young generation.

Box 3 - National Policies on flood management

***Bangladesh.* -** A *National Flood and Water Management Strategy* was formulated in 1996, including policy guidelines for peoples' participation, Environmental Impact Assessment and multi-criteria analysis for future water sector projects. The *National Water Policy* was introduced in 1999, and a *National Water Management Plan* prepared in 2001, crosscutting different sectors of national economy in the light of IWRM, and including also the management of water-induced disasters. A *Comprehensive Disaster Management Plan* and *Guidelines* were also prepared, in which the responsibilities of agencies involved in related activities are delineated during pre-disaster preparedness, rescue and evacuation during disaster and post-disaster relief and rehabilitation.

***China.* -** The water legislation states, amongst others, that water development plans should be formulated on the basis of integration of all the factors, and that water resources development programs should be integrated into the national and social development plan. Accordingly, the central government has laid down specific policies for implementation of these laws, comprising: (i) restoration of reclaimed slope, lake and flood prone areas with government subsidy; (ii) relocation of people from these reclaimed areas; and (iii) restraining economic development and population growth in flood prone areas, especially in frequently flooded areas.

***Ethiopia.* -** The *Water Resources Management Policy,* adopted only recently, shows commitment to the development of water resources infrastructure. In the context of the Policy, flood management is viewed as an integral part of IWRM. The Policy gives priority to grass root participation in integrated water resources development and management. It states specifically a multi-participatory approach and decentralized management. Another action is the country's participation in the *Regional Flood Preparedness and Early Warning System* of the *Eastern Nile Subsidiary Action Program,* which focuses on regional aspects of flood management and strengthening of national capacity of the three riparian countries (Ethiopia, Sudan and Egypt).

***India.* -** As of 1947 the general policy was that the flood plains were to be utilised gainfully by the people living in these areas during the low flood years; it was considered more beneficial to accept occasional flood losses against large benefits accruing out of the use of flood plains. The National Flood Commission laid down the flood management policy for the country in 1981. The 1987 *National Water Policy*, revised in 2002, lays down policies with regard to water resources development and management, to be achieved through an integrated and multi-disciplinary approach to the planning, formulation and implementation of projects, including catchment area treatment, environmental aspects, rehabilitation of affected people and community participation.

***Japan.* -** The *River Law* has been modified to reflect changing needs in flood management over the decades. A *Policy on Comprehensive Flood Control Measures* was introduced in 1979, to strengthen flood-retarding functions in the basins and incorporate these into flood management strategies. An effort for a combination of measures between water and land management was started, thus requiring linkage between water and land-use authorities. Finally, in areas where important damages have occurred due to floods, high tides, etc., a *Special Emergency Project as the Countermeasures against Terrible Disasters in Rivers* is proposed to be undertaken.

***Zimbabwe.* -** The national policy for disaster management requires every citizen to assist wherever possible to avert or limit the effects of disaster. Central government initiates hazard reduction measures through sector ministries, with local administration taking the responsibility for implementing and maintaining their effectiveness. Private and non-governmental organizations, whose regular activities contain elements of prevention and community development also participate. The organizations are adapted structurally, materially and technically so that they can shift rapidly from their regular activities to undertaking protective, relief and rehabilitation measures in times of disaster.

45. In the ***USA***, increasing attention to environmental factors in water resources development has brought greater focus to the need to include preservation and protection of the environment in flood management plans [17]. There is an emphasis on enforcing flood plain regulations by providing increased government support to relocation activities and increased attention in planning is given to

upland wetland restoration and improvement of farming practices. Federal funding support is now provided for farmers to voluntarily place land in conservation reserves to provide flood storage. In 2000, the Parrett Catchment Project (PCP) in the ***United Kingdom*** was set up with the aim to manage flood risk and water in a more sustainable way [16]. The PCP has incorporated the concept of integrated catchment management within its action strategy, grouped under: (i) changes to rural land use; (ii) reducing the runoff from built up areas and stopping construction in the floodable areas; and (iii) improving the system and rate of evacuation.

46. The issue of policy for cooperation in transboundary river basins has not been reported specifically in the case studies; however examples of successful cooperation that have contributed significantly to an improved transboundary flood management can be found in some instances where transboundary river basin commissions have been established.

47. The majority of case studies point to the fact that flood management measures have largely been implemented in a reactive rather than proactive mode, where interventions mainly focus on response to flooding and recovery from disaste,r against a more pro-active approach focusing on prevention. ***Box 4*** below shows some characteristics of reactive approaches that are being followed and pro-active flood management elements that are required for Integrated Flood Management.

Box 4 - Reactive and pro-active flood management	
Reactive	**Pro-active**
• Responding to flooding after it has occurred	• Anticipating and preventing flooding
• Reliance on relief and recovery through external aid	• Infrastructure and flood management agencies with a planning and preventative function are in place
• Flood relief, recovery from disaster and compensation may be emphasised	• Flood relief is not the dominant response, but recovery from disaster and compensation mechanisms are well-developed
• Flood events drive preventative actions to lessen future risks	• The programme of improvements to prevent flooding is driven largely independently of flood events although these might stimulate additional support and funding
• An under-developed capacity for planning to manage floods	• A developed capacity for planning to manage floods

3.4 Flood management instruments

48. The nature of the flood problem generates, in many cases, a requirement for immediate response and action in order to protect lives and properties, particularly after major floods. For these actions to be proactive and within a comprehensive basin approach following risk management principles, there is need for a number of flood management instruments to be in place. These are:

a. Flood and disaster management laws and regulations;
b. Mechanisms for information/data collection and exchange;
c. Financial allocation and use of resources; and
d. Disaster preparedness and response mechanisms.

49. Most of the countries referred to in the case studies reported – with different levels of detail – on laws and regulations. However, the information relating to data collection and exchange as well as on financial instruments for flood management purposes was only provided in a few case studies. The

corresponding information for each case study is summarized also in ***Annex II***, while some relevant case study examples highlighting flood management instruments are provided below.

Flood and disaster management laws and regulations

50. In practice, an institution has formal rules/legal instruments, which define both the functions and objectives the institution can pursue and the geographical space in which it can operate. In ***Canada***, the *Water Act (1970)* allowed for federal-provincial agreements to formulate comprehensive water management plans, develop water management projects, and also of non-structural water management alternatives [4]. Later the *Flood Damage Reduction Program (1975)* discouraged development in high-risk flood plains. In ***China***, the "*Law of Flood Control*" (1997) emphasises that flood control plans should be integrated within the basin plans and coordinated with the land-use plans [5]. It also emphasises that flood control and management should be practised on the basis of co-ordination and co-operation among all the parties concerned. In ***Fiji***, the *National Disaster Management Act* of 1998 gives authority and provides institutional arrangement for all actions related to disaster management and defines the functions and duties of government and other relevant agencies [7].

51. In ***Japan***, the *River Law* determines flood and water management policies. In the revised version of 1997 River Law, environmental aspects have also been incorporated, including the introduction of a river improvement planning system that reflects the opinion of the local residents [10]. In ***Mali***, in addition to the traditional customs and rules of 1818 governing the life and production activities of the Niger Delta inhabitants, there are state laws and rules concerning the protection, use, development and conservation of water resources [11].

Mechanisms for information/data collection and exchange

52. Collection, management and exchange of data and information are vitally important. Information should be made available to all interested parties as required. It is important that the right data, including hydrological data (river flows), social and ecological information is collected and made available in a timely manner, without which no reasonable decision can be made. Investments need therefore to be made in long-term data collection systems to establish trends for planning and design purposes and to capture evidence of processes such as climate change. As reported in ***paragraph 34*** above, flood forecasting and warning systems are in place in most of the countries of the case studies. However, information relating specifically to data collection and exchange is lacking.

53. In a number of the countries with trans-boundary rivers, there are mechanisms for data exchange in form of international river commissions established with neighbouring countries. Some of these mentioned in the case studies are: Eastern Nile Subsidiary Action Programme [6]; Niger Basin Authority [11], Organisation pour la mise en valeur du fleuve Sénégal [11]; Zambezi River Basin [19] and Commission for Indus Waters [13], [14].

Financial allocation and use of resources

54. For the *funding and financing* of flood protection and mitigation measures, one country's strategy draws for this purpose onto the management process of all of the major layers of Government and communities. There is a progressive contribution of all Government levels, which is likely to increase ownership of, and commitment to, flood management strategies. In addition, efforts are made to mobilise funding from multiple sources. In another case reported there is a progressive shift of budget

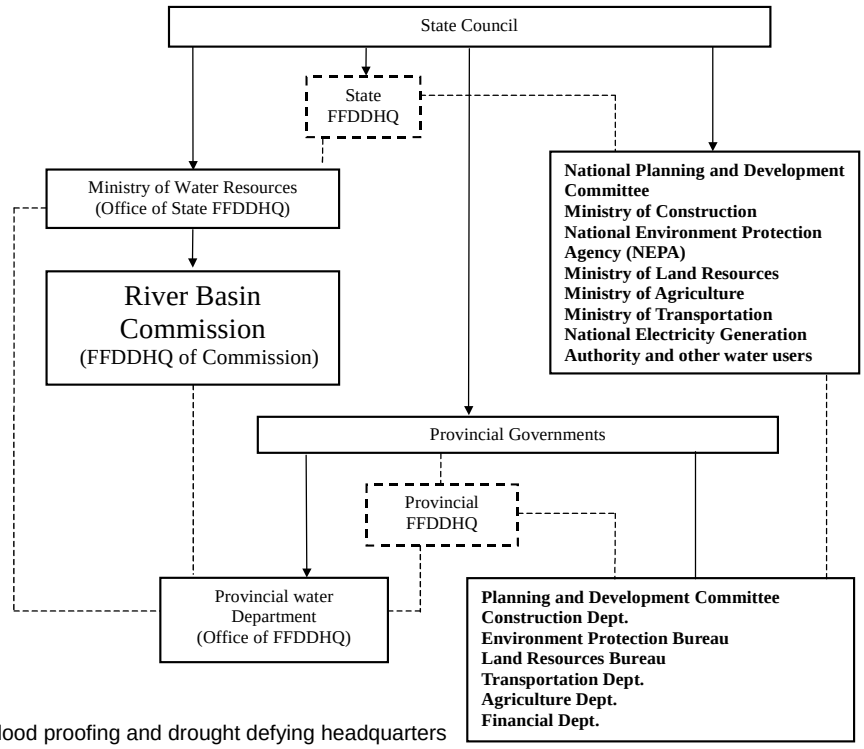
management (allocation, implementation) from Government-centred to more participatory, river-based approaches.

55. Only a few case studies reported on allocation and use of resources for flood management, investments for flood control projects and financing flood related activities. Three relevant examples may be cited in this context. During last 40 years, Government of ***Bangladesh*** has invested approximately USD 4 billion in the water sector, mainly for flood control, drainage and irrigation projects [1]. Annually about USD 200 million are disbursed for water and flood management. The Ministry responsible for Disaster Management in ***Fiji*** has an annual budgetary provision of USD 15,000 for 2004 to finance disaster related activities, including preparedness, prevention, mitigation, emergency response, rehabilitation, long term recovery and related activities [7]. Finally in ***Zimbabwe***, financial resources allocated annually for flood and disaster management in general are very low [19]. If the disaster is such that large resources are required, the international community and private sector are approached for assistance.

Disaster preparedness and response mechanisms

56. The flood management process in many countries involves a multiplicity of agencies and organisations at various levels: going from the federal to regional and local levels. In many cases one ministry or agency is entrusted with overall co-ordination in case of disasters. In ***Boxes 5 and 6*** some relevant case study examples of organizational flowcharts related to water and flood management are presented.

Box 5: China. – Organization flowchart of river basin management



FFDDHQ: Flood proofing and drought defying headquarters

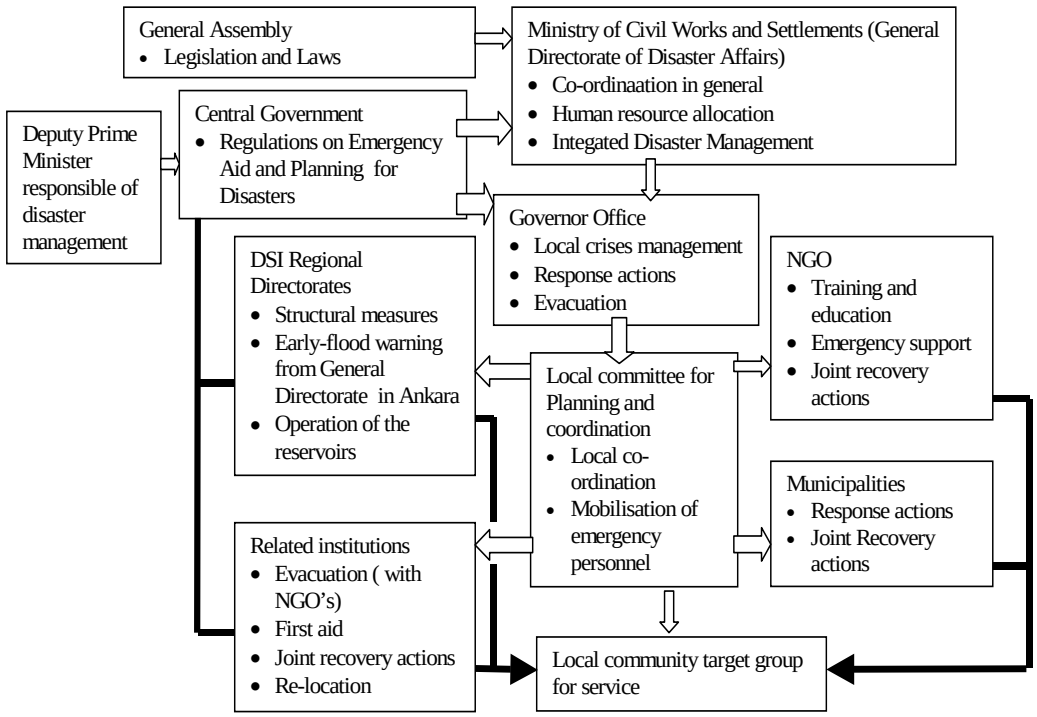
57. The *Revised SADC Protocol on Shared Water Course Systems* (2000) spells out how transboundary rivers such as the Zambezi within the SADC community shall be managed [19]. It also

stresses the importance of information dissemination during floods to neighbouring countries in order to reduce flood impacts.

58. There is also a *Flood Fighting Law*, the objectives of which are to seek the abatement of damage caused by flood disasters by measures such as flood forecasting, publication of areas likely to be flooded, and by ensuring smooth and quick evacuation in the assumed areas of inundation. Finally, the purpose of the *Disaster Measures Basic Law* is to establish the required cooperation through the national government, local governmental and other public organisations with respect to disaster prevention.

59. An interesting example is ***Bangladesh***, where about 53 central government organizations and 13 ministries are identified to be involved in water and different stages of flood management. A *National Water Council* is set up to coordinate all the various activities [1]. On the other hand in Cameroon, from the institutional point of view, currently there are no institutions or administrative services identified and charged with responsibility for the management of flood-related issues [3].

Box 6: Turkey. – Flowchart of disaster management system



60. Various ministries, federal agencies, departments or authorities are involved in water and flood management activities that cover[5] Water Resources Planning and Development; Hydraulic Works, Civil Works and Settlements; Agriculture; Environment and Forests; Mines and Energy; Construction and Rural Development; Equipment, Territorial Planning and Urbanism; Industry, Commerce and Transport; Territorial Administration and Local Communities, etc. With respect to the management of natural disaster emergencies, there are departments, agencies or general directorates established for this purpose, such as: Disaster Management and Relief; Disaster Affairs; Civil Defence, Army, Local Administrations and Municipalities; Provincial Relief; and Federal Emergency Management.

[5] The designations of the ministries/agencies given here as an example correspond to those actually in use in the different countries

61. In a number of countries river basin commissions have been established under the aegis of a national federal ministry or agency. There are also departments and bureaux for related water and flood management activities. Local government offices have also been established for the implementation of small-scale flood management projects, flood information dissemination, relief and rehabilitation of flood victims, etc. In addition, in most of the countries the army plays an important role in flood emergency measures.

62. Co-ordination between various stakeholders participating in water resources and flood management activities is achieved in different forms in different countries, either by means of the establishment of inter-ministerial committees or councils such as: National Water Council; National Disaster Management Council; Central Planning and Co-ordination Council; Inter-ministerial Co-ordinating Committee for the Water Sector and the Sewage; and Inter-ministerial Disaster Management Committee, etc. However, in some countries the overall co-ordination of the post-flood situation is entrusted to one national body; examples are: National Disaster Management Office; Federal Flood Commission; and Civil Protection Organisation, etc.

