World Meteorological Organization

IFM AS AN ADAPTATION TOOL FOR CLIMATE CHANGE: CASE STUDIES

A Tool for Integrated Flood Management

ASSOCIATED PROGRAMME ON FLOOD MANAGEMENT

February 2011

The Associated Programme on Flood Management (APFM) is a joint initiative of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP). It promotes the concept of Integrated Flood Management (IFM) as a new approach to flood management. The programme is financially supported by the governments of Japan and the Netherlands.

The World Meteorological Organization is a Specialized Agency of the United Nations and represents the UN-System's authoritative voice on weather, climate and water. It co-ordinates the meteorological and hydrological services of 187 countries and territories.

The Global Water Partnership is an international network open to all organizations involved in water resources management. It was created in 1996 to foster Integrated Water Resources Management (IWRM).

Note for the reader

This Tool has been compiled on the basis of referenced sources and documented best practices. As such this tool provides a snapshot on the current state of using the IFM practices for climate change adaptation. This Tool addresses the needs of practitioners and allows them to easily access relevant guidance materials. The Tool is considered as a resource guide/material for practitioners and not an academic paper. The Tool is a "Living Document" that is intended to be updated and revised based on materials to become available. Obviously, the Tool is not comprehensive in the sense that case studies from developing countries are presently not documented which will be a point to be addressed in subsequently revised updates. However, in its entirety, the Tool provides practical information covering a wide range of regions and different approaches that countries adopted in their quest to address adaptation to climate change related to floods and related hazards including sediment disasters, storm surges and sea-level rise. References used are mostly available on the Internet and hyperlinks are provided in the "References" section.

The Associated Programme on Flood Management encourages flood managers and related experts engaged in adaptation to climate change in the water sector from around the globe to participate in the enrichment of the Tool. *For this purpose comments and other inputs are cordially invited.* Authorship and contributions would be appropriately acknowledged. Please kindly submit your inputs to the following Email address: apfm@wmo.int under Subject: "IFM as an adaptation tool for climate change: Case studies".

Acknowledgements

This Tool has exploited the works of many organizations and experts, as listed in the references. Acknowledgement is due to the members of the Hydrology and Water Resources Department in WMO and the members of the Technical Support Unit of the APFM for their competent technical guidance and frank discussions on the issues and for bringing various perspectives into focus.

Disclaimer

APFM Technical Document No. 14, Flood Management Tools Series

TABLE OF CONTENTS

FIGURES

TABLES

1. UNITED STATES

1. In United States history of flood management, flood control structures composed of thousands of levees and dams were constructed according to the Flood Control Acts of 1928 and 1936. The safety levels that these levees provided for flood risk was in the range of 500 to 1000 year return periods. In 1986, the cost for flood control projects constructed by the U.S. Army Corps of Engineers (USACE) was to be shared with local authorities, as dictated by the Water Resources Development Act. This additional financial burden made the affordability of new levees and repairs of existing levees an emerging issue; thus, after the Act, many levee systems provided protection for floods with 100-year return periods.
To provide non-structural measures for flood management, in 1968 the National Flood Insurance Program (NFIP) was enacted (National Committee on Levee Safety, 2009).
Responsibilities for each level of government are outlined by the Inter-agency Floodplain Management Task Force (FEMA, 1986) as follows**:**

2. Federal Responsibilities

Improve federal support of state and local governments' role in floodplain management;
Centralize floodplain data sources at the state level;
Accelerate floodplain and hazard studies and improve dissemination of information to state and local users;
Support cost-sharing policies and project evaluation procedures that facilitate achievement of a desirable mix of structural and non-structural approaches;
Continue to evaluate the nature, size and trend of the federal subsidy to the NFIP and develop policies and procedures to decrease or eliminate subsidy in high hazard areas after repetitive losses have been experienced;
Improve flood forecasting and warning systems.

3. State Responsibilities

Enact enabling legislation specifically addressing floodplain management programmes and establish or designate a single state agency to assure responsibility for floodplain management;
Develop an information programme to supplement federal efforts to inform the public and local decision-makers about flood hazards and floodplain management;
Improve management tools;
Establish a hazard mitigation team;
Establish a mechanism to identify and monitor unsafe dams and levees and to provide hazard information to communities subject to their potential risk of failure;
Support regional, sub-state and local entities in implementing their floodplain management activities.

4. Local Responsibilities

Adopt and enforce floodplain management measures, including zoning subdivision and building codes that meet minimum standards recommended by national and state code organizations;

Coordinate with adjacent communities to assure that floodplain management practices do not shift the flood hazard to adjacent communities;
Develop review procedures to periodically assess the effectiveness of local floodplain management programmes.

5. For assessment of the impact of climate change, the Global Change Research Act of 1990 mandates that every four years an assessment of the impacts of global change in the United States be conducted by the U.S. Global Change Research Program (USGCRP, 2010).

1.1 Adaptation strategies and implementation to climate change in flood management

1.1.1 Strategies for Climate Change Adaptation

6. The U.S. Geological Survey (USGS), USACE, Bureau of Reclamation (Reclamation), and National Oceanic and Atmospheric Administration (NOAA) in February 2009 reported a federal perspective about climate change and water resources assessment (Brekke and others, 2009). These four federal agencies have collaborated to explore strategies to improve water management by tracking, anticipating and responding to climate change. Strategies include operational change, demand management and infrastructure changes. For operational change, the adaptation strategies seek better use of existing water resources by building more flexibility into operating plans and revising reservoir storage rules. In the short term, water managers could increase the adaptive capacity to climate change through increased flexibility. One way could be through the use of seasonal to annual climate forecasts. During seasons that are forecast to be dry, reservoir operators could make use of previously stored flood waters. For demand management, there are two possible strategies. One adaptation strategy is to enhance mechanisms for market-based transfers of water among users, which can allocate water rights adequately and provide an incentive to adopt water conservation owing to higher prices. Another strategy is to reduce overall water consumption through conservation and efficiency improvements. For infrastructure changes, the options to manage existing, long-lasting infrastructures – which are ageing and need maintenance, rehabilitation and repair – are discussed. Infrastructure needs to be evaluated for potential risk of possible increases in magnitude, frequency and duration of large floods. As part of management of existing long-lasting infrastructure, the National Committee on Levee Safety has been authorized to develop recommendations for the National Levee Safety Program in Section 9003 of the Water Resources Development Act of 2007 (U.S. Congress, 2007).