3.5 Lessons from current flood management practices

63. There are certain similar developments taking place in flood management practices in different parts of the world, as reported in the case studies, which are leading towards an Integrated Flood Management approach. These practices are characteristic of, and vary with socio-economical situation prevailing in the countries and their geographical setting. This is also reflected in the main lessons learnt reported in the case studies, where mention is made of strategies that proved successful, but also of some that failed. In this context, however, it should be noted that not all the lessons can be transferred from one setting to another without being appropriately adapted.

64. Information on the main lessons, as reported in the case studies, is summarised below, grouped under aspects such as flood management, flood forecasts and warning, land-use regulation, urban flooding, community co-operation and participation, and international co-operation.

65. ***Flood management*** interventions have in the past and in certain cases still continue to be stand-alone actions. Emphasis on structural measures in the past has generated a false sense of security among the flood plain residents and induced intensive flood plain developments, thereby increasing the potential of higher flood damages. Increasing annual flood damages despite large investments in flood management measures is a result of such an approach. Addressing flood damage reduction problems in a certain basin, while concurrently protecting and enhancing the flood plain environment, requires judicious use of structural and non-structural measures. Whether the challenge is protection of an individual, a community, or the basin as a whole, all damage reduction approaches should be considered and integrated into the solutions aiming at minimising the adverse effects on local communities and users and maximising overall benefits. [4], [8], [16]

66. ***Flood forecasts and warnings*** constitute an important non-structural flood management tool. Real-time data collection and flood-warning systems have been established to provide flood information and early warnings, which have proved extremely useful. However, uncertainties in meteorological forecasts and occasional “false alarms” have sometimes resulted in loss of impact and a de-sensitization of population failing to react to warnings. Certain sections of the society are not yet reachable for flood warnings due to lack of infrastructure and remoteness. It is necessary to ensure that all sectors of society can be reached by the existing warning systems, which in turn requires strengthening of communication and outreach [9], [11], [13], [14], [19].

67. Of the non-structural measures, ***land use regulation*** warrants particular attention. Encroachment on the flood plains and upstream development increases vulnerability of the flood plain occupants especially in the downstream reaches. These regulations are sometimes stand-alone and lack comprehensive legislation. It is evident that poor enforcement and inconsistent application of land use regulation by authorities greatly reduce the effectiveness of this strategy. In cases, there is lack of political will to enforce unpopular legislation that could conflict with commercial interests. Effective solutions based on land-use control, zoning, building ordinance, and modifications in building codes are absent in majority of cases. This also requires restructuring of both present legal systems and institutions responsible for management. Reforms in the institutional framework to implement such measures are largely absent. [4], [15].

68. ***Urban flooding*** is one of the major threats to cities, causing damages to property along streams flowing through the populated areas. In many cases illegal settlements along the banks of the streams suffer the most. In addition, the urban flood damage potential is increasing in many metropolitan areas, where population and assets are increasing year after year, thus making it impossible to cope with unexpected floods [2], [6], [10]. Proper zoning and protection of waterways from obstructive structures to allow flood passage can avoid damages of property due to floods. Most of the existing urban policies in developing countries are neither technically, socially nor economically sustainable [2]. Integrated Urban Drainage and Flood Plain Master Plans can form an important instrument in developing a sustainable policy to manage flood impacts in urban areas. These should be developed based on available urban space, hydrological conditions, hydraulic network and environmental conditions in order to reduce flood risks. There should be strong interactions between urban land-use master plans, urban drainage and flood control master plans, and other city plans related to water supply and sanitation and solid waste management. [2]

69. ***Community co-operation and participation,*** which is essential for the success of flood mitigation programmes, have so far been largely confined to post flood relief and rehabilitation measures. Nevertheless in certain countriesthere is a perceptible move towards involvement of the stakeholders during planning of certain projects. However, this involvement still lacks proper mechanisms and requires building of the capacity of the communities in understanding the intricacies of development processes. Floods can be managed in a more sustainable way through partnership and consensus if members of stakeholder communities support the changes and have a sense of ownership. Such schemes should also directly contribute to poverty alleviation in the developing countries. Local communities should be brought together to agree on long-term basin management plans and be pro-actively involved. Their participation needs to be supported with strengthened institutional arrangements, public awareness and education and resources. Trust, benefits and the integration of indigenous knowledge are key to building relationships with and among local communities. [1], [7], [12], [16]

70. Flood management in transboundary rivers has an ***international component***. A number of case study countries share rivers with neighbouring countries. While there are some formalised arrangements for planning and sharing of data and information, mostly they are informal. There is need to maintain effective communication links between existing relevant institutional infrastructure to support the international cooperation for the generation of transboundary flood warnings. Regular exchange of data and information between countries, specially during flood events, is of particular importance.

71. It is also interesting to note that in co-basin states different “flood cultures” can emerge. For example, with regard to the level of personal responsibility for flood damages quite considerable

differences can be observed within the Red River Basin, shared between Canada and the United States. While in Canada compensation for flood damages is perceived as the government's responsibility, the US has established a system, which is built on the responsibility of the individual to meet the cost through flood insurance [4], [17]. Finally, there are also a series of specific lessons, related to a region or case study in particular; some of the latter have been summarised in ***Annex III***.

4. NEED FOR AN IFM APPROACH

72. *Disaster risk management* [V] comprises the systematic process, administrative decisions, organisation, operational skills and abilities to implement policies, strategies, and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards, including flood hazards.

73. Essentially, "*risk*" is a construct of the magnitude of the hazard, exposure to the hazard and the vulnerability of the exposed activity/society. Magnitude of the hazard is a function of the probability of flooding and other physical and hydrological parameters. On the other hand, flood "*exposure*" is a measure of the human population, land uses and investment located in flood zones exposed to flooding. Increasing exposure is a prime, contributory cause of flood hazards turning into disasters. The concept of "*vulnerability*" includes "a set of conditions and processes resulting from physical, social, economic and environmental factors that increase the susceptibility of a community to the impact of hazards". In short, vulnerability considers the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard. Promoting access to knowledge and resources, through poverty reduction programmes and through general development as reflected, for example, in better health care, housing and infrastructure can enhance resilience.

74. The current flood management approaches and the lessons learned described in the previous chapters clearly show that there is ability in the countries to apply flood management measures that reduce the flood risk by avoiding increase in flood hazard, avoiding exposure and decreasing vulnerability or increasing resilience in the society against floods. The extent of these measures depends on the economic development in the country, level of investment in capital and human resources. Moving away from concepts such as "*flood control*" or "*taming the river*" form a welcome departure point for IFM.

75. In light of the assessment of the flood management measures applied in various countries that provided case studies, one can qualitatively outline the possible *consequences of not adopting an integrated approach to flood management*. Highlighted in ***Box 7*** is a set of potential consequences that might be perceived as a worst-case scenario of not applying IFM; however, each item may by itself already be an argument of making the case for an IFM approach. It is to be understood that these consequences will vary with the conditions prevailing in the respective countries, both as regards their geographical setting, as well as their socio-economical situation.

76. A number of the case study countries have already adopted IWRM as the basic philosophy in their water policy and its natural extension to IFM while in others, where these have not been adopted yet, the need for such management measures has or is being recognized. However, bearing in mind that the concepts of IWRM/IFM are relatively new, and that its implementation normally takes a number of years – or even decades – to become effective, it is felt convenient to again reiterate here the case for IFM, as established in the IFM Concept Paper.

77. The defining characteristic of IFM is integration, expressed simultaneously in different forms: by an appropriate mix of strategies, points of interventions, types of interventions (i.e. structural or non-structural); short and long-term and participatory and transparent approach to decision making, and in particular in terms of institutional integration and how decisions are made and implemented within the

given institutional structure. ***Figure 4*** below illustrates the schematic structure of IFM and its deliverables (items between the pillars). It should be noted in this context that deliverables are to be distinguished from IFM objectives.

Box 7 - Potential consequences of not adopting IFM

1. Decisions in one sector of water management (e.g. drought management) are likely to have adverse consequences for the management of another sector (e.g. flood management) reducing the overall benefits of water management to society. Another way of putting this is that 'negative externalities' of decisions are likely to be felt throughout the water management cycle.
2. Land management decisions are likely to negate flood management decisions rendering the latter ineffective. Consequently flood losses will be higher than necessary and negative impacts upon the economy will be larger than they need to be.
3. Upstream decisions are likely to have negative effects on downstream users, reducing the overall benefits of water management to the economy and to society.
4. The full range of options for flood management is unlikely to be considered with the consequence that an optimal mix of strategies is unlikely to be identified and adopted. The consequence is that opportunities to reduce the costs of flooding and to capture the benefits of flooding will be lost.
5. Flood management strategy is likely to become over-dependent upon a small range of options, skewing choice, perpetuating ineffective strategies in some cases, and generally not delivering the socio-economic benefits which are realizable. This may well have a drag effect on socio-economic development and lead to economies and societies remaining in an under-developed condition.
6. Key legitimate interests are likely to be excluded from flood and water management decision-making, leading to adverse impacts upon some sectors of society and economy.
7. Opportunities to gain ownership of flood and water management strategies may well be lost, with the consequence that opportunities for strategies to be reinforced by social action will be foregone. Systems designed to provide early warning and reaction to floods may well be one of the casualties leading to loss of opportunities to reduce costs to the economy and society.
8. The negative environmental impacts of flood and water management decisions are unlikely to be adequately recognised and catered for leading to unnecessary environmental damage and loss, which may well have adverse knock-on effects on economy and society either immediately or over time. Strategies are unlikely to be sustainable ones.
9. In all cases above the impact on GDP may be not as beneficial as possible, and there may be negative GDP effects in the worse cases.
10. In the long-term, a symptom of non-integrated flood management is likely to be delay in decision-making and implementation of projects caused by fragmented responsibilities, the requirement for multiple approval, etc.

78. One common problem for national economies in developing flood management policies is the *externalization of costs* from one sector to another, worsened by the lack of adequate methods to assess the wider impacts of flood management measures on the national economy. For example, a number of case studies reflected a lack of ecological considerations in flood management, leading to the externalization of costs from sectors directly linked to income generation such as navigation or hydro-power towards the environment.

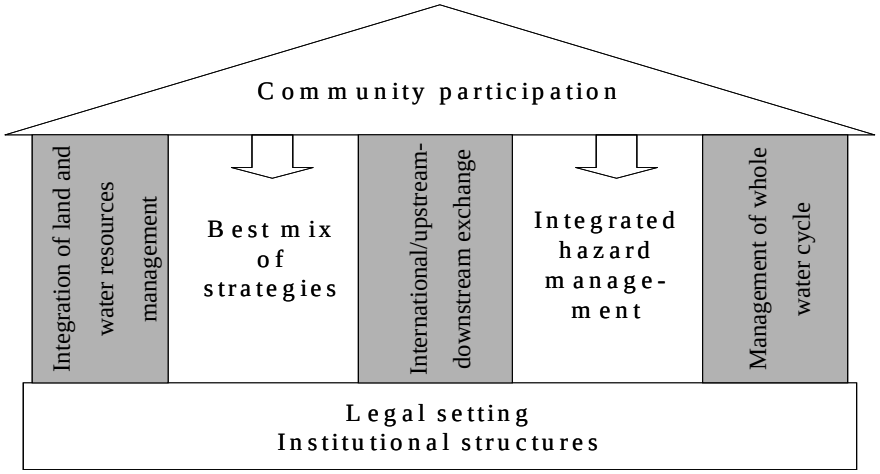


Figure 4: Schematic structure and deliverables of IFM

79. Therefore IFM promotes the integration of cross-functional teams in planning and implementation of flood policies and a participatory approach to flood management, including a representative range of stakeholders into the decision making process. Recognition is also given to the fact that in situations where competing interests over natural resources exist (which is in practice mostly the case), trade-offs have to be made and perfect solutions do not exist. Consequently, the application of IFM principles as mentioned in the following chapters may *reduce the risk of developing a suboptimal mix of strategies* towards flood management and may provide for the institutional mechanisms that facilitate in finding acceptable trade-offs.

5. CURRENT COVERAGE OF IFM ELEMENTS

5.1 Level of IFM development

80. IFM looks at flood issues from various ***aspects*** – which can be grouped under five categories herein termed as key elements. These aspects need to be integrated through IFM, meeting the objective of sustainable development. These are:

- Addressing Water Cycle (land phase) in totality
  - Flood and drought management
  - Effective use of flood waters
  - Ground water and surface water interaction in flood plains
- Integration of land and water management
  - River basin approach
  - Land use planning and water management
  - Water and Flood Laws
  - Multi-functional options
- Best mix of strategies
  - Harmonization of Structural and non-structural solutions
- Participatory approach
  - Stakeholders participation
  - Coordination between institutions
  - Building resilience in the community
  - Addressing Gender based requirements
  - Exchange of data and information
- Integrated Hazard Mitigation
  - Cross-sectoral integration of disaster management strategies
  - Disaster risk assessment
  - Early warning and forecasts

81. A summary of the extent to which these aspects are addressed in current flood management practices is provided in ***Table 2***. It may be noted that some aspects of IFM may overlap others. None of the case studies addresses all the aspects of IFM. Out of 16 aspects, maximum number reported to be covered in the case study vary from 12 to 14 (six of the 19 case study countries – Canada, China, Italy, Japan, United Kingdom and USA) [4], [5], [9], [10], [16], [17]. In general, for those studies that provide information on practices in a specific basin or region, the level of coverage is generally low. "*Land use planning and water management*" is recognised as a key aspect and is reported in all the 19 cases. "*Building resilience in the community*" being followed in flood management practises is reported in 16 cases. "*Coordination between institutions*", "*Water and Flood Laws*" and "*Early warnings and forecasts*" in 14 cases are also recognised as important. However, some of these aspects are reported to be covered only marginally. The "*Addressing Gender based requirements*" and "*Groundwater/surface water interaction in flood plains*" appear to be the least appreciated aspect. The fact that some of the IFM aspects were not covered in a given case study could also be a reflection that these might not be relevant in the given social-economic or geographic conditions.

Table 2 – Level of coverage of main IFM aspects

Case study	ELEMENTS AND MAIN ASPECTS OF IFM																*Category of IFM Development*
	ADDRESSING WATER CYCLE IN TOTALITY			INTEGRATION OF LAND AND WATER MANAGEMENT				BEST MIX OF STRA-TEGIES	PARTICIPATORY APPROACH					INTEGRATED HAZARD MITIGATION			
	Flood and drought management	Effective use of floodwaters	Groundwater/ Surface water interaction in flood plains	River basin approach	Land use planning and water management	Water and Flood Laws	Multi-functional options	Harmonization of structural and non-structural solutions	Stakeholder participation	Coordination between institutions	Building resilience in the community	Addressing gender-based requirements	Exchange of data and information	Cross-sectoral integration of disaster management strategies	Disaster risk assessment	Early warnings and forecasts	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
[1] Bangladesh (preliminary)	✓(MG)	✓		✓	✓	✓		✓	✓	✓	✓		✓			✓	*II*
[2] Brazil (Urban Flooding)				✓	✓	✓		✓							✓	✓	*II*
[3] Cameroon (Fleuve Logone) (preliminar)		✓			✓		✓										*IA*
[4] Canada (Red River Basin) (preliminar)		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	*III*
[5] China	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	*III*
[6] Ethiopia				✓	✓						✓				✓		*IB*
[7] Fiji Islands (Rewa River)						✓				✓	✓		✓			✓	*IB*
[8] India (Damodar river basin)	✓(MG)	✓		✓		✓	✓			✓	✓					✓	*II*

MG = marginal

* As defined/established in ***Table 3*** and ***Figure 5*** below

Case study	ELEMENTS AND MAIN ASPECTS OF IFM																
	ADDRESSING WATER CYCLE IN TOTALITY			INTEGRATION OF LAND AND WATER MANAGEMENT				BEST MIX OF STRA-TEGIES	PARTICIPATORY APPROACH				INTEGRATED HAZARD MITIGATION			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
[9] Italy (Piemonte region)				✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	*III*
[10] Japan (Tokay)	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	*III*
[11] Mali (Inner Niger Delta) (preliminar)	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓				✓	*IB*
[12] Mauritania (Senegal river) (preliminar)		✓			✓		✓	✓	✓		✓	✓					*IB*
[13] Pakistan (Chenab river)		✓(MG)	✓		✓	✓			✓	✓	✓		✓			✓	*IA*
[14] Pakistan (Lai Nullah Basin)					✓	✓		✓		✓	✓		✓			✓	*IB*
[15] Turkey (North Western Black Sea Region)					✓	✓		✓		✓	✓		✓			✓	*II*
[16] United Kingdom (Parrett Catchment Project)		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		*IV*
[17] U.S.A. (Mississippi)				✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	*III*
[18] U.S.A. (NAI)				✓	✓	✓		✓	✓						✓		*IV*
[19] Zimbabwe (Zambezi basin)					✓					✓	✓		✓			✓	*IB*
Total number of case studies covering main IFM aspects	***5***	***10***	***1***	***12***	***19***	***14***	***7***	***13***	***9***	***14***	***16***	***2***	***12***	***6***	***9***	***14***	

82. Analysis of case studies indicates that the flood management approaches being followed around the world are far from integrated. But the need for a shift is surely but slowly being recognised. The concept of IFM can be said to be in the early, or perhaps, post-early stages of development. There are examples of coverage of IFM elements wherein principles are being translated into policy and practice. There is evidence of these policies and practices beginning to make positive impacts. At the same time, there are case studies, which indicate that a relatively mature IFM approach has been put in place. In these cases coverage of IFM elements is good, but perhaps with a number of shortcomings emerging requiring serious attention for IFM to make a full impact. Finally, there are a couple of case studies, which demonstrate that IFM is at a relatively advanced stage of development. However, this evolution has been rather recent and may not yet have had time for its effects to become fully apparent.