7. The strategy also stresses the importance of research and monitoring to fill knowledge gaps stemming from uncertainties in climate change predictions. Current planning, which mostly employs stationary methods, needs to apply appropriate non-stationary methods. Efforts also require inter-agency collaboration to develop existing models for climate change and spur further new thought to create new methods and models.

8. At the state level, there are some states that have their own adaptation strategies. California has established Integrated Flood Management in the California Water Plan, which

provides a framework for water managers, legislators and the public to consider options and make decisions regarding California's water future (California Department of Water Resources, 2009). The state recognized the necessity of paradigm shifts and decided to introduce an Integrated Flood Management (IFM) approach in flood management. Management consists of structural approaches; land-use management; disaster preparedness, response and recovery. The state will establish a System Reoperation Task Force comprising state personnel, federal agency representatives and appropriate stakeholders. The Task Force will provide analyses for river basin management. In particular, it will support the update of flood frequency analyses on major rivers and streams (California Department of Water Resources, 2008).

9. Other states have also tackled climate change adaptation. In New York, the New York State Legislature created the Sea Level Rise Task Force in 2007 to assess impacts to the state's coastlines from rising sea levels and to recommend protective and adaptive measures. The final report will be submitted to the Legislature by January 2011 (New York Department of Environmental Conservation, 2009). In addition to the task force, the state and local governments established a committee that aims at combating the impact of climate change. As an adaptation strategy, the committee raised adaptive management of infrastructures and operations to the municipal level and land-use management to the local government level.

10. In Maine, the Maine State Legislature passed a Resolve in April 2009 charging the Department of Environmental Protection (DEP) with establishing and convening a stakeholder group to evaluate the options and actions available to Maine's population and businesses to prepare for and adapt to the most likely impacts of climate change. The stakeholder group has developed a preliminary assessment of climate change impact on the state (Jacobson and others, 2009).

1.1.2 Implementation of Climate Change Adaptation Strategies

The NFIP can also promote the reduction of exposure by restricting the increase of exposure in hazard areas. Also, transfer of residual risk can be applied to a wider population of stake holders. In other words: NFIP forbids to build in hazard areas, but the buildings already there have to be insured in order to "transfer" the residual risk: in that way the population living in hazard areas will not be completely broken after the flood strikes

11. As the NFIP is an existing programme, it can be modified to suit changing climate circumstances. A possible increase in climate change factors makes it important for the NFIP to be updated to represent the most applicable data and methods. There are 10 states whose flood frequency analysis is more than 15 years old (Brekke and others, 2009). Flood insurance maps use these estimates to delineate Special Flood Hazard Areas for the NFIP. The current projects related to the updating of existing risk assessment are presented in section 1.2.

1.2 Risk assessment for climate change adaptation strategy

12. In the United States, FEMA is primarily responsible for flood risk assessment, including the NFIP, which consists of flood insurance, floodplain management and flood hazard mapping. Local communities located in floodplains that are delineated by a 100-year flood must apply to the NFIP to receive support after flooding. The rate of insurance will vary according to the safety level of the area where communities are located. A Flood Insurance Rate Map (FIRM) shows flood elevation, flood zone and floodplain boundaries.

13. From fiscal year 2003 to fiscal year 2008, FEMA carried out the project called “Flood Map Modernization”. The project made most of the nation’s 100,000 flood maps widely accessible electronically, and significantly improved the horizontal accuracy of flood hazard maps and made some focused investments in vertical accuracy, based on improved GIS databases. The project also provided useful measures to increase stakeholders’ awareness. As a follow-up, the project “Risk Mapping, Assessment and Planning (Risk MAP)”, which aims at delivering quality data for public awareness and leads to action for risk reduction, has been proposed (FEMA, 2009).

14. The Risk MAP has five goals for the period 2010–2015. One of the goals is to “Address gaps in flood hazard data to form a solid foundation for flood risk assessments, floodplain management and actuarial soundness of the National Flood Insurance Program”. It takes into account needed periodic flood hazard analysis to consider physical changes, climate changes and engineering methodology changes in the analysis.

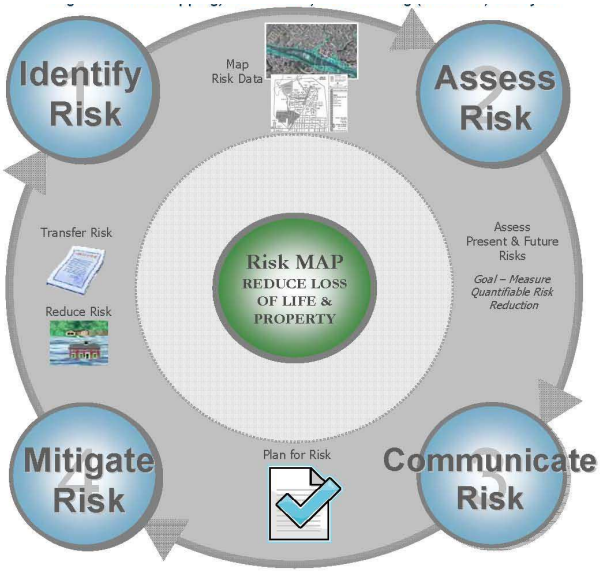


Figure 1. Risk MAP lifecycle (FEMA, 2009)

2. UNITED KINGDOM (England)

15. In England, flood risk management is complex and involves a variety of agencies that carry out this responsibility. The Department for Environment, Flood and Rural Affairs, known as Defra ,has policy responsibility for flood and coastal erosion risk management, whereas delivery on the ground in relation to river and coastal flooding is the role of operating authorities such as the Environment Agency (EA), local authorities and Internal Drainage Boards (IDBs) . The EA is responsible for management of flood risk from main rivers and seas, flood forecasting and flood warning, and exercising general supervision over matters related to flood defense. Local authorities are responsible for planning for emergencies, dealing with the consequences of flooding, such as humanitarian assistance; emergency housing and clean up operations; and building and maintaining defenses on ordinary watercourses. The EA also operates grant aid for flood risk and coastal erosion projects. IDBs are responsible for land drainage; thus, they have authority to undertake work to secure drainage and water level management of their district. They may also undertake flood defense work on ordinary watercourses within their district. IDBs' flood management is supported by Defra at a rate of 45 per cent.

16. Defra and the EA have prepared detailed instructions designed to provide integrated guidance on all aspects of project appraisal to assist practitioners.

17. In Scotland, the Scottish Executive has a similar responsibility to that of Defra (Defra, 2008). In addition, the Scottish Environment Protection Agency (SEPA) is responsible for operating flood warning and providing advice to local authorities on flood risk and flood prevention for planning purposes. SEPA is also responsible for preparing flood risk assessment, which is described in section 2.3.

18. In Wales, the Welsh Assembly Government has a similar responsibility to that of Defra.

19. For assessing the impact of climate change, the Government of the United Kingdom established the UK Climate Impacts Programme (UKCIP) in 1997, which is funded by Defra. UKCIP's climate change scenarios for the United Kingdom are based on dynamic downscaling from the global climate model (HadCM3) to the regional climate model (HadRM3) of the Hadley Centre[1]. UKCIP released the set of climate change scenarios, UKCIP02, in April 2002, and a new package of climate change scenarios, UKCIP09, in June 2009. In UKCIP09, individual model runs have been carried out for the three emissions scenarios (low, medium and high) as well as for the entire period (UKCIP02 was limited to a single emission scenario and a single future time period) (HM Government, 2006).

[1] For further details on these two models, see figure 7 in section 5.2 - *Downscaling of models* of the *Guidance on Water and Adaptation to Climate Change* (UNECE, 2009)

20. In Scotland, the Scottish Climate Change Impacts Partnership (SCCIP) derives more detailed information from the UKCIP.

2.1 Adaptation strategies and implementation to climate change in flood management

2.1.1 Strategies for Climate Change Adaptation

21. The United Kingdom's climate change adaptation strategies are focusing on risk management approach.

22. The United Kingdom established a law for climate change, the Climate Change Act, on 26 November 2008. The Act sets the year 2050 as a target for mitigation and adaptation to climate change. In its adaptation chapter, the report mentions the submission of the first report on assessment of the risks for the United Kingdom of the current and predicted impact of climate change. Subsequent reports must be presented before Parliament no later than five years after the previous report is presented (OPSI, 2008).

23. The climate change strategy for flood management has been undertaken by the EA since 2005. The EA published the first strategy paper, which targeted 2005–2008; and the second strategy paper, which targeted 2008–2011. The Act is taken into consideration in the second strategy paper. The contents of strategies related to flood risk management are as follows:

Revision of National Flood Risk Assessment (NaFRA), which includes new climate change science and use of the UKCIP scenarios;

Flood risk management long-term investment strategy;

Revised climate change allowances in the technical guidance;

Development of inter-agency climate change adaptation programme and establishment of a Board to oversee and drive delivery of both the strategy and the programme (EA, 2008).

24. NaFRA has already been revised with new inputs; and a long-term strategy has also been established with the results of NaFRA. The Act and the strategies focus on risk assessment of the impacts of climate change.
The national government also added supplementary notes in its technical guidance for dealing with climate change impacts. Local authorities must take these notes into account when preparing their development plans. The guidance also gives precautionary sensitivity ranges of rainfall intensities and peak river flows for assessing the impacts of climate change (Table 1).

25. The Government of Scotland enacted the Climate Change Act in 2009, which designates the Scottish Ministries responsible for developing programmes to adapt to climate change (OPSI, 2009).

Table 1. Recommended contingency allowances for net sea level rise
(UK Government, Department of Communities and Local Government, 2006)

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South West	3.5	8.0	11.5	14.5
NW England, NE England (north of Flamborough Head)	2.5	7.0	10.0	13.0

2.1.2 Implementation of Climate Change Adaptation Strategies

26. Flood risk assessment, which was stated in climate change adaptation, has been updated in 2009, including inputs from UKCIP09. It shows that about 5.2 million properties (2.4 million at risk of river and coastal flooding, and 2.8 million at risk of surface water flooding) in England, or one out of six properties, are at risk of flooding (EA, 2009*b*). NaFRA 2008 identifies the number and types of important infrastructure and public services in flood risk areas. The detail of this assessment is explained in section 2.2.

27. At the regional level, there are flood management projects that consider the impact of climate change along with the guidance provided by the federal government.

Integrated Planning: Brent Cross Cricklewood regeneration, London

28. According to the guidance, regeneration projects for Cross Cricklewood have been implemented. By using a computer model, the effects of climate change on flood risks for the site were assessed. In designing a flood process, the effect of climate change is taken into consideration by using an allowance of +20 per cent, which is instructed in the guidance. The projects leave the undeveloped areas at risks of flooding undeveloped, so that these areas behave as extra storage during flooding.