83. The level of adoption of IFM principles can roughly be categorise into four stages:

- Ad-hoc approaches to flood management;
- IFM concept is appreciated but means and mechanisms are not in place;
- IFM concept is accepted and appropriate mechanisms are in place; and
- IFM is being practised.

These IFM development stages are displayed in ***Table 3.*** The left hand side characterizes four general IFM development levels. The degree of development of IFM practices is normally linked to a growing number and diversity of flood policy and strategy elements being applied in a country, as is depicted in the right side. It should be noted, however, that the grouping of policy/strategy elements shown in the right hand are rather indicative. In accordance with the above categorization, the current level of IFM development is shown for each case study in the last column of ***Table 2*** and is essentially subjective. According to this scaling, there are only two case studies, which would seem to near category IV of development, namely the United Kingdom [16] and the USA-NAI cases [18]. The USA-NAI case study however, is different from the others as it more conceptually describes an approach to flood management, which at this stage is still in advocacy stage.

Table 3 - IFM Development Stages

Category	IFM Development Level	Main Flood Policy/ Strategy Elements
I	Ad hoc approaches to Flood Management	Structural measures (local); flood forecasting
II	IFM concepts are appreciated. Mechanisms are required.	Structural & non-structural measures (including flood forecasting, land use regulation); peoples participation in relief and evacuation
III	IFM concepts are well accepted. Mechanisms are in place.	Structural & non-structural measures (including flood forecasting, flood plain regulation, land use legislation); community participation; basin wide approach
IV	IFM is being practiced.	Structural & non-structural measures (including flood forecasting, flood plain regulation, land use legislation); community participation in policy formulation, planning and implementation; basin wide approach; ecosystem & environmental considerations

84. The level of IFM concept being practised appears to have, expectedly, a direct correlation with the socio-economic development in the country, expressed in terms of the GDP per capita (***Figure 5***). This should however not lead to the assumption that IFM development can only progress in the course of, or after a certain overall economic development has been reached in a country. As can be observed from the graph, there are significant differences in IFM development stages between countries with similar GDP per capita. Moreover, in many developed countries there is a dependency on a limited number of flood management options, as they are historically committed to a structural legacy.

Developing countries, on the other hand, are constrained by the limited resources and governance issues and may not be able to take measures at all levels simultaneously, and might be driven by compulsions to fix the problem 'now'. However, the integrated approach to flood management can help in dealing with competing demands by planning the measures at the basin level and prioritising the interventions through community consultations and participation.

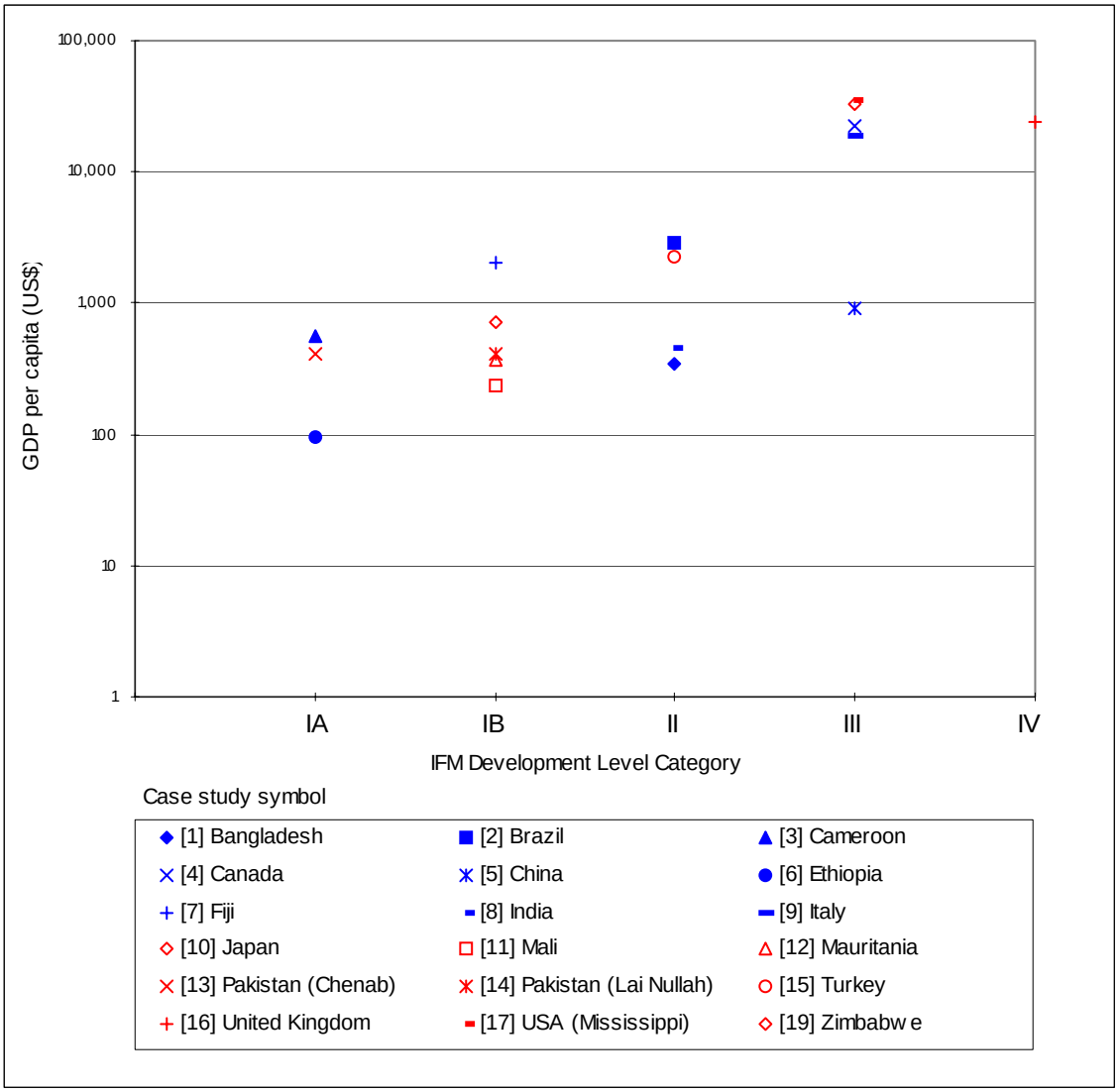


Figure 5 - IFM Development Level Category

5.2 Gaps in existing flood management approaches vis à vis IFM

85. There are a number of impediments in adopting a holistic IFM framework as emerged from various case studies that can be summarised as under:

a. Lack of policies and long-term strategies;
b. Absence of appropriate legal framework;
c. Inadequate institutional arrangements;
d. Ineffective flood forecasting and warning;
e. Limited community participation;
f. Absence of mechanisms for information/data collection and exchange; and
g. Inadequate environment concerns.

86. ***Lack of Policies, and long-term strategies****:* Flood management has largely developed in a fragmented way, with only a short-term perspective in view. Many countries lack a clear policy on how to deal with flood hazards. Some of the flood management policies are formed in isolation and fail to address the inter-relationship between economic development and flood risks. More often than not they concentrate on the disaster relief operations rather than imbibing culture of prevention. Although some countries have adopted IWRM as the basic philosophy in their water policy and legislation, its natural extension to flood management is conspicuously missing.

87. Flood management measures, their design and implementation and monitoring of their impacts and effectiveness lack systematic policy, and wherever they exist, are ambiguous or are not transparent. In number of cases they are not being implemented effectively to generate the expected positive benefits. This is particularly very critical in the case of maintenance of structural flood protection measures, which do not get adequate attention.

88. Structural interventions of one sort or another have largely been successful if judged from a given criterion. Some others appear to have not performed as well as expected and in turn have caused unforeseen or unavoidable adverse consequences. An underlying reason for the poor performance of some of these interventions is the lack of basin planning incorporating flood management measures. Detrimental impacts have been caused, particularly when handled by a complex web of agencies. There is comparatively little systematic evidence of evaluation of the degree to which implementation has been successful, partially successful or perhaps wholly unsuccessful. In particular there is little coverage of post-project appraisal and reflection upon the success of measures employed. Post-project appraisal, a powerful tool that can lead to change and improvement, is generally under-used.

89. In the past the flood management strategy has in general emphasised structural flood protection measures. In certain cases federal laws make it easier to justify structural rather than non-structural interventions, and local governments therefore gravitate towards structural solutions. Consequently, there is a powerful legacy of dependence on flood management structures. Shift towards a broader mix of strategies, notably including non-structural ones, is now well recognized for quite some time. Project appraisal methods for selecting best mix of available options, sometimes conflicting, do not appear to have been used.

90. In developed countries there has been extreme reliance on structural measures in the past. In numerous instances implementation of structural measures have led to a false sense of security with resultant “project-induced development” in flood plains. Substantial capital and effort on flood management measures has been invested in these countries and despite this there is a steady increase in annual flood damage in real terms. These countries seem to be locked into a cycle of structural protection, intense urban use of flood plains, and higher potential for catastrophic flood losses especially when levees are breached. Although some of these countries have adopted risk management strategies today, it is very difficult for them to escape from large dependence on structural protection measures. It seems almost inevitable that economic flood losses would continue to rise, more or less in line with rising living standards, which reflects the development dilemma, especially in countries where there are limited alternatives in terms of areas for urban and agricultural development.

91. There is also a history, of federal compensation to flood victims in the aftermath of flood disasters in almost all countries. While human solidarity principles justify such measures, the culture of flood compensation often acts as deterrent to adoption of a broader range of flood management measures. Continued compensation of flood victims weakens the desirable message that individuals have the

prime responsibility to avoid risks and should do more to help themselves, depending on their individual capacities.

92. Public understanding of the flood issues, in cases, appear to be somewhat complex and is often driven by narrow short-term individual gains rather than the understanding of long-term impacts at a basin level. For instance, there are a number of cases reported where property owners have cut through dikes on their property exposing whole communities to flood risk. In some delta areas there are also problems with dikes being cut by local fishermen and cultivators, potentially creating increased flood risk to others.

93. ***Absence of Appropriate legal framework***: Comprehensive legislation to support flood management are missing. The concepts of IWRM itself being relatively new, promulgation of enabling legislation and its implementation is taking its own time. A number of countries still have old legislations that do not incorporate the IWRM principles. Very few countries have appropriate legislation and regulations governing occupation and use of the flood plains and enforcement thereof. In addition, the substantial population growth in a number of countries in the past 20 years is placing even greater pressure upon flood plain land and other resources. Exposure to flooding has therefore grown and vulnerability remains a major problem exacerbating flood impacts. Land use regulations are attempted in isolation for specific purpose, which are partially effective. Strong political will to enforce unpopular legislation for effective flood plan management appears to be absent.

94. ***Inadequate Institutional Arrangements:*** Institutional management is frequently scattered and lacks coherence, transparency and well-defined responsibilities. This allows various players to act in an un-coordinated manner and forms a basis for potential tensions or conflicts. The decision-making processes in these institutions suffer from sectoral outlooks and are generally not shared for obvious reasons. Such lack of transparency increases distrust towards both authorities and structures' owners and managers. Variety of agencies involved at various levels and inter-disciplinary solutions required to deal with flood issues call for skills, which are often not present in a number of national agencies responsible for flood management, both at local level as well as central government ministries and departments.

95. The administrative systems in some countries appear to have strong vertical authority lines, but weak horizontal connections, thus making it difficult for agencies to design and implement cross-sectoral strategies, although such mechanisms may appear to exist on paper (legislation). Furthermore, local bureaux for water resource management or for environmental issues often are financed by local administration such as provincial authorities or municipalities, which jeopardises their independence and law enforcement capacity. Local authorities face a dichotomy of sorts in balancing the requirements of basin-wide hydrological solidarity and immediate protection of their local constituency. This is generally reflected in upstream-downstream tension, for example during operation of structures during extreme flood situations.

96. ***Ineffective Flood forecasting and warning***: Flood forecasting and warning has been well recognised as an essential complementary tool in flood management. However, it is not appropriately integrated into the overall framework of flood hazard impact mitigation. Its role in terms of its value and efficiency are not fully understood and accounted for. Flood forecasting and warring institutions generally sit outside the flood management organisations. They are considered as service providers in disaster response, relief and rescue operations and are hardly associated with the flood management strategy planning process. There is lack of comprehensive end-to-end flood forecasting and warning systems.

97. ***Limited Community Participation***: Public participation in long-term planning of flood management measures is seriously lacking. There is hardly any mechanism for community participation in basin level planning. Although at local level, in post flood situations, the neighbourhood communities are the first to organise relief and rescue operations, these are largely un-organised.

98. ***Absence of Mechanism for Information and data collection and exchange:*** There is serious lack of exchange of information among various institutions involved. Some of the recent trends towards commercialisation of meteorological and hydrological data appear to have broadened the information gap among various agencies. Collection of hydrological, social and ecological data, without which no reasonable project planning nor decision can be made, is expensive and time consuming, and is loosing priority among the national planners. There is grave concern at the investments in long-term data collection and adequate operation and maintenance of the existing observation networks. Management of transboundary river basins require exchange and sharing of hydrological and meteorological data and information on reservoir operation. There have been successful cases of transboundary cooperation in exchange of flood information. But these are generally incident oriented and are largely informal. Flood management, and specifically flood forecasting and warning in such basins requires institutionalised transboundary cooperation.

99. ***Inadequate Environmental concerns***: Only a few case studies reflect environmental concerns factored in flood management strategies. There is a clear recognition of flooding as a process that can provide benefits to people and the environment. However, more often than not environmental impacts of flood protection measures on the condition of river and flood plain habitats and their natural resources are not fully factored. Inter-relation of flood management measures vis-à-vis ecosystems is not well understood. Negative impact of hydro-agricultural infrastructure in some studies is presented as obvious.

6. PUTTING IFM INTO PRACTICE

100. Integrated Flood Management requires certain basic inputs and the conducive environment for its effective implementation. These requirements are a function of the specific hydrometeorological and physical conditions of the basin, coupled with cultural and socio-economic interactions and existing development plans for the location. The IFM Concept Paper has identified the following main requirements:

1. clear and objective policies supported with legislation and regulations;
2. institutional structure with appropriate linkages;
3. participatory processes;
4. information management and exchange; and
5. appropriate economic instruments.

6.1 Clear objectives and policies supported by legislation and regulations

101. It is important to clearly spell out the ideology, policy, objectives and consequent strategy with respect to flood management in consonance with the development goals of the country. There is a need to build up resilience in society against floods through an encompassing process of economic and social development, whereby persons and groups exposed to flood risks become less vulnerable by means of improved access to employment, education, health care and ultimately to income. A sustainability framework which integrates risk management within development planning in the country could be crucial. A comprehensive flood *management strategy* is an essential step towards IFM approach.

102. Integrated flood management calls for a river basin approach. However, design of a basin-wide ***flood management policy*** does pose technical as well as political challenges. Besides, political leaders need to be prepared to take such "holistic" decisions in the light of the IFM concept, which calls for planning at basin level and implementing at local level.

103. It would be necessary to define how IFM as a policy concept should be designed and implemented. IFM should preferably be established under the "umbrella" of Integrated Water Resources Management (IWRM), duly making use of the legal and institutional framework provided in the process of IWRM. In many cases this would mean that flood management is considered as national priority by Government authorities. However, absence of an IWRM strategy does not preclude that an IFM approach could not be adopted. IFM should be assimilated as an inclusive set of concepts and principles to be incorporated in all development policies such as water and land management policy, urban planning policy, public communication and education policy, etc

104. In this context, strategy of “bearing the losses” or “living with floods” could be a well studied flood *risk management strategy*. This is particularly relevant in densely populated flood plains with few or no alternatives with lesser degree of risks of other kinds to the society and its development. In such cases, however, adaptation strategies for reducing the sufferings of the weaker sections of the society have to be developed and supported by Governments as a compensation for a politically accepted level of risk. Establishing an "accepted flooding level" requires consensus-based decision-making with stakeholders, including issues involving compensation and resettlement and require appropriate decision support systems.

105. Many governments are attempting to control *intensification of land use* on the flood plains and wetlands through appropriate flood plain zoning, land use planning regulations and building codes. The

land use regulation strategy, as being attempted in some countries identifies high, medium and low flood risk zones and seeks to adjust development activities according to these parameters. While planning such regulations authorities have to consider developing land use control, which is sustainable, providing adequate compensation and making it economically attractive for land owners who otherwise might be reluctant to accept regulations. In certain cases state acquisition of flood prone land to prevent development could prove helpful in implementation of flood management strategies. However, such a policy to be successful calls for strong political will and adequate funds to adopt and enforce.

106. In certain circumstances intensification of flood plain land use can contribute to an increased economic efficiency of the flood plain and building resilience in the flood effected communities, thereby averting overall adverse consequences on the society. The basic challenge faced by policy makers, therefore in such cases is a trade-offs between increased economic efficiency and an increased flood risk for the flood plain residents. Therefore, design and enforcement of such legislation should address equity in development.

107. One of the impediments of such an approach, which undermines its successful implementation, is the *presence of a large informal sector* within the society and economy of developing countries. These informal sectors work largely outside the regulatory regimes. In many cases enforcement of legislation is directly related to the general governance issues and how the vested interests influence the process. Sometimes, enforcement could be achieved through public opinion pressure which could help trigger additional governmental efforts. For this purpose it is essential to make the flood reserved area an attractive and useful one to the public, so that public pressure will bear down on any illegal invasions of the reserved area. Social and economic structural change and equitable development for poverty alleviation is the only long-term solution to this problem.

108. Within the broad context of *integrated water resources development and management,* the issue of water allocation for flood management (space or flood cushion within reservoirs) should be squarely addressed. Water development plans should emphasize multi-purpose use of infrastructures and allocate water use for livelihood, development and environment including flood management. For the purpose operation rules of hydraulic infrastructure (reservoirs) should be clearly defined through a participatory process, thereby avoiding any kind of public misunderstanding, distrust or discontent. Management plans should be circulated among local partner institutions allowing increased public trust.

109. Many flood management schemes focus on flooding as an in–river or riparian issue and ignore water retention functions of wetlands. Decisions are made on economic grounds and cost benefit analysis is generally used to justify flood management schemes. However, social and ecological services and benefits are often very difficult to cost economically. Consequently, a wider approach, such as multi-criteria analysis that includes scores and appropriate weightings for a wide range of economic, social and environmental issues and provides the basis for more holistic, integrated and sustainable solutions need to be adopted. Under specific conditions, the flexible design, or in justified cases decommissioning of embankments to restore the natural flood storage function of floodplain wetlands, should be taken on board as an option. Flood management should be integrated with environmental conservation (e.g. releases from the dams to maintain downstream ecosystems to maintain downstream channel structure, sediment movement and river ecosystems).

110. The canalisation of rivers in urban areas often increases flow velocities and makes the river uninhabitable for fish and macro-invertebrates because refuges, such as back waters and flood plains, are eliminated by channel straightening and building of flood banks. Creation of flood storage areas may have environmental enhancement potential.

111. Land and water resources planning should address the issue of reducing flood risks. However, any planning or management process is only as good as its outcomes. It is therefore important to check back on whether projects which have been carefully planned and implemented have or have not achieved the outcomes that they were designed to achieve. Project planning requires a great deal of attention and total quality management in order to capture the benefits that apparently sound combinations of flood mitigation options can promise. A hallmark of sound management is that it includes technical evaluation at post-project appraisal stage. IFM should therefore be based upon this "learning through experience" process, which is capable of identifying past inadequacies and correcting them and providing opportunities for institutional learning. In this context, *post flood reviews* of the previous flood season and *disaster impact assessment with feedback approach* to identify future actions/improvements needed are useful measures. Finally, the need for post facto environmental impact assessments should also be highlighted. Studies should be undertaken to assess the impacts of the existing or proposed flood management measures on rivers and flood plain habitats and their natural resources. Such appraisals are generally under-used but are a powerful tool often leading to change and improvement where used

112. In countries affected by both floods and earthquakes an opportunity exists to *transfer lessons* from one hazard to another: in this case from earthquake management to flood risk management. Adequate building codes for sensitive land use planning are important requirements within earthquake planning. Similar principles could be extended to flood management through an integrated set of standards.

113. Public perception that flood management is fully a *government obligation* leads to shifting all responsibilities on authorities. However, individuals and communities cannot be absolved of their responsibility. Developing this sense of responsibility is strongly linked to maintaining awareness at a reasonable level and is vital in terms of building resilience and self-protection capacity to floods. Second, to obviate post-disaster conflicts between public and authorities, community has to agree to share the responsibility. However, responsibility sharing should not be conceived by the public as a way for the government to avoid its responsibility. This calls for building a consensus in terms of the role of the state in risk management, the risk level a society is ready to accept, and how investment is directed.

114. ***Legislation*** is a way of clarifying federal/provincial allocation of responsibilities and duties, particularly when flood management responsibilities are scattered among several ministries. Water legislation should have IWRM as the underlying principle and should deal with the *total water cycle* including groundwater. Such legislation may include issues such as environmental and social considerations, public participation and those crossing administrative boundaries and jurisdictions. Although the rationale for these will be wider than flood management, and sometimes wider than even IWRM, it is important that such legislation and regulatory regime, adequately addresses the sustainable development needs including risks due to flooding.

115. Major legislative change normally requires corresponding institutional change. Thus, legislative reforms can lead to the institutional rationalization and reform in order to improve the effectiveness of different institutions. For example, there may be no authority responsible for application of IFM for the river basin as a whole. Legal reforms, therefore, may be necessary to introduce such functions and if needed, the establishment of the required organization (e.g. river basin agency) for its implementation. It should however be noted that legal regimes are extremely site specific and transferability potential between developed and developing countries seems to be marginal, especially in view of its enforceability. Therefore, legislation should be developed to cater for the specific characteristics of a

case instead of using existing legal regimes from developed countries as a blueprint. Developing countries may well suffer from 'under-legislation' i.e. there may be no or insufficient legislation for the purposes of IFM development.

116. As part of institution building, a proposed legislation needs early thorough examination and evaluation to determine the extent to which it provides support for establishing the powers and responsibilities of concerned institutions and organisations. Legal instruments for the development and delivery of IFM will need to specify organisational arrangements and relationships, line of reporting responsibilities, financing and funding mechanisms, duties and powers. Responsibilities and accountability of agencies and individuals needs attention. A common example is with regard to the legal responsibility to issue and disseminate flood warnings to the public. New legislation may be required in order to establish an appropriate system of flood forecasting, warning, dissemination and rescue and relief operations.

117. In certain countries not only the organizations but also the individuals have *legal responsibilities* for flood alleviation (e.g. a stipulation in the Flood Control Law in that every individual has the obligation to protect the flood infrastructure). This approach encourages public and community awareness of the flood risk, and community action and awareness of ways of responding appropriately to flood warnings. Therefore, strengthening individual legal obligations and liabilities is a strategy that might be worth considering, particularly where the actions of individuals exacerbate community risk.

118. Flood management in ***trans-boundary river basins*** requires cooperation between trans boundary institutions within the basin. Sharing of hydro-meteorological data, including catchment runoff characteristics, provides an understanding of the hydrological processes necessary for adopting any flood management strategy. Sometimes, a lack of transparency in the data sharing with neighbouring countries results in overprotection of the data, thereby rendering it unavailable to sister organisations within the countries.

119. Second area of cooperation, therefore, concerns assistance for relief against, and rehabilitation from water-related disasters as a way to build trust between riparian countries. Contiguous nature of river basins could mean spilling over of disaster related problems across the boundaries in form of migration of flood victims. Cooperation in relief and rescue operations could be mutually beneficial in the long run. Post-disaster debriefing sessions, such as joint fact-finding missions, strengthening the networking of technical staff in administrations of riparian countries are some of the useful tools.

120. Together with the principles of the *UN Convention on the Law of the Non-navigational Uses of International Watercourses* [VI], IFM can be helpful in designing legal and institutional options, at both national and regional levels, that are best relevant to support these transboundary partnerships. Yet such cooperation on flood-related activities should integrate, or be integrated with other transboundary issues. In that sense, a transboundary IFM approach can help link technical cooperation with political stability.

121. Finally, one of the pre-requisites for successful introduction and adoption of IFM in a country would be *high-level political leadership, legitimisation* and *promotion of IFM* (within the context of IWRM). This would be accomplished amongst others if an appropriate high-level political authority publicly and strongly endorses and promotes the concept and principles of IFM.

6.2 Institutional structure through appropriate linkage

122. Alignment of institutions along an accepted flood management policy is very important and requires special efforts and skills to achieve its objectives. Indeed, quite too often flood management projects fail, or end up in conflict situations, as stakeholders may not agree on a joint definition of the problem at hand. In these cases the importance of an IFM approach, while not easy to implement, is further accentuated. Therefore, in such cases, *mechanisms for effective co-ordination* between the involved institutions are of vital importance and a key aspect for an effective IFM implementation.

123. ***Inter-institutional cooperation*** would require a clear allocation of authority and responsibilities to help addressing cross-sectoral issues; it could provide an encouraging basis for dialogue on such issues. In this context one option would be to put a single authority in charge of coordinating all specialised agencies by establishing tradeoff principles, providing strategy and policy directions, gathering feedback information, informing stakeholders and overall leadership. Another option is the possible setup of a permanent secretariat or similar structure to help integrate cross-sectoral technical features in the decision process, and to facilitate dialogue between (and often within) institutions. It is important however that such a coordination mechanism is armed with sufficient financial, technical and human resources, as well as with an appropriate bargaining clout to fulfil its task.

124. In terms of cross-sectoral management and dialogue among stakeholders, *institutional coordination* is also needed especially in cases where private sector entities in a country are in charge of water-related activities, such as hydropower. It is often the case that authorities and private sector water managers may have conflicting goals, especially in terms of operation rules for reservoirs. Where it is felt appropriate, a law establishing priorities (in terms of cost/benefit or values) may assist in clarifying the process through which authorities should take the required decision. Many countries are moving towards *river basin organisations* (catchment management authorities), wherein there is also a large measure of public and stakeholder participation on water issues. Such organisations can be used effectively for flood management purposes thus avoiding creation of new bodies; their field of action could also be extended to transboundary river basins.

125. A critical element of appropriate institution-building is the *cultural and disciplinary composition of key agencies* which are either set up to manage floods, or to provide flood protection or flood control, or which impinge upon flood plain management in one way or the other. For IFM to take roots, it is necessary to ensure that agency specific culture, option 'leanings', choices and decision-making processes are not controlled by a single disciplinary profession or lobby. An optimal mix of strategies and solutions seems to arise where a multi-disciplinary team of experts (engineers, sociologists, ecologists, economists) works together with local stakeholders. Co-operation between institutions may be enhanced by the use of *modern and effective communication systems* such as Internet where available or other means. It should be recognised, however, that such systems are vulnerable during major flooding events and therefore redundancy of systems is needed. The value of "informal" relations between flood management agencies should also not be underestimated as they do contribute to enhanced coordination.

126. However, it should also be noted that institutional change gives rise to much uncertainty within organisations, as it affects people and their careers and requires careful change management. Costs of changing and implementing legislative reforms are considerable and need adequate resources. Well-trained and skilled staff from various disciplines is often necessary for sound flood management. Progress with IFM adoption should go hand-in-hand with a significant broadening of disciplinary

composition and agency culture to bring in inter-disciplinarity in decision making process. Appropriate training programmes are required to carry through such cultural transformations within existing organisations and/or following re-organisation and re-structuring. Reforms will probably also be needed to redefine jurisdictions and responsibilities of various agencies.

6.3 Participatory processes

127. Through participation the local communities may influence the decisions that are made providing them much required sense of ownership to these decisions. A ***participatory process*** comprises the following general steps or components: (i) identification of stakeholders including assessment of delegates' representativeness and constituency; (ii) appropriate information sharing (background information disclosure [transparency] and feedback on decision status [accountability]; (iii) facilitation of dialogues between all stakeholders; and (iv) management of human behaviour: skills of facilitators and training of civil servants; These general steps might serve as a template that can be adapted to local conditions.

128. One case suggests some methodological features for designing such a participatory process: (i) initial motivation of stakeholders; (ii) equality of dialogue partners; (iii) iterative dialogue process; (iv) invitation of experts; (v) sharing of information; and (vi) mediation of dialogue by neutral facilitators. The significance of local knowledge should be stressed in this context. Besides, a long-term vision developed together with short- and mid-term objectives would be an asset, as it eases ownership by providing "tangible" results.

129. Stakeholders' participatory process requires awareness building. Flood hazard maps and flood warning dissemination activities help improve understanding of social vulnerability patterns and an increase in social acceptability and ownership of flood-related strategies. To assist the involvement at planning as well as implementation stages, Government support to local stakeholders is very appropriate in terms of training, logistics, planning and of course providing information. This has to be complemented with the involvement of local media, with NGO follow-up for information of the community. Local-level participatory process may take place at various stages of flood management (design studies, preparedness, relief). Other options are the undertaking of polls to assist in decision-making, as well as application of the principle of "negotiated flooding level" (controlled flooding). All these solutions allow pro-active conflict mitigation and offer ways to reduce public discontent and social unrest. Most important need is to build trust between the population and the authorities. This provides a backup to local-level involvement, and is likely to increase public trust in Government strategies for flood management.

130. *Public understanding* of the flood problem and the overall strategy elements should be encouraged. There would appear to be a need to devise a strategy for public involvement and education which can progressively address this and related issues. In this context, it would be convenient that agencies undertake a user-oriented enquiry to assess requirements and "customer" needs. Such an initiative could help increase awareness of the public about who pays for flood damage reduction and how it is in their interests to be active in flood damage reduction. However, it should be noted that education can be relatively short-lived; if no practical proof of the theoretical information is provided, the knowledge and awareness of the risk will be lost within a few years.

131. Finally, in flood management the *principles of sustainable development* should be followed, in the sense that the self-adaptive and self-protective behaviours of communities and individuals (which have evolved over generations) need to be preserved, reinforced and sustained where-ever possible and where the magnitude of a disaster does not exceed the coping capacity of a community. Flood risk

management practices should be evaluated in appreciation of local knowledge. Otherwise local capacities decline and communities and individuals become less resilient and more dependent upon the Government. However, local communities should recognise that someone has to make a decision and this will be the recognised authority that may need to take account of wider, e.g. basin wide and often national interests.

132. Process of *decision-making* should be transparent, so that local communities can appreciate how a decision was arrived even when they disagree. Similarly, the decision-making process should be transparent and participatory at higher levels too, and ensure that all relevant ministries are informed of the decision process, and actually support it during implementation. In that sense, participatory design and implementation of IFM should be considered at all government levels.

133. In terms of enforcement of legal standards, it appears that insufficient monitoring of protection dikes (either removed or cut by dwellers) causes increased risk. Where applicable a programme focusing on the ***responsibilities of flood plain residents*** may ensure sustainability of flood control structures, and establish penalties for those breaking the law. Involvement of dwellers in dike control/maintenance, with adequate funding, training and legitimacy, may also increase awareness and sense of responsibility.

6.4 Information management and exchange

134. Without basic data no reasonable planning or appropriate decision can be made. IFM and IWRM are based on long-term scientific data. Information management and exchange are vitally important for any negotiated decision-making and should be made available to all interested parties as required. In this context, the international principles on data access and exchange are relevant, such as the *Aarhus Convention on "Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters" (1998)*[VII] or the *WMO Resolutions No. 25 on "Exchange of Hydrological Data and Products (1999)*[VIII] *and No. 40 on the "WMO Policy and Practice for the Exchange of Meteorological and related Data and Products" (1995)*[IX].

135. In order to be made available to all stakeholders, it is important that the required information is collected in a timely and coordinated manner. Investments need to be made in long-term data collection to establish trends for planning and design purposes and to capture evidence of extreme conditions and their frequencies to assess the risk they pose.