29. This undeveloped area will become a riverside walkway and a green space to a more natural state, incorporating a wetland area. Sustainable drainage, such as green roofs and permeable paving, is also planned to reduce surface water under intense rainfall at the location (Brent Cross Cricklewood Partners, 2008).

Flood alleviation scheme: Carlisle

30. In January 2005, over 1,800 Carlisle properties were flooded; two residents died as a result and more than 70 individuals were injured. The EA now has a flood alleviation scheme

in place. During the first phase, which was implemented in 2008, 4 km of embankment were raised to protect nearly 1,500 properties. During the second phase, new information was gathered and expected impacts of climate change were taken into consideration. The phase included 5 km of raised embankment, which could protect an additional 1137 properties. Both schemes will allow the area to cope with a significant flood event; and the likelihood of this event will increase due to climate change. These two phases significantly improved the standard of flood defense to a level of service equivalent to a 200-year flood, based on current design criteria (EA, 2009*a*).

2.2 Legal and institutional role in climate change adaptation

31. In April 2009, Defra drafted a new Bill for flood and water management. The provisions changed the effect of the law only in England; the Welsh Assembly Government supports the principles of this change, and intends to extend these provisions to include Wales. The purpose of the revised Bill is to adapt to climate change and satisfy the EU Floods Directive. Current flood and coastal erosion risk management is based on outmoded approaches and organizational structures that were constructed in the 1930s and 1940s. The draft Bill clarifies the responsibility for flood and coast erosion risk management because the current legislation does not reflect the creation of institutions for flood management; the impact of climate change and other pressures; environmental, cultural and social interests; flooding source management; or the recent EU Floods Directive. For climate change adaptation, the Bill does not set out particular provisions but an approach that provides scope to manage all risks. The Bill will give the EA a strategic overview role; provide for new local authority leadership in local flood risk management; and clearly set out which organization is responsible for managing the risk.

32. Currently, the responsibilities of different entities for flood risk management are not entirely clear. Defra has policy responsibility for flood and coastal erosion risk management in England, whereas delivery on the ground in relation to river and coastal flooding is the responsibility of operating authorities – the EA, local authorities and Internal Drainage Boards. There is no organization identified, however, as the responsible authority for flooding from surface runoff or groundwater (Defra, 2009).

2.3 Risk assessment for climate change adaptation strategy

33. NaFRA is an assessment of the risk and vulnerability (infrastructure, services, and so forth) caused by flooding from rivers and sea in England. The assessment includes the extent to which flood defense structures reduce the chance of flooding and what might happen if they are overtopped or fail. The assessment provides a picture of the damage that may occur. This includes costs, numbers, types and location of properties affected, but does not include risk to life, damage to crops and livestock, disruption of commerce and transport, long-term changes to habitats, land use and land value.

34. The assessment identifies land at risk from flooding using three risk categories. These categories consider the chances of severe weather causing floods and the likelihood of overwhelming defense structures to their failure.

Table 2. Flood risk categories in NaFRA (EA, 2009*b*)

Risk category for a location	The chance of flooding in any year at that location	
Low	Less than 0.5 per cent	One in 200 chance in any given year
Moderate	0.5-1.3 per cent	One in 200 to 1 in 75 chance in any given year
Significant	More than 1.3 per cent	One in 75 chance in an given year

35. Based on NaFRA, 2008, and the UK Climate Projection, 2009, EA has published a long-term strategy for investment (2010–2035), which concludes that a steady increase in investment is needed (EA, 2009*c*).

36. EA predicts that by 2035, if investment in flood risk management is kept at current levels, there could be an additional 350,000 properties at significant risk of flooding from rivers and seas in England (currently 490,000 properties are at significant risk), and by the 2080s, annual economic damage from flooding in the United Kingdom could increase from £1 billion to between £15 billion and £21 billion (EA, 2009*a*).

37. In Scotland, the Flood Risk Management Act was enacted in June 2009. The Act is aimed at introducing a more sustainable and modern approach to flood risk management, taking into consideration the impact of climate change and the EU Floods Directive (see Chapter 3). Specific measures within the Act include the following (The Scottish Government, 2009):

A framework for coordination and cooperation between all organizations involved in flood risk management;

Assessment of flood risk and preparation of flood risk management plans;

New responsibilities for the Scottish Environment Protection Agency (SEPA), Scottish Water and local authorities in relation to flood risk management;

A revised, streamlined process for flood protection schemes;

New methods to call on stakeholders and the public to contribute to managing flood risk;

A single enforcement authority for the safe operation of Scotland's reservoirs.

3. EUROPEAN COMMISSION

38. In April 2009, the European Commission published the White Paper, which introduced a framework for adaptation measures and policies to reduce the European Union’s vulnerability to the impact of climate change. For flood management, the paper focuses on the importance of integrated basin approach and risk assessment through existing Directives. The Water Framework Directive (WFD) and Floods Directive require Member States to apply integrated approaches based on existing river basins (European Commission, 2009). The Floods Directive requires Member States to assess risk of flooding,

publish flood hazard maps and have risk assessment plans, providing a comprehensive mechanism for assessing and monitoring increased risk of flooding owing to climate change and for developing appropriate adaptation approaches. The paper therefore states that adaptation should be integrated into the implementation of these Directives.

39. The risk assessment mentioned in the Floods Directive contains three steps. Preliminary flood risk assessment, consisting of maps that include river basin, topography, and so forth, and information about floods that occurred in the past and caused damages in the flooded area. Preliminary flood risk assessment should be completed by December 2011. Based on the result of preliminary flood risk assessment, Member States have to complete flood hazard maps and flood risk maps by December 2013. Flood hazard maps should contain information on flooding extent, water depth and flow velocity (if required), which are simulated according to the following three scenarios: extreme event, medium probability event and high probability event. Flood risk maps should contain information about population, economic activity and potential source of pollution in the simulated inundation area through the three scenarios mentioned above.