136. The development of IFM, and indeed IWRM, requires a sound and well-developed information system that should include not only the hydrologic data but also all other related development data including social economic and ecological information. The basic information calls for a representative *hydrometric network* backed up with the necessary telemetric *data gathering and processing* technologies. The relevant and related data may be required to be made available by various agencies depending on their technical and geographical jurisdiction. This information needs to be synthesised and analysed in a form that is easily comprehensible and forms part of the information base to be made available to all stakeholders. Assessment of degree of risk due to floods and other related risks and the design standards for infrastructure to be resistant against floods require long series of data collected over the years. Importance of long series of data is enhanced in order to discern the climate variability trends and design adaptability measures.

137. In developing countries hydrometric networks may require major attention not only because of sparse land coverage but also because instrumentation is not functioning owing to lack of maintenance or ageing. River flow gauges installed to measure low flows will, on the whole, not be suitable for

measuring high flows and possibly vice versa. In a number of countries, budget cuts negatively affect data collection activities.

138. Access to information, reliability of forecasts and public trust are critical issues to be addressed when developing an advanced *flood forecasting system.* This would require not only a good quality-controlled data acquisition system but also a set of multi-disciplinary (meteorology, hydrology, hydraulics, geo-mechanics and information systems) approach to analyse it and produce a coherent forecast. Greater coordination and cooperation between meteorologists and hydrologists is called for to increase the lead-time, especially in flash flood situations. Another challenge is the *accuracy of the forecasts*. Improved data collection, continual model development, calibration and verification, etc. would help in improved accuracy of the forecasts. An important aspect of evaluation of the flood forecasts and warning for their effectiveness is surely missing and appears to have deprived their important tool to realise its full potential and find appropriate place in flood management policy strategy.

139. The development of an advanced, accurate and modernised flood forecasting and warning capability needs to be followed by further projects/activities designed to ensure a really robust set of *communication systems for disseminating flood warnings* in a timely manner to those who need them, especially the flood-prone population. These forecasts need to be disseminated in a language that in easy for the general public and the authorities responsible for rescue and relief operations to understand and respond appropriately in pre-determined manner. The means of dissemination adopted should cater to the flood-prone public or to identify the most vulnerable in society - who have the most to lose and who find it the most difficult to recover from floods. Modern communication technologies, in addition to radio and TV, now provide a whole ranges of fairly new personalised communication technologies for disseminating flood warnings to the public and in providing access to real-time warning data such as mobile telephone, the internet, in-home radio alerts and so on. It is important that traditional (folk) technologies are not driven out by the spread of modern technologies, and that the flood forecasting and warning authorities do not perceive their role as ‘replacing’ or ‘supplanting’ traditional methods with ‘scientific’ ones. Appropriate technologies need to be utilised given the stage of development and socio-economic characteristics of flood plain occupants.

140. Public understanding and *willingness to respond* adequately to warnings are an important component of flood protection and mitigation. The flood-prone public's knowledge of what to do when receiving a flood warning, particularly where there are short lead times, needs to be addressed as part of the flood awareness raising initiatives because this cannot be taken for granted. A well-informed citizenry is a prerequisite for functions like early warning and flood forecasting. Thus, one of the challenges for the successful implementation of the early warning systems is the education of the public with respect to the credibility of the forecasts.

141. ***Flood hazard maps*** are very useful for relief and rescue authorities as well as for residents. The relation between *flood hazard maps and warnings* should be clearly explained for the easy understanding of rural people. For example, if water levels are related to well-known local features, people can easily decide on actions to be taken. Furthermore, in order to take relief-oriented action and for evacuation purposes, a visualisation using GIS techniques and flood hazard mapping will be effective. Compilation of such a map will help organisations concerned to achieve both meaningful catchment area management and land-use planning. The task of compilation itself will make a good training for officials/engineers to understand the characteristics of the corresponding area and if the map is compiled through the co-operation of residents, it is more effective in achieving the desired objectives. Flood hazard maps will be more effective and fruitful if the communities contribute their knowledge and express their wishes. Their *distribution* may positively influence social behaviour, land-

use practice and real estate prices. Flood maps may indeed turn flood hazards into an issue of public debate, reduce social tensions related to risk analysis and may help reduce post-flood criticisms.

142. It is convenient to consider the development of a *database of flood-affected people* and of the circumstances that caused the problem. In this context, it is useful to establish a typology of disaster impacts, and to clarify social vulnerability patterns. Coupled with a GIS and with socio-economical data, such a data bank can provide a cross-sectoral vision and helps to link this with flood characteristics or identify most risk-prone target groups for prioritisation in investment. However, it is important to ensure that the relevant services be capable of feeding this database with frequent updates. Furthermore, there should be an efficient bottom-up flow of data collection to get information from flood victims.

6.5 Appropriate economic instruments

143. ***Economic instruments*** are means to improve economic efficiency. They permit governments to alter the monetary incentives or disincentives for using resources, and the prices of resources, to help achieve a desired outcome (usually for the nation). A range of planning, regulatory and economic instruments can be used to encourage and develop IFM. The following types of instruments could possibly support an IFM approach: (i) resource pricing which is based upon the full social costs of using flood plain land including the capital, operational, maintenance and external costs associated with its use; (ii) taxes or levies upon new use of flood plain land (i.e. new development or intensification); (iii) subsidies to encourage the introduction and adoption of measures designed to reduce exposure to flood loss in existing flood plain properties. However, often the use of economic instruments will be limited. Governments and agencies tend to rely upon planning instruments rather than exploring a wide range of possibilities. The range of instruments used therefore needs to be critically reviewed.

144. In continuation of the above, the prevailing *resource pricing regime* will be an important starting point. Normally consumers of water and flood management services are expected to pay prices for these services in accordance with the principles of economic efficiency. Pricing policy will seek to equate supply with demand at the economically appropriate level and in an environmentally acceptable way. The services which can be expected to be priced include: water treatment and supply (e.g. for domestic and irrigation purposes); effluent discharges; and flood protection. In well-developed regimes, the pricing of flood protection might be broken down into various different types of flood protection (e.g., it may be possible to price levee protection for a community or even for individuals in some cases; and it may be possible to price flood proofing and flood warning services where desirable to do so). Through developing such resource pricing regimes consumers start to contribute to the costs of their use of water resources, including the costs of using flood plain land. Although it is not always the case, flood protection is often regarded as a public good (i.e. not divisible and deliverable to individuals). This means that there may well need to be mechanisms for communities to contribute to flood protection costs.

145. Another way of considering economic instruments is to analyse the structure of the underlying regime of ***taxes and subsidies***, or financial incentives and disincentives, which applies to the human processes and activities that impact flood magnitudes. For example, a Government may decide to subsidise the cost of flood mitigation in order to encourage and provide appropriate incentives in flood mitigation programmes. On the other hand, Government could levy a land and property development tax on all land use intensifications and development in floodplains, in order to make it less lucrative and discourage increased use of floodplains. In theory, levying a tax on new flood plain development in this way encourages users to pay the full costs of such development. However, if they pay the tax, this would appear to mean that the “developers” have the right to develop the flood land and that the

Government has a responsibility to protect the flood plain developments (e.g. residential and industrial areas). Another commonly used way is making it necessary that developers contribute to the costs of flood plain development, i.e. the costs of flood protection. Repeatedly providing flood relief and compensation to flood victims may be humane but in economic terms provides a subsidy for flood plain use and fails to discourage flood plain occupancy. In practice, however, withdrawing flood relief and compensation to flood victims raises a moral dilemma.

146. As another option, in one country, for example, there is subsidised federal flood insurance programme which flood plain occupants can only access if their communities agree to adopt flood plain land use regulations. There is controversy about whether this particular regime encourages or discourages economically efficient land use decisions, but the principle of making a subsidy available on condition that land use controls are adopted is an interesting one (it is a combination of regulatory and economic instruments).

147. The *contribution of the private sector* through the insurance companies is an asset, provided that authorities make sure that the pricing policy is not speculative and that adequate mechanisms for re-insurance are provided for. Furthermore, insurance companies may contribute to incremental control of land use (by accepting or not to provide flood-prone dwellers with insurance policies). However, such private sector involvement should not lead to a reduction of the participation of the State, especially in terms of co-ordination function and awareness-raising through public campaigns.

148. *Cost sharing* is another form of economic instrument. Organisations or interests which may benefit from a flood management project might be able to drive down their total costs by integrating and sharing costs. They may be able to alter the benefit-cost equation in this way (by driving down costs), making projects more viable.

149. ***Funding arrangements*** are a very important part of institutional arrangements. Funding and financing arrangements critically influence option choice. The quantity of financial resources available for flood management will also be a key factor, as will arrangements for cost-sharing. Where a traditional, structural approach to flood management has developed and has become embedded, flood management funding arrangements are likely to reflect and only reinforce the traditional approach rather than a broader, more IFM approach. Evidence of this might be found in funding and economic appraisal arrangements being well-developed for structural measures, but undeveloped or underdeveloped for non-structural measures. For example, there may be a well established stream of funds for levee construction and river improvement works, but little attention may have been given to developing funding sources and streams for flood forecasting and flood warning dissemination systems and for flood-proofing. Early critical review of funding arrangements on how they impact upon the full range of flood management options and strategies is recommended. There is likely to be a mutually-reinforcing ‘alliance’ between existing, established flood management agencies and funding bodies and mechanisms which serves to reinforce the *status quo*. However, changes should be introduced where imbalance is present in these arrangements. Government might choose to incentivise cooperative and integrative IFM projects by laying down cooperation and integration criteria that organisations should perform well against, before funding is released.

7. CONCLUSIONS

150. Development of IFM and IWRM processes in a country depend largely on national circumstances, socio-economic conditions, styles of governance, traditions and values within the country in question and the long-term experiences. Development and implementation of integrated flood management processes cannot be undertaken without considering these national attributes. Nevertheless, there are certain steps that are required to be taken to guide actions and arrangements which take the process forward towards an IFM approach. These are as follows:

1. Expression of flood management objectives in clear terms, appropriately relating them to IWRM and to other government policies (e.g. for land management, development, agriculture, housing etc.).

2. A clear demonstration of political commitment to the IFM process.

3. Analysis of existing legal and institutional frameworks in order to align them to integrated approach to IFM and IWRM (sometimes by replacing existing sector based legislation).

4. Clear demarcation of jurisdiction and definition of responsibilities of agencies through legal or other supporting instruments (which may sometime require establishment of new agencies specifying their roles, duties, powers and accountabilities).

5. Identification and specification of planning, regulatory and economic instruments for IFM duly aligned with defined objectives.

6. Clear definition of spatial or territorial planning unit for IFM, spelling out the rationale for the choice (the river basin or catchment area is the most suitable unit).

7. Establishing mechanism to ensure inter-agency coordination and cooperation and allocation of funds for the integration initiatives.

8. Concrete steps to bring inter-disciplinarity in the working of agencies concerned (this may sometime require strengthening human resources).

9. Definition of organisational hierarchy in all management issues and functions allocated at local, regional, national levels and international levels.

10. Establishment of flood information database with clear definition of responsibilities of its collection, supported with required resources and policies of sharing and dissemination.

11. Establishment, through legal backing wherever required, of mechanisms for public participation and stakeholder engagement, with clear inventory of technical and social expectations.

12. Establishment of community-based flood management groups with appropriate policy and resources for their capacity building enabling effective participation.

151. The principal vehicle of progress towards an IFM approach is based on *knowledge, expertise and competence* in the areas of IWRM and IFM. Processes such as planning, designing, monitoring,

early warning and conflict resolving, in a multidisciplinary mode, call for setting up of a comprehensive Flood Information System consisting of:

(i) *knowledge base*: technical data; social and economic data; land and water uses;
(ii) *relational base*: who's who; contacts and coordinates; allocation of duties;
(iii) *dialogue base*: data exchange protocols; communication channels; rules and language;
(iv) *monitoring base*: indicators; information systems; and
(v) *conflict-solving base*: early warning threshold; notification protocols; negotiation processes (location, timing, authority chosen for trade-off; compensation options, etc.)

152. Further, *institutional capacities and capabilities* might in some cases require a great deal of fresh inputs to enhance the capacities of: (i) central Government ministries responsible for natural resource development; (ii) flood management agencies such as river basin commissions or agencies; (iii) land planning agencies; (iv) emergency planning and response agencies; (v) local community groups; and (vi) others (e.g. large utilities or public infrastructure organisations such as a housing or transport authority). It will be very important to establish high quality but appropriate ***training programmes*** for all of those involved in flood management, from the local community to the highest level. This should also include data-holders and users to ensure an adequate exchange of data and will require a large and on-going commitment.

153. One of the general lessons learned about flood management strategies is that the start-up is usually rather slow. A steep learning curve may be involved and the ability to reflect on lessons learned and to adjust strategies to get the best out of them is critical in successful flood management. Persistence and perseverance are fundamental to the success of the Integrated Flood Management process.

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ANNEX I – FLOODS AND THEIR IMPACT IN THE CASE STUDY AREAS – SUMMARY

1. Type of floods

1. In ***Ethiopia***, as the topography of the country is rugged with distinctly defined watercourses, large scale flooding is limited to the lowland flat parts of the country. The rainy season is concentrated in the three months between June and September, when about 80% of the rains are received. Torrential downpours are common in most parts. Intense rainfall in the highlands causes flooding of settlements in a number of river basins. On the other hand, for reasons yet to be determined the level of the waters of two main lakes (Awassa and Besseka) has been gradually increasing causing damage to infrastructure in a number of areas.

2. The inundations in the Inland Delta in ***Mali*** follow the hydrograph of the Niger River and its tributaries, produced by monsoon rains in the upper catchment areas of the neighbouring countries. Seasonal flooding from around August to January, are due to the flat slopes in the Delta area, leading to a large spread of the water. The hydrographical network in the Delta is relatively complex; with the Niger river, a number of lakes, three main tributaries and a multitude of secondary rivers and streams diverting water to, or draining water from different lakes and plains. During flooding, the water is mainly contained in large flood plains covering several hundreds of km^2, filled during the flood season and emptying themselves during the recession of the floods.

3. The natural hydrological flooding process in the flood plain of Logone in ***Cameroon*** has three distinct characteristics: at the beginning of the rainy season (May to July), the clays in the plain swell and become impervious. If rains are abundant they fill the wetlands and produce the first inundation in the lower parts of the plain. Immediately after this is increased by the runoff coming from the adjacent mountains, highly loaded with limestone. Then overflows of the Logone River, which contribute the largest volume of water, normally start in September. Thus, water will cover the plain during 3 to 4 months. When the dry season starts a part of the floodwater returns to the river, but an important volume is also lost by evaporation and the rest flows into Lake Chad.

4. The rainy season in the Zambezi Basin in ***Zimbabwe*** is largely dependent on the inter-tropical convergence low-pressure system, which peaks in January or February. The large storms due to tropical cyclones from the Indian Ocean also affect the basin. As a result, there are two types of floods: the first and most frequent is the seasonal flood, occurring in most years normally during the peak of the rainfall season. The second and not so frequent one is the cyclone-induced flood, having become more frequent in the recent years than before.

5. ***Bangladesh*** covers the deltaic area of the two largest rivers of the continent, the Ganges and the Brahmaputra. The country generally experiences four types of floods. *Flash floods* occur during mid-April before the on-set of the monsoon mainly in the north-eastern hilly part of the country. *Rain-fed floods* generally happen in the deltas in the southern and south-western part of the country and are increasing in low-lying urban areas. *River floods* are the most common; the areas along the rivers are inundated during monsoon season and in cases far beyond the riverbanks. *Storm surge floods* occur along the coastal areas (about 800 km along the northern part of Bay of Bengal). In case of intense cyclones the coastal belt is flooded. The situation worsens when the rain-fed floods coincide with the storm surges associated with tropical cyclones. Coastal areas are also subjected to *tidal flooding* from June to September and are a great source of fish.

6. In ***China***, the floods produced by the Eastern Asia monsoon storm rainfall in the summer with large coverage and high concentration mainly cause flood disasters in the plain areas of the seven major rivers; in addition, isolated local storms frequently produce flash floods and land-slides in mountainous regions. Ice jams during the spring season in the upper reaches of some of the rivers often result in disastrous floods in their middle and downstream reaches. China's coasts, with a total length of 18,000 km can be affected by storm surge, tides and tsunamis; these can result in serious consequences when some of these events occur concurrently with river floods.

7. The four months from June to September form the core of the rainy season all over ***India***, decreasing in duration from south to north and from east to west. Between three-fourths and nine-

tenths of the total annual rainfall is concentrated over this period. An area of 40 million hectare in the country is prone to floods. Generally these areas are subjected to drainage congestion whereas certain areas are also prone to flash floods due to cloud bursts, snowmelt, burst of natural barriers caused by land slides in the Himalayas or cyclonic storms and storm surges in the coastal areas. As regards in particular the case study catchment of the Damodar River, this area experiences seasonal south-west monsoon rains and depending upon the intensity of the storms, floods occur. A heavy storm preceded by another storm normally causes flooding in the downstream fertile plain of West Bengal area. Due to the silting process going on for immemorial times, the cross-section of the lower Damodar in the delta areas has become considerably shallower, reducing its drainage capacity.

8. Similarly, floods in the Chenab River and the Lai Nullah Basin in ***Pakistan*** result from heavy south-west monsoon rainfall in the upper drainage basin. There are also snowmelt contributions, on the average, 40% of the total flow in July, when the maximum snow melt are attained. They synchronize with the early monsoon in July, but not with the peak values occurring in August and September, when the tributaries flowing into the Chenab River can aggravate the floods.

9. About 50% of the population and 75% of the real estate of ***Japan*** are concentrated in the areas below flood level, which accounts for only 10% of the total land area. Due to its geophysical features and climatic conditions, rivers in Japan are short and steep and flow rapidly and violently. This has been causing continuous occurrence of flash floods that resulted in serious economic and human losses. Rapid urbanization has been in progress in many parts of Japan, which is impairing the water retention capabilities of nature. Consequently floods have been concentrating in a shorter time and in greater flow rate. As regards the Syonai river system, this area is affected in the summer and autumn by thunderstorms, often as a result of the combined effects of an autumn rain front and a typhoon. Due to the country's mountainous topography many rivers are of the torrential type, having steep riverbed gradients. Hence, the flood waves have a fast arrival time in the lower parts. Furthermore, the embankments are generally built above the protected lowland. The floods overtopping the embankments cause the inundation of the protected lowlands and urban areas.

10. In ***Fiji***, tropical cyclones are the main cause of major floods. Rainfall begins while the centre of the cyclones is still some distance out at sea; rainfall intensity increases as they approach. The magnitudes of floods are dependent on the tropical cyclone system. Rapid runoff from an already saturated catchment results in extensive floods. Storm surges exacerbate flood levels on the coastal zone. When the eye of the tropical cyclone passes close to shore or traverses land, surges are inevitably generated. Floodwater discharge is restricted and riverbanks are often breached.

11. In the Metropolitan Area of Curitiba in ***Brazil*** there are two types of floods: due to urbanization, which happen in the highly urbanized Metropolitan area; and those caused by inefficient drainage systems due to: (i) flood plain occupation by the population; and (ii) flow obstruction due to urban infrastructure such as bridges, landfill, etc.

12. Periodically weather conditions promote widespread flooding in the Red River Basin in Manitoba, ***Canada***; the most troublesome ones (especially when most or all happen in the same year) are: (i) heavy precipitation in the autumn; (ii) hard and deep frost prior to snowfall; (iii) substantial snowfall; (iv) late and sudden spring thaw; and (v) wet snow/rain during spring break-up of ice.

13. These conditions are very similar to those causing floods in the Mississippi River Basin in the ***USA***. Significant floods result from regional rainfall and snowmelt events that cause slow rise of rivers and extend for days or weeks. Due to the influence of tributary flows the magnitude of flooding increases moving downstream to the mouth. Short, intense rainfall events can cause flash floods or quick rise and fall floods on the tributaries, but do not normally affect the main stem.

14. The complex hydrological regime of the Piemonte Region in ***Italy*** has an obvious impact on the flood response of catchments. In the winter, the Alps are covered with snow and most of the precipitation is stored in that form and glaciers. In the spring the snow melts, aided by rainfall, which can result in the spring floods. Summer rainfall can be stormy and the bare, rocky Alps give high runoff with a rapid response. Autumn rainfall can be heavy and prolonged, mainly caused by southwest wind coming from the Mediterranean that can carry a large volume of precipitation. Generally, the major floods occur during the autumn and spring. In addition, many man made structures, such as bridges

and weirs for water diversion have been constructed across and along minor or main rivers. These interact with the flood waves propagation and often can produce local but heavy flooding problems.

15. In the Western Black Sea Region of ***Turkey*** the drainage areas of the rivers have short main courses, with steep slopes and rather dissected with deep valleys. During floods the flows have a high speed and, due to elevated sediment load, are muddy and viscous. A large amount of erosion and debris materials are dragged by the flows and deposited in the more plain low-lying areas. Sudden floods, especially occurring in the short river courses are common and these produce widely devastating flash floods in the study area, most frequently between May and July.

16. Finally, a large portion of the Parrett Catchment located in the south-western region of the ***United Kingdom*** lies below high tide level; it is protected from the sea itself by coastal defences. Much of the catchment receives higher than average rainfall and the capacity of the river channels in the lower reaches is often exceeded. This is often compounded by high tides preventing evacuation of floodwaters. The embanked rivers overflow into washlands known as moors, which act as storage areas until the rivers subside. If the rivers remain high, the moors can be subjected to prolonged flooding. In many moors the floodwaters cannot return by gravity and can only be drained by pumping back into the rivers.

2. Severe flood events, their frequency and their impact

17. In ***Table I -1*** a statistical summary is presented on the number of flood events (in general since the second half of the last century) and their frequency, and on the most severe recent floods, with an indication (when available) of the areas affected, the human losses and number of people and houses affected, as well as a cost estimate of the damages. It should be noted also that in some cases not all the authors have provided the same level of detail of information or in others the final version of the case study is not available as yet.

18. With respect to severe events having occurred in each country during recent years, some figures may be highlighted: in ***Bangladesh***, at least 50 to 70% of the country's territory is exposed to intermittent extreme flooding that has far-reaching negative impacts on the national economy, or in ***China***, where on the average about 78,000km^2, which accounts for about 7.8 % of the total farmland, was affected annually during the period 1950-1990. Similarly in ***India*****,** on an average (1953-2000) 75,000 km^2 which is 5.5% of the cultivable area in the country is effected by floods. In ***Japan***, average damage due to floods during last 10 years has remained stable due to a higher degree of protection provided. However, vulnerability of the population prone to flooding is increasing steadily. As an example, an extraordinary event in that country during 2000 occurred in the Syonai River system, which affected Nagoya City; the reported damage amounted to a death toll of 10 people; recommendations for taking refuge were made for about 580,000 people; the number of damaged houses was 63,440. ***Pakistan*** has seen important flood damages: during the flood of 1998 in the River Chenab Basin 1,243 villages and some 460,000 persons, over an area of 2,555 km^2, were affected; in the Lai Nullah Basin a flood in 2001 inundated Rawalpindi City, with a total of 74 lives lost, about 400,000 people affected, and 3,535 houses damaged; estimates indicate a damage/loss of more than USD 0.25 billion to infrastructure. In ***Fiji***[6] a major flood in 1993 caused damages amounting to some USD 100 million, 23 lives were lost, and more than 120,000 people (approximately 10% of the population) suffered serious losses adversely affecting the national GDP and government's development plans and programmes and resources earmarked for capital development works had to be urgently redirected for relief and rehabilitation.

19. In ***Ethiopia***, flood problems affect almost all of the area for irrigation development, amounting to 2,000-2500 km^2 during high flows. In the Niger River Inland Delta in ***Mali*** in wet years the flooded area exceeds 20,000 km^2; however, while exceptional high floods may cause damage to habitats and irrigation, and in cases loss of lives, the floodwater plays a determinant role in the regeneration of the Delta's natural resources, which form the basis of the different production systems. In a similar situation, managed flood releases from a storage dam on a tributary of the Senegal River have allowed the continuation of traditional recession agriculture in the lower delta flood plains in

[6] In view of the fact that there is only one case study of the South-West Pacific region, it has been grouped with Asia

Mauritania, especially in the years of important natural floods; this compensatory measure has attenuated the negative impacts of the dams on the quality of life of the traditional flood plain users. Recent floods in the Zambezi Basin in ***Zimbabwe*** produced losses of livestock and human life, destruction of crops and infrastructure, affecting mostly the rural population; disease outbreaks like malaria and cholera were quite common during this period.

20. In 1983 and 1995 two major urban floods occurred in the Curitiba Metropolitan Area, in ***Brazil*****,** with severe damages amounting to US$ 50.3 million and 40.2 million, respectively.

21. Devastating flood events have occurred in various river basins of ***Turkey***, especially in recent years. Based on a flood inventory of 776 cases during the period from 1945 to 1995, on the average 18 flood events occur in a year causing a loss of about 23 lives. Almost after each flood, the government has paid a large proportion of the damage, in addition to losing significant revenues due to the consequences of economic disruption. Finally, recent floods in the Parrett Catchment in the ***United Kingdom*** caused that new areas of farmland, major roads, businesses, houses and ecological interests were flooded for several weeks.

Table I - 1 – Some statistical information on severe flood events and the damages they caused (as provided in the case studies)[7]

Case study	Case study Area (thou-sand km^2)	Inhabi-tants (millio n)	No. flood events/ period	Flood frequen-cy (years)	Recent severest event(s) (year)	Area affected (km^2)	Death toll (per-sons)	People/ Houses affected	Damage losses (million USD)
Cameroon (Fleuve Logone)	8.0	0.7							
Ethiopia	1,100	65				6,000-7,000			
Mali (Inner Niger Delta)	60.0	1.0			1967	34,400			
Mauritania (Senegal river)	0.160		4/1988 to 1999	2.8	1989, 1991				
Zimbabwe (Zambezi Basin)	8.0	0.3			2000, 2003				
Bangladesh			8/1950 to present		1998	50-70% total area			
China			1 every two years	2.0		78,000			
India (Damodar river basin)	22.0	8.9	14/1958 to 2000	3.2	1978, 1995				
Japan (Tokay)			10/1957 to 2000	4.3	2000		10	580,000/ 63,440	
Pakistan (Chenab river)	1.120	0.453	5/1988 to 1998	2.0	1998	2,555		460,000/ --	
Pakistan (Lai Nullah Basin)	0.240		19/1944 to 2002	3.1	2001		74	400,000/ 3,535	0.25 billion
Brazil (Urban Flooding)	1.0	2.5	5/1982 to present	4.2	1983				50.3
Canada (Red River Basin)	116.5	720.0	5/1950 to present	10.6	1997	1840			6.0 (esti-mated preven-ted damages
U.S.A. (Mississippi)	360.0		11/1849 to 2001	13.8	1993	6.6 million acres	38	--/ 100,000	12 to 20 billion

[7] Blank spaces indicate that data were not available in the case studies

U.S.A. (NAI)			14/1950 to 1999	3.5					6.0 billion/year
Fiji Islands (Rewa River)	3.0	0.2	7/1983 to present	2.9	1993			120,000/-	100.0
Italy (Piemonte region)	25.0	4.0	1 every two years	2.0	1994				
Turkey (North Western Black Sea Region)	30.0		10/1972 to 1998	2.6	1998	250	30	--/ 2,200	2 billion
United Kingdom (Parrett Catchment Project)	1.690		Long history of flooding		1997; 1999/2000				

ANNEX II - PRESENT TRENDS AND APPROACHES TO FLOOD MANAGEMENT PRACTICES IN THE CASE STUDY AREAS - SUMMARY

- The information provided in this Annex on the present trends and approaches to flood management practices such as management measures, instruments, organisational response for flood management, and existing national policies has been extracted from, and has been summarised[8] for each one of the case studies

1. Flood management measures

1. The approaches of implementation and application of the various measures in the different countries are highlighted as follows, as well as also some of the problems or negative effects encountered as a result of their application. A summary of the different types of options applied in the various countries is also provided in ***Table II - 1.***

2. In ***Bangladesh,*** flood management strategies adopted have continuously evolved over the last 50 years. Initially, the emphasis was on the implementation of some large-scale flood control, drainage and irrigation projects. However, it was soon recognised that this involved large investments and a long duration for their completion. It was then opted for the construction of small and medium scale projects so as to sooner provide benefits. As a result, these projects provide flood protection to about 5.37 million ha of land, which is about 35% of the total area of the country. Non-structural measures such as flood forecasting and warning were later incorporated, now covering all the flood-prone areas of the country.

3. In ***Brazil***, to solve the flooding problem of the Iguaçu River in the Curitiba Metropolitan Area, according to past practice the usual approach would have been to carry out construction works to increase the river capacity so as to cope with the 50 or 100-year flood. Under these conditions, because of the fact that flood frequency decreases as a result of these works, the population would feel protected and start to occupy the flood plain. Parallel to this, after a few years the development of the upstream basin would increase the flood frequency and peak of the floods. In order to avoid such a future scenario, the conceptual approach was: (i) to create a space for flow and storage in the flood plain of the Iguaçu; (ii) to develop a way to control population invasion of the flood plain; and (iii) to develop the Urban Drainage Master Plan for the Metropolitan Region for the tributaries.

4. In ***Cameroon,*** dikes and a storage dam were constructed between 1950 and 1979 on the Logone River in order to protect the population and the irrigated areas. As a result of these, the hydrological system of the flood plain was profoundly altered, having resulted in a reduction of the flooded surfaces in the order of 60%, as well as in the retention in the dam of the water highly loaded with limestone, which plays a very important role for the fertility of plain soils. All this has had a negative effect on the survival of the population in this region, where the flooded lands are very much used for the agriculture, grazing and fishing activities.

5. In ***Canada***, a flood in 1950 clearly revealed the vulnerability of settlements along the flood plain in south-eastern Manitoba, and the high costs associated with flood damages. A benefit–cost analysis was prepared for a range of flood protection schemes, considering different traditional structural approaches. The comprehensive flood control system finally adopted included an extensive plan to divert water around the city of Winnipeg. However, a false sense of security as a result of the protection provided has encouraged a “project-induced development” in the flood plain, so that with each successive flood the potential damage if structural measures fail is escalating. This has highlighted the need for a long-term approach to flood protection, as well as the implementation of non-structural measures to complement structural ones that can both maximize the efficiency of existing measures and reduce damages in vulnerable areas. The main non-structural measures applied are flood fighting, forecasting and warning, post-flood recovery, land use regulation and mapping, and flood proofing.

[8] More detailed information may be found in the extended summaries prepared for each of the case studies, available separately

6. The integrated approach to flood management in ***China*** is comprehensive and complex; it comprises: (i) storing the flood-water in up stream areas to the extent possible; (ii) protecting the flood prone areas against ordinary flood in middle and down stream reaches of major rivers; (iii) making joint use of the levees and storage and detention basins for handling the extraordinary floods; and (iv) flood preparedness and flood fighting before and during flood season relying on the well organized emergency management system. The flood mitigation strategies are grouped under three main areas: soil and water conservation, building of flood control systems and flood proofing. The latter ensures the mobilisation of the necessary resources and operation of the flood control system throughout the country.

7. Integrated water resources management in ***Ethiopia*** is not at an advanced stage, and flood management has not been treated separately on a sustainable manner in the country. The main flood control and management activity being carried out in the country is in the Awash River Basin. In addition, the city administration of Addis Ababa has prepared a flood protection scheme including structural and non-structural activities to be implemented over a 15-year period.

8. Dredging of the Rewa riverbed in ***Fiji*** is the major structural flood management measure to increase flood discharge capacity. The dredged material is used amongst others to provide relief from floods. In many low-lying flood prone areas a network of drains and out-fall structures (floodgates) enable floodwaters to escape and prevent seawater entering.

9. In ***India***, the multiple objective of the Damodar Valley Scheme is achieved mainly through a set of reservoirs at five sites on Damodar and its tributaries. However, in the resulting absence of frequent floods the Lower Damodar valley gained great value and importance due to a false sense of security and there has been extensive encroachment into the flood plains. The importance was recognized of the productive value of the flood plains of Damodar, given the density of population and high level of investment on flood plains; in addition, that such protection can only be imparted at great expenses and at the cost of not allowing the productive use of flood prone land. While there are losses in the high flood years, the flood plains are utilised gainfully by the inhabitants during the low flood years. The approach, therefore, has been to ”bear the losses” at the time of flood disaster while enjoying the benefits of the land during the rest of the time.

10. Flood management practices Piemonte Region of ***Italy*** are highly influenced by the natural peculiarities, comprising mainly: (i) the structural mitigation of floods by means of levees; and (ii) non-structural safety measures subdivided into land use planning and emergency plan activation. Reforestation and the standard structural bio-engineering measures are widely used in small mountain catchments for mitigation of hilltop erosion and shallow landslides. A comprehensive hazard map has been developed highlighting the interaction between human activities, river and hill slope dynamics. The other measure comprises an alert and warning system based on a decision support system for real-time flow forecasting, combining an advanced database with hydrological and hydrodynamic modelling and a real-time forecasting system.