40. The Directive also mentions that these assessments as well as maps should be reviewed and revised every six years. Frequent revision enables the impact of climate change to be taken into account according to the latest knowledge (European Commission, 2007).

4. FRANCE

41. In France, the Government was not responsible for flood management up until the implementation by the Local Law in 1987, which involved local authorities in flood protection. Prior to that, as had been established by the Civil Law of 1807, landowners along the river were responsible for protecting themselves from flooding. In 1994, responsibility for natural disasters of local governments was strengthened, and the implementation of Risk Prevention Plans (PPRs) was obliged.

42. PPRs are the main zoning instruments in France. PPRs are set up by the central government, through the responsibility of local representatives. They identify the limits of floodplains and develop mapping of different hazard zones, each of them associated with specific regulatory restrictions (Enjolras and others, 2008).

43. The zoning defined by PPRs is made available to the public by the Ministry of Ecology, Energy, Sustainable Development and the Sea through the website of the PRIM (Prevention Risques Majeurs – Prevention of major Risks) www.prim.net, including the Cartorisque initiative (http://cartorisque.prim.net/index.html). Maps shown on the Cartorisque Website include a number of natural risks including floods, landslides, avalanches, and seismic areas., For flood hazard risk, maps show the extent of 10-year and 100-year floods and a number of historical floods (depending on the region).

44. Since 2002, France has promoted an integrated basin-wide approach by providing public financial support and Flood Prevention Action Programmes (PARIs) to all state and local authorities in the basin. The programmes include actions to improve the local population's knowledge about floods; set up prevision and warning systems; continue protection of housing and reduction of vulnerability with PPRs; promote local protection of urban areas with building of new infrastructure; and help regulate water flows within floodplains through dynamic flood retention.

4.1 Adaptation strategy and implementation to climate change in flood management

4.1.1 Strategies for Climate Change Adaptation

45. France's adaptation strategies for flood management are focusing on river basin approaches and risk assessment through the strengthening of two programmes.

46. In November 2006, the National Strategy on Climate Change was announced by the National Observatory of Climate Change Effects (ONERC). ONERC was embodied by the Act of 19 February 2001. It has the following responsibilities:

Collecting and disseminating information, studies and research on risks to global warming and climate extremes;

Making recommendations on prevention and adaptation to consider limiting the risks of climate change;

Contributing to dialogue on climate change with developing countries.

47. The strategy outlines how to address the subject of climate change adaptation, and establishes an approach on adaptation measures. For water resources in France, all operations aimed at reducing vulnerability of flood risk, such as those advocated in the programmes of prevention of floods (PARIs), should consider the change of probabilities of occurrence of extreme events risk maps (as part of Risk Prevention Plans (PPRs)). This approach should be in accordance with new knowledge about climate change (ONERC, 2007).

48. The Programme Management and Impacts of Climate Change (GICC), led by the Ministry of Ecology, Energy, Sustainable Development and the Sea, the Environment and Energy Conservation Agency, and ONERC,, was launched in 1999. GICC works with concerned ministries developing knowledge on climate change impacts to back up public policies on climate change adaptation and mitigation measures (GICC, 2009).

49. Research on climate change impacts and adaptation is ongoing in a large number of research organizations. Scenarios that describe possible future climate in France have been developed by Meteo France; the Central European Research and Advanced Training on the Scientific Computing (CERFACS); and the Institute Pierre-Simon Laplace (IPSL).

4.1.2 Implementation of Climate Change Adaptation Strategies

Flood Prevention Action Programmes (PARIs)

50. Total cost for PARIs is €79 million, which will be implemented over 2006–2013. In 2004–2008, PARIs was financed in 42 basins across France. PARIs are usually developed and implemented by a water and flood management institution led by an elected group of representatives of all local councils in the basin. The programmes include actions to improve the local population's knowledge about floods to set up forecast and warning systems; to continue the protection of housing and the reduction of vulnerability with PPRs; to allow local protection of urban areas with the building of new infrastructure; and to promote the regulation of water flows within the floodplain through "dynamic flood retention" (Enjolras and others, 2008).

51. In the watershed of the Meuse River, in France, there are 700 municipalities and 465 000 individuals living in flooding risk areas. Local states, prefects and authorities have outlined projects along the concept of PARIs, which would cost €27 million. The projects consist of improvement of flood forecast and warning systems, education activities and some structural measures. As one of the structural measures, they introduced a levee that transverses (see Figure 2) the Meuse River to make the river flow slow down only during a flooding situation and to store flood waters upstream (EPAMA, 2009).

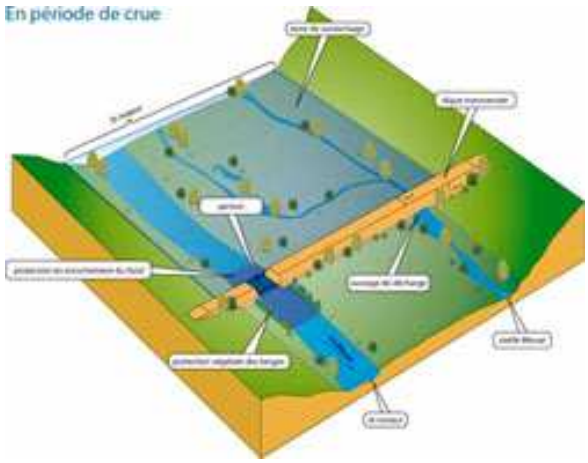


Figure 2. Mechanism of transverse embankment (EPAMA, 2009)

52. For basins of the Allan and Savoureuse Rivers, a PARIs has been in existence since 2004. The project consists of capacity development, forecasting, reserving or creating new storage areas and protecting populated areas. The total cost for the programme during 2004–2007 was €10 million (EPTB, 2007).

4.2 Risk assessment for climate change adaptation strategy

53. With collaborating regional authorities, the federal government created an atlas that shows the areas with the highest risk of flooding. The maps were developed by using the "hydrogeomorphic method". These maps are used as reference tools for country departments so that they can provide services they are responsible for. The Flood Risk Prevention Plan (PPRI), one of the PPRs focusing on flood risk, has been developed based on the atlas.

In the central part of Paris, the flooding area has been determined by past flooding, which in 1910, was the largest observed flood in the Seine River basin. The depth of flooding was also quantified from computing simulations that used the magnitude of the floods in 1910. The flood hazard map, therefore, shows the extent and depth of the flooding. For the PPRI, the Regional Environmental Directorate (DIREN - Direction regional de l'environement) of the Ile-de-France region has established four zoning areas, which are delineated by the depth of flooding and degree of urbanization.

54. At the Loing Valley, zoning is delineated by the highest water level (PHEc) observed during a period of more than 100 years and the current land use. In the region, the PHEc was determined by the historical 1910 flood and partly by the 1955 flood. The floodplain is divided into seven zoning areas, and depending on the zoning, the local government has established regulations for local development and construction (DDEA de Seine et Marne, 2009).

Enjeu / Aléa	champs d'inondation à préserver	espaces urbanisés		
		autre zone urbanisée	zone urbaine dense	centre urbain
Faible à moyen : 0m<h<1m				
Fort : 1m<h<2m				
Très fort : h>2m				

Tableau synthétique simplifié du règlement
(autorisations de constructions nouvelles)

Enjeu / Aléa	champs d'inondation à préserver	espaces urbanisés		
		zone urbaine peu dense	zone urbaine dense	centre urbain
Faible à moyen : 0m<h<1m	ZONE JAUNE FONCÉ - équipements collectifs - équipements à usage sportif récréatif, et/ou de loisirs, y compris les installations fixes d'accueil	ZONE JAUNE CLAIR - habitations individuelles en "dent creuse" - locaux à usage d'activités - équipements collectifs - équipements à usage sportif récréatif, et/ou de loisirs, y compris les installations fixes d'accueil	ZONE BLEU CLAIR - habitations individuelles ou collectives en "dent creuse" ou en ZAC, en lotissement, etc. - locaux à usage d'activités - équipements collectifs - équipements à usage sportif récréatif, et/ou de loisirs, y compris les installations fixes d'accueil	ZONE VERTE toutes constructions
Fort : 1m<h<2m	ZONE MARRON - équipements à usage sportif récréatif, et/ou de loisirs, y compris les installations fixes d'accueil à condition d'être en rapport avec la présence du milieu naturel aquatique et sur pilotis	ZONE MARRON - équipements à usage sportif récréatif, et/ou de loisirs, y compris les installations fixes d'accueil à condition d'être en rapport avec la présence du milieu naturel aquatique et sur pilotis	ZONE BLEU FONCÉ - habitations individuelles ou collectives en "dent creuse" - locaux à usage d'activités - équipements collectifs - équipements à usage sportif récréatif, et/ou de loisirs, y compris les installations fixes d'accueil	ZONE VERTE toutes constructions
Très fort : h>2m	ZONE ROUGE - équipements à usage sportif récréatif, et/ou de loisirs, à l'exclusion des installations fixes d'accueil autres que celles destinées aux activités nautiques	ZONE ROUGE - équipements à usage sportif récréatif, et/ou de loisirs, à l'exclusion des installations fixes d'accueil autres que celles destinées aux activités nautiques	ZONE ROUGE - équipements à usage sportif récréatif, et/ou de loisirs, à l'exclusion des installations fixes d'accueil autres que celles destinées aux activités nautiques	ZONE ROUGE - équipements à usage sportif récréatif, et/ou de loisirs, à l'exclusion des installations fixes d'accueil autres que celles destinées aux activités nautiques

ATTENTION : CE TABLEAU N'A QU'UNE VALEUR INFORMATIVE - SE REPORTER AU RÈGLEMENT POUR L'APPLICATION DU PPR

Figure 3. Criteria for zoning at the Loing Valley_(DDEA de Seine et Marne, 2009)

5. GERMANY

55. In Germany, responsibility for flood management is mostly at the state level (Länder). The federal government enacted the Federal Act in their Länder laws, obliging Länders to include floodplain management, designation of floodplains and implementation of regulations designed to protect against the risk of flooding. Länders are also in charge of developing flood control plans to help minimize damage. Plans should include preservation or restoration of retention areas, relocation of dykes, preservation or restoration of alluvial meadows and retention of precipitation water (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2002).

5.1 Adaptation strategy and implementation to climate change in flood management

5.1.1 Strategies for Climate Change Adaptation

56. The German Strategy for Adaptation to Climate Change was published in December 2008 by the Federal Ministry for the Environment, Nature Conservation and Nuclear safety. The strategy pursues an integrated approach to assessing risks and action needs, supporting sustainable development.

57. By transposing the EU Water Framework Directive and the EU Floods Directive into the national law in the German Environmental Code, the German Government will introduce an integrated river basin approach and risk management in flood management.

Infrastructures such as dams, reservoirs and retention basins are managed in an integrated manner in the catchment areas' overall water management system.

58. At the Länder level, nine Länders have presented adaptation strategies. These Länders have developed their future regional climate projections through climate models. The majority of Länders use two or more regional climate models, including the dynamic and statistical models. For the emissions scenarios, all Länders except one use the scenarios given in the IPCC Third Assessment Report (SRES scenarios) (German Federal Government, 2008).