11. In ***Japan****,* structural measures can look back at a long history since about the 1660’s; these include embankments, excavation of riverbeds, dams and retarding basins, diversion channels, etc. The non-structural measures are of two types; the first geared to decrease the run-off by means of storage of water in the basin (infiltration of rainwater, storage in each house). The second is related to disaster prevention through local prevention plans (including information on disaster prevention), local ordinances (construction regulations, etc.) and the distribution of hazard maps. As regards flood forecasting and warning, a user-friendly information system has been developed available to users and to the public through a web site, cell-phones and Internet.

12. In ***Mali***, the *structural measures* that can be observed in the Niger River Inland Delta depend on its geo-morphological characteristics comprising: (i) simple dikes to delimit a low-lying area or temporary lake, being destroyed by the population after the floods to drain the water for agriculture or fishing; (ii) traditional dikes with intake or outflow structure, to regulate the in/outflow of flood plains and temporary lakes etc.; (iii) large dikes to protect agricultural and urban areas; and (iv) two reservoirs on the Niger River and its tributaries. As regards forecasting and early warning, besides the use of hydrometeorological analyses, traditional forecasting based on climatic and biological indicators (intensity and direction of winds, presence of migrating birds, flowering of herbs, proliferation of insects, etc.) allow the local population to anticipate the yearly flood season.

13. As regards specifically the Chenab study area in ***Pakistan***, each district authority has prepared structural measure plans, in which construction of flood dikes, levees to confine flows, and by-pass flood ways to divert flows have been worked out. Since there is no dam/reservoir in this area to store the floodwaters, these are therefore only used for groundwater recharge and as a soil conditioner for the agricultural land to improve land fertility.

14. For over two centuries, structural measures dominated the ***USA*** response to flooding. As a result, on the Upper Mississippi and its tributaries, levees and floodwalls provide the bulk of the flood protection. Flood storage reservoirs exist on the tributaries to provide protection, primarily to communities on the tributaries. Since the 1993 flood a comprehensive plan for the Upper Mississippi is now under development. In the Lower Mississippi Valley the bulk of the protection is also structural but has been put in place under a comprehensive plan developed in 1928 and implemented and modified over the succeeding years. In the mid 1950's, initial proposals were made for the use of also non-structural measures and the *National Flood Insurance Program* was instituted; it combines subsidised flood insurance with requirement for participating communities to regulate land use in the flood plain.

15. There are structural and non- structural flood mitigation measures in place in ***Zimbabwe***. The first consist of dams and weirs. Although these were put in place to improve water security, they also serve as flood mitigation structures. The flood control is however limited by the amount of storage available and the way these dams are operated prior to, and during the rainy season. Zimbabwe being in a semi-arid region, it is difficult for the water managers to release water in anticipation of floods because of uncertainties in the occurrence and magnitude of runoff during the coming season. While there is also flood forecasting, two problems have been noted: the models being used for meteorological forecasts only provide very short forecasts in an accurate form, which may not allow enough time to reduce the impact of the event. The second one is the accuracy of the forecasts; due to previous false alarms, people no longer take forecasts seriously, as was demonstrated during the recent cyclones.

2. Flood and water management instruments

16. Most of the countries referred to in the case studies reported – with different levels of detail – on laws and regulations. However, the information relating to data collection and exchange as well as on financial instruments for flood management purposes was only provided in a few case studies. The relevant information is summarised below.

Institutional arrangements

17. In ***Bangladesh,*** since ancient times legal instruments were used for flood management. During the latter part of 19th Century, many acts and rules for flood management were introduced, e.g. Embankment Act, Drainage Act and Canal Act, etc. However, these acts addressed the flood issue from a specific angle and failed to deal with floods comprehensively. Later in the early 1960s some more acts were introduced to manage floods. Due to inconsistencies in these laws it was decided to promulgate a unified law and work is currently going on in framing a National Water Code.

18. In ***Cameroon*** there are a number of recent laws related to the environment and to the use of water resources, which were promulgated after 1990. The legal framework for an efficient management of the environment is understood as "*the total living and interdependent physical media*" composed of air, soil and underground, the animal and vegetable world, as well as the human settlements.

19. In ***Canada***, the evolution of federal – provincial policy on flood damage reduction has been based on federal legislation related to the topic. The *Canada Water Act (1970)* outlined the nature of federal involvement in water resource management and water quality programs. It allowed for federal-provincial agreements to formulate comprehensive water management plans, develop water management projects, and also of non-structural water management alternatives. The objective of the *Flood Damage Reduction Program (1975)* was to discourage development in high-risk flood plains. To identify the latter, the program included a flood mapping agreement, and a public education component; this would allow the "designated flood areas" to be formally determined, mapped, and shared with the public to discourage further inappropriate development.

20. A series of laws and regulations in the water sector have been enacted since the 1980s in ***China***. These include (i) the "*Water Law*" (1988) and its revision (2002), the latter stressing in particular the integrated planning of water resources, and that it should be an integral part of the national economic plan; (ii) the "*Law of Flood Control*" (1997), which emphasises that flood control plans should be integrated in basin plans and coordinated with the land-use plans, and that flood control and management should be exercised on the basis of co-ordination and co-operation among all the parties concerned; and (iii) the "*Law of Soil and Water Conservation*" (1991), which states that the protection of soil and water loss is the first priority of conservation work. In addition, there are administrative regulations like *the "Regulation of Flood Proofing"*, "*Regulation of River Course Management*" and "*Guide to Safety Building of Flood Storage and Detention Basins*", etc.

21. In ***Fiji***, the *National Disaster Management Act* of 1998 gives authority and provides institutional arrangement for all actions related to disaster management and defines the functions and duties of government and other relevant agencies. There is no specific legislation to restrict land use although a proposed *National Land Use Plan* has been prepared. An old *Land Conservation and Improvement Act* has means to place restriction on land use, but this has never been applied for flood mitigation.

22. The National Law 225/92 defines and organises emergency planning in ***Italy*** in phases: survey, warning, alarm and emergency, activated successively on the basis of the forecasted events and their observed evolution. The main phenomena taken into account are floods in the main rivers, flash floods and shallow landslides for small mountain or hill catchments.

23. In ***Japan***, there are a number of laws for the development of water resources and for flood and land management. The *River Law* is the main legislative instrument determining flood and water management policies within the country, modified several times to reflect changing needs in flood management over the decades. In the revision of 1997, environmental aspects were incorporated in the river management. Besides, revisions were made such as the introduction of a river improvement planning system that reflects the opinion of the local residents in the basin. There is also a *Flood Fighting Law*, of which parts are being revised, the objectives of which are to seek the abatement of damage caused by flood disasters by measures such as new practices of flood forecasting, publication of likely areas of inundation, and by ensuring smooth and quick evacuation in the assumed areas of inundation. Finally, the purpose of the *Disaster Measures Basic Law* is to establish required systems through the national government, local governmental and other public organisations with respect to disaster prevention.

24. In ***Mali***, in addition to the traditional customs and rules of 1818 governing the life and production activities of the Niger Delta inhabitants, there are state laws and rules concerning the protection, use, development and conservation of water resources. A law instituted in 1990 defines among others the standards for surface and groundwater intake, the measures to guarantee maintaining the water quality and the standards for hydraulic infrastructure; the application texts and the water code are currently being elaborated.

25. Disaster management in ***Pakistan*** basically evolves around flood disasters, with a primary focus on rescue and relief. There exists legislation that addresses some critical aspects of preparedness, mitigation, early warning and response to natural and human induced disasters. There is also legislation that prohibits development of illegal dwellings/encroachments in the flood plain/river catchment areas. In ***Turkey*** a number of laws deal specifically with IFM: (i) the *Law of Turkish State Hydraulics Works* relates to the prevention of disaster effects of both surface and groundwater; and to build protective structures against the floods; (ii) the *Law of General Directorate of Rural Affairs* refers to the preparation and application of service and investment programs in the rural areas in order to protect, develop and achieve effective use of water and land resources in compliance with the policies determined in the national development plan; and (iii) the *Law of Bank of Provinces and Municipalities* also establishes the responsibility of local organisations to fight against the all natural disasters faced in the region under consideration.

26. In ***Zimbabwe***, the *Civil Protection Act* spells out the legal instruments for disaster management and the powers vested in organisations in the case of disasters such as floods. This Act is undergoing revision and is soon to be renamed *Emergency Preparedness and Disaster Management Act;* its main thrust is to address structural and organisational gaps to ensure a multi-sectorial representation. The

Water Act (1998) promotes IWRM, which has since been adopted as a basis for water resources management in the country.

27. As an international component, the *Revised SADC Protocol on Shared Water Course Systems* (Aug. 2000) spells out how international rivers such as the Zambezi River within the SADC community shall be managed. It also stresses the importance of information dissemination during floods and droughts to neighboring countries in order to reduce flood impact.

Mechanisms for information/data collection and exchange

28. ***Bangladesh*** has developed an overall hydrological data collection system, as well as an integrated hydrological database with about 40 years of data. Besides flood forecasting, all these data are used for planning, design and construction of different types of hydraulic structures.

29. The hydrological information and flood forecasting system in ***China*** comprises (as of 1992) 3,172 hydrological stations (measurement of rainfall, water level and discharge), 1,149 gauge stations and 15,368 rain gauges. Of the above stations, 8,525 are mandated to report/release hydrological information during flood periods.

30. With regard to the collection and transmission of information and data for the daily management of rivers in ***Japan***, the national and prefecture river authorities are operating thousands of rain gauges and water level stations throughout the country. These data are then provided to local people and users according to their needs.

31. With regard to information/data collection and exchange in ***Mali***, the national network of hydrological stations is constituted of 90 stations on the Niger and Senegal Rivers. 24 stations are equipped with a telemetry system, and recently eight automatic stations were installed for an early warning system for floods and pollution in the upper Niger River basin.

32. In the ***USA***, the federal Government provides a vast array data collection, storage and dissemination in support of integrated flood management. There are 84 sites on the lower Mississippi and its tributaries and 406 on the upper Mississippi and its tributaries (not including the Ohio and Missouri). There are remotely operated selected gauges in the Mississippi basin for use in water control activities.

Financial allocation and use of resources

33. During the last 40 years the Government of ***Bangladesh*** has invested approximately USD 4 billion in the water sector, mainly for flood control, drainage and irrigation projects. Annually about USD 200 million are disbursed for water and flood management.

34. The Ministry responsible for Disaster Management of ***Fiji*** has an annual budgetary provision to finance disaster related activities, including preparedness, prevention, mitigation, emergency response, rehabilitation, long term recovery and related activities; the budget for 2004 is USD 15,000.

35. In ***Pakistan,*** since 1977 up to now an approximate sum of USD 0.65 billion (including foreign loans) has been spent on construction of flood protection works, restoration of flood affected irrigation and flood control schemes, besides improvements in the flood forecasting capability. Recently there is a new trend to spend funds on implementation of disaster/flood control strategies based on an integrated river reach basis. Very recently, women and men have got access and control over the resources through the induction of social mobilisation.

36. In the ***USA***, the largest allocation of federal resources through a number of agencies to support integrated flood management is made annually for activities on the Mississippi River and within this, the majority is directed to the lower river project activities for various purposes. Additional funds are provided to the information and data agencies, and to support flood mitigation activities such as relocations, preparation for floods and flood insurance. States and communities also provide resources to support flood management and the development of both structural and non-structural

projects. Communities and organisations such as levee districts normally provide the 25 % non-federal cost share of federal projects, both structural and non-structural.

37. Finally in ***Zimbabwe***, financial resources allocated annually by Government for flood and disaster management in general are very low. If the disaster is such that large resources are required, Government will provide funds as available, and the international community and private sector are approached for assistance.

3. Flood management institutions

38. The flood management process in many countries is multifunctional, involving a multiplicity of agencies and organisations involved in the water resources field going from the federal to regional and local levels. In addition, in many cases one ministry or agency ensures overall co-ordination in case of disasters. This is also clearly reflected by the information provided in the case studies (see details in ***Section 3.3*** of the OSP). ***Table II - 2*** provides summarised information on national institutions involved in water and flood management activities, as extracted from the studies.

4. Flood management policies

39. As reflected in the case studies, most of the countries have established national policies relating to, or covering issues of water resources and flood management. Interesting to note is the recent shift of trend in the policies towards IWRM and also, in cases, to IFM, through a change of strategy towards efficient management of flood plains, flood proofing and forecasting, and flood insurance. Relevant examples are summarized below[9].

40. In ***Bangladesh***, a *National Flood and Water Management Strategy* was formulated in 1996. It already included policy guidelines for peoples' participation, Environmental Impact Assessment and multi-criteria analysis during planning process in all future water sector projects. In 1999 the *National Water Policy* was introduced, which guides all the water sector activities. A *National Water Management Plan* was prepared in 2001, crosscutting different sectors of national economy in the light of IWRM, to address conflicting water needs and to ensure equitable water use and balanced economic growth, into the next 25 years. It also includes the management of water-induced disasters. A *Comprehensive Disaster Management Plan* and *Disaster Management Guidelines* were also prepared, in which the responsibilities of different agencies involved in disaster mitigation activities are delineated during pre-disaster preparedness, rescue and evacuation operation during disaster, and post-disaster relief and rehabilitation.

41. No information on national policies is contained in the case study of ***Cameroon***. However, a Permanent Secretariat for the *Management of Natural Disasters* has been established, charged with the organisation of protection and mitigation activities in case of catastrophes.

42. In ***Canada***, the evolution of federal – provincial policy on flood damage reduction has been based on federal legislation related to the topic, information on which is provided in ***Section 3.4*** above. It relates mainly to the nature of federal involvement in water resource management and water quality programs. In addition, there is a Flood Damage Reduction Program that has the objective of discouraging development in high-risk flood plains.

43. The water legislation in ***China*** has laid down the legal foundation for IWRM and IFM. It states amongst others that water development plans should be formulated on the basis of integration of all the factors emphasizing on multipurpose use and the coordination of the water use in livelihood, development and environment, and that water resources development programs should be integrated into the national and social development plan. Accordingly, the central government has laid down specific policies for implementation of these laws, comprising: (i) restoration of reclaimed slope, lake and flood prone areas to natural forest and lakes with government subsidy; (ii) relocation of people from these reclaimed areas and economic compensation and tax exemption for the settlers; and (iii) restraining economic development and population growth in flood prone areas, especially in frequently

[9] It should be noted that for some countries no specific information was provided on national policies (Brazil, Cameroon, Italy, Mauritania and United Kingdom)

flooded areas. Specific policies have also been established to cope with soil and water loss in mountainous and hilly areas.

44. The *Water Resources Management Policy* of ***Ethiopia*** was adopted only recently. Its main thrust shows commitment for the development of water resources infrastructure, the building of dams for hydropower generation and irrigation including the construction of main canals, so as to encourage private participation in irrigation development. There is also a strong call for intensive watershed management to protect the environment and reduce soil erosion and land degradation. In the context of the Policy, flood management is viewed as an integral part of IWRM. The Policy gives priority to grass root participation in integrated water resources development and management. It states specifically that: (i) participation of stakeholders, user communities and particularly women's participation in water resources development should be promoted; and (ii) water resources development shall be underpinned on rural centered, decentralized management, participatory approach as well as integrated framework, etc.

45. Another action by ***Ethiopia*** in implementing its water policy is the active participation in the Eastern Nile Cooperative program known as the *Eastern Nile Subsidiary Action Program,* which includes the three riparian countries of Ethiopia, Sudan and Egypt. The *Regional Flood Preparedness and Early Warning System* is a sub-project under the Nile Basin Initiative, which focuses on the regional aspects of flood management including strengthening of national capacity.

46. ***Fiji's*** water legislation is fragmented and out-dated, and a national water policy for the country is in the process of being drawn up. A bill has also been drafted for legislation to support a comprehensive sustainable development policy. The already mentioned *National Disaster Management Act* (1998) was prepared after repeated disastrous events in recent years and after much consultation, having resulted in the development of comprehensive policies on disaster management. Sustainable and economically viable solutions and policies are being explored.

47. As of 1947 the general policy adopted by the state governments of ***India*** was that the flood plains were to be utilised gainfully by the people living in these areas during the low flood years. This emerged from the necessity to safeguard the interests of already densely populated flood plains and the difficulty envisaged in the resettlement of the occupants living off the flood plains; furthermore, it was considered more beneficial to accept occasional flood losses against large benefits accruing out of the use of flood plains. The *National Water Policy*, formulated in 1987 and revised in 2002, lays down policies with regard to water resources development and management, to be achieved through an integrated and multi-disciplinary approach to the planning, formulation and implementation of projects, including catchment area treatment, environmental and ecological aspects, the rehabilitation of affected people and area development.