- In April 1999, the Climate Change and Consequences for Water Management (KLIWA) was established by water agencies in the states of Baden-Württemberg and Bavaria as well as the German Weather Service. This project aims at assessing the impact of climate change, developing climate projection models and disseminating results of their research (KLIWA, 2009). The influence on discharge of 100-year floods of the Neckar River is estimated to increase by 15 per cent. Therefore, flood management structures will be designed based on the new value, which is multiplied by the climate factor of 1.15 (KLIWA, 2008).
- In Länder Sachsen-Anhalt, the government has set up a departmental and cross-disciplinary working group on climate change, which consists of several ministries, national offices, institutions and local organizations for flood control and water management. The working group deals with the topics of climate change and climate adaptation and notes the regions and sectors particularly exposed to climate change impacts (Sachsen-Anhalt Ministry of Agriculture and Environment, 2009).
- In Niedersachsen, to deal with climate change, the government, in 2001, gave additional responsibility to the state Ministry for Environment and Climate Change, which is responsible for the protection of water, soil, nature, air and climate policies for waste, radiation protection and nuclear safety and energy policy. For flood management, the state government is planning to take into consideration the impact of climate change into flood management planning.
- The state of Hessen launched a programme for climate change, which aims at integrating existing programmes under the aspect of climate change.

5.1.2 Implementation of Climate Change Adaptation Strategies

59. The Federal Act defines "floodplains" as those areas that are subject to 100-year floods, and thus obliges Länder to designate floodplains by 10 May 2012 (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2005). The current status for flood hazard mapping according to each Lander's Website is presented in Table 3.

Table 3. Current practices of risk assessment and mapping in German Länders

Länder	*Flood Hazard Map*				
	Return period	Water level	Other factors	Risk	Source
Baden-Württemberg	1/10, 1/50, 1/100, extreme	1/100	-	-	Document
Bayern	1/30, 1/100, 1/300	-	-	-	Internet
Berlin					
Brandenburg					
Bremen	1/5 summer, 1/100	1/5 summer, 1/100	-	-	Document
Hamburg					
Hessen	1/100?	1/100?		-	Internet
Mecklenburg Vorpommern					
Niedersachsen					Internet
Nordrhein-Westfalen	1/100?	-		-	
Rheinland Pfalz	1/50, 1/100, 1/200, extreme		Danger (matrix)	-	Internet
Saarland	1/200	-	-	-	Internet
Sachsen	1/20, 1/50, 1/100 or 200/300	extreme	-	Damage (extreme)	Internet
Sachsen-Anhalt	1/100?			-	
Schleswig-Holstein					Internet
Thüringen					

60. Most Länder have published their hazard map on the Internet. All flood hazard maps show at least the extent of 100-year floods, which was obliged in the Federal Act. Types of information in the hazard map, however, are different for each Land.

5.2 Risk assessment for climate change adaptation strategy

61. As mentioned above, although there are differences in the approach for assessing risk in Länder, this section introduces some advanced examples.

62. In Sachsen, the extent of high probability (20-year); medium probability (100-year); extreme event (200 or 300-year); and water level of extreme event are shown. The state also shows on the map estimated damage caused by an extreme event, such as economic, or direct, losses (damage to buildings, properties and households), but does not show indirect losses.

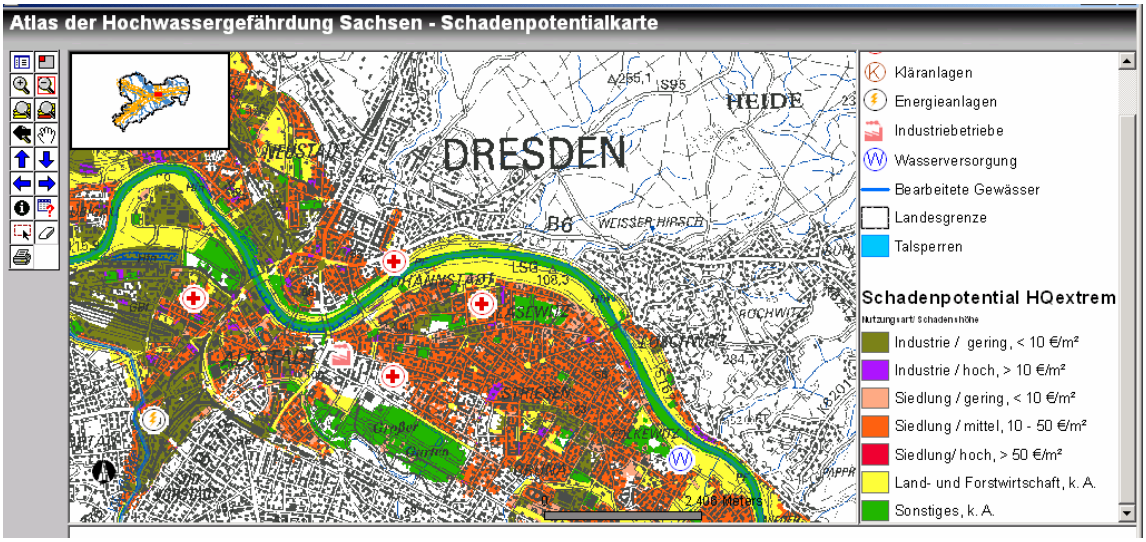


Figure 4. Flood damage map of Sachsen

(Source: http://www.umwelt.sachsen.de/de/wu/umwelt/lfug/lfug-internet/wasser_13888.html)

63. In Baden-Württemberg, the state government has published flood hazard maps that contain the extent of a 10-year flood, 50-year flood, 100-year flood and extreme flood (if available), and the water level of 100-year flood. Maps are used by individuals, local authorities and regional associations, and so forth. Maps show information on flood prone areas and therefore are a spatial planning tool for local authorities and regional associations