48. In ***Italy*** the *Po River Authority*, which establishes the guidelines for the land use and its development, has produced a comprehensive hazard map, which identifies the areas in the catchment exposed to hydrogeological risk. Three levels of hazard are defined along all the main rivers, which establish whether buildings are permitted or not, or where human activities are allowed only in accordance with the objective of the area, or where there is need to enhance the safety level by means of non-structural measures in accordance with Civil Protection authorities.

49. As already mentioned above, in ***Japan*** there are a number of laws determining flood and water management policies within the country. The *River Law,* the main legislative instrument, has been modified to reflect changing needs in flood management over the decades. As of 1997, revisions were made such as the introduction of a river improvement planning system that reflects the opinion of the local residents in the basin, achieved through the *Basic Policy for River Improvement* and the *River Improvement Plan.* In addition to the *Flood Fighting Law*, currently being revised, a *Policy on Comprehensive Flood Control Measures* was introduced in 1979, to strengthen flood-retarding functions in the basins and incorporate these into flood management strategies. An effort for a combination of measures between water and land management was started, thus requiring linkage between water and land-use authorities. Finally, in areas where important damages have occurred due to floods, high tides, etc., a *Special Emergency Project as the Countermeasures against Terrible Disasters in Rivers* should be undertaken.

50. In ***Mali***, the *National Water Policy* was defined in the *Master Plan* approved in 1991. Through the exploitation of water resources it aims to improve the food security, living conditions, environmental protection, and the regional integration with neighbouring countries. The policy covers the management and prevention of flooding by means of: (i) reinforcement of the hydrological forecasting and early warning system, related especially to the effects of flooding and droughts; the system will also allow to determine the role of the main reservoirs for a rational water management for upstream and downstream users; and (ii) identification and mapping of flood-prone areas and development of an early warning system for inhabitants of these risk zones. A new national water policy is being elaborated and will be based on the principles of IWRM.

51. The national water policy for ***Pakistan*** is under formulation; a draft has been issued in 2002 and is due to be finalized and adopted soon. At present the first priority is to utilize the available water in equitable and judicious manner to encourage the migrated agrarian population to settle evenly within the Indus basin. The new policy amongst others states the involvement of the public and private stakeholders in water sector issues, involving users in planning and management of water projects and encouraging stakeholders to contribute towards policy formulation. An institutionalized planning exercise has been carried out in the form of five-year plans, which were implemented from 1955 onwards. In addition, in the Third *National Flood Protection Plan* (1998-2012), the concept of community participation in all aspects of flood control is also clearly spelt out.

52. The experiences gained from the floods show that structural measures implemented basin-wide in the case study area of ***Turkey*** are effective but too costly in reducing the risk of flood damages. Therefore, after the 1998 floods more importance was given to non-structural measures. This change of policy is reflected in the implementation of the *Turkey Earthquake and Flood Emergency Recovery* (TEFER) Project. Under the latter, a work programme is being implemented to develop flood management and to reduce and when possible to eliminate long-term risks and damage to people and their property from natural hazards and their effects. Local stakeholders are assisting in defining the integrated flood management policy and participate in decision-making.

53. In the ***USA***, the national *Flood Control Act* of 1936 states that "…flood control is a proper activity of the Federal Government" and that "…the Federal Government should improve or participate in improvements...for flood control purposes if the benefits to whomsoever they accrue are in excess of the estimated costs...". While this Act remains in force, over time it has shifted from a program of almost full federal funding to one in which states and local sponsors share the costs of both structural and non-structural activities. The evolution of attention to environmental factors brought increased focus on the need to include preservation and protection of the environment in plans for flood damage reduction. This led to major initiatives to encourage development of comprehensive watershed plans that would also integrate other water resource development activities. Federal agencies are directed to coordinate with each other and the relevant state agencies in the development of any actions within a watershed, thus encouraging the integration of flood management activities within the context of IWRP. Following the 1993 flood Government increased its support of relocation activities; funding support is now provided for farmers to voluntarily place land in conservation reserve to provide habitat and flood storage.

54. Finally in ***Zimbabwe***, the National policy for disaster management is that every citizen of the country should assist wherever possible to avert or limit the effects of disaster. Central government initiates hazard reduction measures through sector ministries, with local administration taking the responsibility for implementing and maintaining its effectiveness. The system uses existing government, private and non-governmental organizations whose regular activities contain elements of prevention and community development. The organizations are adapted structurally, materially and technically so that they can be shifted rapidly from their regular activities to undertaking protective, relief and rehabilitation measures in times of disaster. After a recent cyclone this policy was changed so as to reflect a major shift towards an IFM approach.

Table II - 1 – Summary information on the application of *structural and non-structural* measures[10] (as provided in the case studies)

Case study	Area (thou-sand km2)	Source control (affores tation)	Run-off storage	Increa-sing capacity river	Separa-ting river/po pulation	Flood warning s	Emer gency works	Flood recovery	
Cameroon (Fleuve Logone)	8.0		✔		✔				
Ethiopia	1,100	✔	✔		✔			✔	
Mali (Inner Niger Delta)	60.0		✔		✔	✔			
Mauritania (Senegal river)	0.160		✔						
Zimbabwe (Zambezi Basin)	8.0		✔			✔			
Bangladesh			✔	✔	✔	✔	✔	✔	Controlled flooding
China		✔	✔	✔	✔	✔	✔	✔	✔
India (Damodar river basin)	22.0		✔		✔	✔			
Japan (Tokay)			✔	✔	✔	✔	✔	✔	
Pakistan (Chenab river)	1.120		✔		✔	✔			
Pakistan (Lai Nullah Basin)	0.240		✔	✔	✔	✔	✔		
Brazil (Urban Flooding)	1.0	✔	✔	✔	✔	✔			
Canada (Red River Basin)	116.5		✔	✔	✔	✔	✔	✔	
U.S.A. (Mississippi)	360.0		✔	✔	✔	✔	✔	✔	
U.S.A. (NAI)									

[10] As established in the APFM Concept Paper

Fiji Islands (Rewa River)	3.0		✔	✔	✔	✔			
Italy (Piemonte region)	25.0	✔			✔	✔	✔	✔	
Turkey (North Western Black Sea Region)	30.0		✔	✔	✔	✔	✔	✔	✔
United Kingdom (Parrett Catchment Project)	1.690	✔	✔	✔	✔				

Table II - 2 – Summary information on national institutions involved in water and flood management activities[11] (extracted from the case studies)

CASE STUDY	Ministries/Federal Agencies			Interministerial Coordination/ committees		National River basin commissions/agencies	Departments/Bureaux		Regional/ local offices	Inter-national river commissions
	Planning	Sectoral (Water etc.)	Disaster management	Water resources	Disaster management		Meteorology, hydrology, flood forecasting	Disaster management /Relief		
Cameroon (Fleuve Logone)		✔						✔		
Ethiopia		✔				✔				✔
Mali (Inner Niger Delta)	✔	✔		✔		✔			✔	
Mauritania (Senegal river)		✔							✔	✔
Zimbabwe (Zambezi Basin)		✔			✔		✔		✔	
Bangladesh	✔	✔	✔	✔	✔		✔	✔	✔	✔
China		✔		✔	✔	✔	✔	✔		
India (Damodar Basin)		✔				✔	✔	✔		

[11] At the time of preparing this document the *final versions* of four case studies were still outstanding (Bangladesh, Cameroon, Mali and Mauritania).

CASE STUDY	Ministries/Federal Agencies			Interministerial Coordination/ committees		National River basin commissions/agencies	Departments/Bureaux		Regional/ local offices	Inter-national river commissions
	Planning	Sectoral (Water etc.)	Disaster management	Water resources	Disaster management		Meteorology, hydrology, flood forecasting	Disaster management		
Japan (Tokay)		✔	✔							
Pakistan (Chenab river)		✔					✔	✔		✔
Pakistan (Lai Nullah Basin)		✔	✔				✔	✔	✔	✔
Brazil (Urban Flooding)	✔	✔		✔						
Canada (Red River Basin)	✔	✔	✔				✔	✔	✔	
U.S.A. (Mississippi)	✔	✔	✔			✔	✔	✔	✔	
U.S.A. (NAI)	✔	✔	✔			✔	✔	✔	✔	

CASE STUDY	Ministries/Federal Agencies			Interministerial Coordination/ committees		National River basin commissions/agencies	Departments/Bureaux		Regional/ local offices	Inter-national river commissions
	Planning	Sectoral (Water etc.)	Disaster management	Water resources	Disaster management		Meteorology, hydrology, flood forecasting	Disaster management		
Fiji Islands (Rewa River)		✔			✔		✔	✔	✔	
Italy (Piemonte region)									✔	✔
Turkey (North Western Black Sea Region)	✔	✔	✔	✔	✔			✔	✔	
United Kingdom (Parrett Catchment Project)	✔	✔	✔						✔	

ANNEX III – MAIN LESSONS FROM CURRENT FLOOD MANAGEMENT PRACTICES IN THE CASE STUDY AREAS - SUMMARY

- In ***Section 3.5*** of the OSP information is provided on the ***general*** main lessons learnt reported in the case study countries, which have emerged from, and are similar in a number of cases, grouped under aspects such as flood management, flood forecasts and warning, land-use regulation, urban flooding, community co-operation and participation, and international component

- There are also a series of ***specific*** lessons learnt, related to a region or case study in particular. These have been extracted from, and have been summarised[12] in this Annex for each one of the case study areas

Region or country specific lessons

1. The flood plains and delta areas in Western Africa, such as the ecosystems of the ***Niger River Inland Delta*** and of the ***Sahelian Plains***, as well as the traditional farming systems that exploit their natural resources in the flood plains and the lakes, depend directly on the extent of the annual river floods. Any extension of planned irrigation schemes upstream of the deltas or the installation of dams is going to have an impact on the ecosystem and thus on the traditional farming systems. Therefore any intervention, whatever the scale, should be preceded by an impact study and based on a good knowledge of the mechanisms which underlie the normal functioning of the environment, the interrelations between the natural phenomena and the various communities with different and sometimes contradictory interests. Improving the design and concepts of the infrastructures constitutes an important challenge for the rural development of these areas. [3], [11]

2. Involving local communities in the management of a protected wetland is feasible and beneficial and the ecosystem approach, applied to managed flood releases to restore the structure and function of a severely damaged wetland ecosystem, can have positive impacts on biodiversity and livelihoods. The fundamentals of the ecosystem approach, such as applied in the ***Lower Senegal River Delta***, have been: (i) an open-minded and respectful listeners' attitude, permeated by an appreciation of the local historical and socio-cultural background; (ii) development issues were taken as seriously as environmental issues; (iii) the management plan development process targeted the entire Lower Senegal River Delta and not only the protected area; and (iv) continuous presence in the field was a prerequisite; in this way, the signals, emitted by both the ecosystem and the stakeholders, can be read and flexible responses provided. [12]

3. In the *Red River Basin* of ***Canada*** [4], the institutionalisation of flood mitigation is a concern. Flood fighting, management of flood control systems, and responsibility for post flood recovery all rest largely in the hands of government, freeing the individual from a perception of responsibility until a crisis. This reduces the effectiveness of flood damage reduction initiatives. In addition, there are nine municipalities in the Designated Flood Area, each with different approaches to flood risk management. A detailed analysis of the impacts of flood damage reduction strategies requires significant resources and municipal cooperation. Cooperation and exchange of information between departments and different levels of government must lead to a rigorous analysis of which strategies warrant the input of financial and human resources in future. This is a long-term goal in the Red River basin.

4. In ***China*** [5], the reclamation and use of lakes, flood plains and slope land in up-stream areas have reduced the storage/discharge capacity of floodwater in these areas. The flood control plans were difficult to put into practice and the conflicts between the local interest and overall river basin management led to inefficient flood operation during the flood periods. On the other hand, appropriate policies including economic ones were not emphasized in flood management before the 1998 large flood event. Local governments and people were often reluctant to follow the planned activities in flood management.

[12] More detailed information may be found in the extended summaries prepared for each of the case studies, available separately

5. The most important river basin in ***Ethiopia*** [6] in terms of existing developments and associated flood management is the Awash River. Uncontrolled soil erosion and land degradation resulting in heavy sediment transport in streams and rivers has caused significant reduction of the capacity of the only impounding reservoir for Awash flows. Water supply for irrigation and hydropower generation downstream depends on releases from this reservoir, which also serves as means of flood retention to protect downstream developments.

6. The *Regional Flood Preparedness and Early Warning System* for the ***Eastern Nile Countries*** under the *Nile Basin Initiative* (see also ***Section 3.2***), mainly to benefit Sudan, Ethiopia and Egypt, is to be started soon. Successful completion of this project will enable these countries to improve flood management and reduce flood damages to life, property and infrastructure, as well as to the environment. This is in sharp contrast to the previous situation of non-existence of exchange of advance information for early warning of flood occurrence.

7. The *Damodar Valley Commission* (DVC) of ***India*** [8], acting as a River Basin Organisation, is implementing the concept IWRM, through the development of irrigation, power generation, flood control and water supply facilities, while applying environmental protection measures in an integrated manner. The DVC is self-sufficient and self-sustaining. Models like DVC might be replicated and appropriate River Basin Organisations could be established for the integrated planning, development and management of other river basins, taking into account the needs of different uses of water with a multi-disciplinary approach.

8. In the geographical context of the Piemonte Region in ***Italy*** [9] it is almost impossible to cope with floods during the evolution of the phenomena; the flash floods generated prevent the opportunity to manage the events. For this reason, the main activity in coping with floods is provision of an early warning to the Civil Protection authorities, so that the safety measures predefined in the emergency plan can be organized in time. The objective of the system is mainly focused on preventing human losses during floods, while the active defence of infrastructures such as bridges, railways and villages is almost impossible to be achieved.

9. In ***Mali*** [11], existing legislative texts and rules related to the management of water need to be adapted to provide a more comprehensive and integrated view of the constitution and the uses of water resources. In addition, the on-going process of decentralisation with the creation of *communes* will modify some of the responsibilities related to water resources management, which needs to be reflected in the laws and regulations.

10. In ***Pakistan*** [13], [14], to further increase coordination and integrated effort at a broader level, pre- and post flood meetings are organized every year at national level, as a follow-up action to review the lapses and shortcomings during each previous flood season; this helps in further fine-tuning of the existing network and coordination system. A Manual (official document) has been prepared, listing the role of each and every organization and details of action to be taken for an integrated flood forecasting and management.

11. The present situation in ***Turkey*** [15] as regards risk assessment, underwriting and rating needs to be further developed. Floods are not only the result of climatic conditions but also of uncontrolled urbanization and inefficient infrastructure. Consequently, they represent a real risk for both insurance industry, their re-insurers and to the state. The insurance companies need to be equipped with the knowledge necessary to deal with the insurability of high floods in terms of geographical areas and for individual risks. In addition, the need to modernize the current disaster management system and increase its capability has been recognized. Recently proposed new legislation will give more power to local administrations and they will have their own budgets. It is expected that floods will be managed at local level.

12. The innovative nature of Parrett Catchment Project partnership approach in the ***UK*** [16], and the strength of a mutually agreed strategy have been recognised as a model for best practice, the principles of which may be applied to other areas hit by flooding.

13. In the ***USA*** [17], flood management policies and activities to deal with flooding on the Mississippi have shifted in nearly three centuries from ‘let the locals do it’ to full federal responsibility for an essentially structural-only approach, and subsequently moving to a federally led, locally shared mix of

structural and non-structural elements, that are gradually being combined with other water resource activities in a an integrated and comprehensive approach to basin water resources management. The sheer size of the Mississippi and the constitutional authorities of the states that comprise the basin lessen the ability of Government to develop a uniform approach. The technology of powerful data storage and manipulation devices, geographic information systems, remote sensing capabilities and global positioning are now making integrated planning of this complex river possible.

14. Also in the ***USA*** [18], current management approaches for reducing flood losses too often have allowed development to occur without considering its adverse impact on other properties within the watershed or on future flooding potential. This has contributed to steadily rising flood losses and is increasing the potential for future flood damage.

15. ***Zimbabwe*** [19] has a considerable number of dams, where water is stored as security for the dry years or seasons. There is therefore reluctance to release water from the dams in order to accommodate floods. The non-structural approach, which includes flood forecasts, is therefore used as an alternate strategy for flood management. If forecasts were accurate and the lead time reasonable, water resources managers would be in a better position to make decisions on whether to release water or not. Thus both structural and non-structural approach to flood management could be used to reduce the impact of floods and drought. The involvement of a broad spectrum of the population in management of floods, with particular emphasis on management at local level, has recently made the management of floods a lot easier than the traditional centralized approach.

16. The international ***Zambesi River Basin*** needs to be managed as one unit. At the moment each country has its own way of managing floods. A coordinated approach to flood management is needed, which would involve all eight countries sharing the basin.