6. NETHERLANDS

64. In the Netherlands, inhabitants have traditionally organized communities for flood protection and water management themselves. Before the thirteenth century, organization was limited to local flood protection. Inhabitants maintained their own part of the dike. Also during the thirteenth century, inhabitants organized the damming off of tidal inlets and creeks. Involved communities sent representatives to meetings, which were called water boards (waterschap or *hoogheemraadschap*). The water board is based on the triple concept: interest, taxation and representation. After realizing the difficulties of managing the Rhine and Meuse Rivers, the central government began its task in late 1798 – it created the State Water Authority (Rijkswaterstaat, or the Directorate-General of Public Works and Water Management). This authority has been functioning since that time. The Provinces have since remained competent and create or renovate the water boards, under the supervision of the central government. In addition, the general budget allocates for states' flood protection and water management. Water boards organize regional flood protection and quantitative water management according to the profit principle. The size of everyone's profit from activities of the institution defines the tax contributed to and the participation in the board. Public authorities have the duty to fulfil the requirements formulated by state or provincial governments.

65. The states' flood protection and water management activities include:

Formulation of the national, strategic policy on flood protection and water management; supervision of its realization; and enforcement.
Operational tasks for infrastructure.

66. The provinces take care of interpretation and application of the national policy at the provincial level. Activities are financed by the general budget of the province, which is funded by the state budget and by surcharges on the motorcar tax (Huisman, 2002).

6.1 Adaptation strategy and implementation to climate change in flood management

6.1.1 Strategies for Climate Change Adaptation

67. In September 2007, the Dutch Cabinet appointed a new Delta committee to formulate plans for the long-term protection of the Dutch coast and its hinterland. The committee has drafted the Delta Programme to implement its recommendations for a climate-proof Netherlands, which will be embedded, financially, politically and administratively in a new Delta Act (Delta Committee, 2008).

68. Recommendations are based on the scenario that was given by the Royal Netherlands Meteorological Institute (KNMI). In 2006, the KNMI worked out two scenarios for sea level rise off the Dutch coast. KNMI assumes a temperature increase in 2100 of 2℃ in its “low temperature scenario” and of 4℃ in its “high temperature scenario”. This results in a sea level rise of 15 to 35 cm in 2050 and of 35 to 85 cm in 2100.

69. According to a 2007 IPCC report, in 2100, the Netherlands will be faced with temperatures from 1.5℃ to 6.0℃ higher than the av erage temperature in the time period from 1980 to 2000.. Given a temperature increase of 6.0℃ in the Netherlands, the sea level is expected to rise from 0.55 to 1.2 m. Owing to glacial isostasy and subsoil compaction, the Dutch coast will be well over 10 cm in 2100. For 2050, the Delta Committee has used the KNMI 2006 scenarios (KNMI, 2006) for a sea level rise of 0.2 to 0.4 m.

70. According to the KNMI 2006 scenarios, the increasing temperature and changing air circulation patterns will result in lower summer discharges and higher winter discharges for the Rhine River. The design discharge (1/1 250) will rise from 16,,000 m^3/s to 17,000–22,000 m^3/s. 18,000 m^3/s of the total discharge will reach the Netherlands. The design flood for the Meuse River (1/1250) will increase from 4,200 to 4,600 m^3/s. Under this scenario, a regional sea level will rise from 0.65 to 1.3 m by 2100 and from 2.0 to 4.0 m by 2200. For the Rhine and Meuse Rivers, maximum design discharges are likely to be about 18,000 m^3/s and 4,600 m^3/s around the year 2100.

71. Based on these changes in design discharge under KNMI 2006 scenarios, the following measures are recommended:

72. Safety level: The present safety level of all embanked areas must be improved 10-fold by the year 2050. After 2050, safety levels must be regularly updated, in accordance with the EU Flood Risk Framework Directive.

73. New building plans: Decisions on new building plans in physically unfavorable areas should be based on integral cost-benefit analysis, to include total present and future costs to all parties. The cost of local decisions must be borne by those who benefit.

74. Floodplains: The government will not offer any protection in the floodplains that can decrease river discharge capacity or increase the water level in lakes or the sea. In the floodplains, residents/users are responsible for their own protection measures. The government plays a role in facilitating public information, advice and warnings to such areas.

75. North Sea Coast: Coastal safety along the sandy shores of Zeeland, Holland and the Wadden Islands is maintained by beach nourishment. Tidal channels will be relocated where necessary. By 2050, 85 million m^3/year of sand will need to be replenished.

76. Wadden Region: Beach nourishment along the North Sea Coast will help the Wadden Region maintain its pace. Developments must be carefully observed and analysed.

77. South-western Delta, Eastern Scheldt: The Eastern Scheldt storm-surge barrier is adequate until at least 2050. The barrier's disadvantages should be alleviated in the future by compensating the losses in the inter-tidal zones by nourishing and bringing in sand from the outside. After 2050, the Eastern Scheldt storm-surge barrier will be extended.

78. South-western Delta, Western Scheldt: Safety depends on strengthening the dikes.

79. South-western Delta, Krammer-Volkerrak Zoommeer: Temporary storage of river water in the Krammer-Volkerrak Zoommeer, the Grevelingen and possibly the Eastern Scheldt will be required in cases where high river discharges coincide with closed storm-surge barriers in the mouth of the Rhine River.

80. Rivers region: The current programme, "Room for the River", aiming to increase the discharge capacity in the Dutch Rhine, will result in the safe discharge of 16,000 m^3/s through Rhine River distributaries by 2015. Until 2050, measures to cope with discharges of 18,000 m^3/s through the Rhine River and 4 600 m^3/s through the Meuse River must be implemented in a cost-effective manner. Consultation with neighboring countries will be necessary under the EU Floods Directive. After 2050, the remaining measures to allow the Rhine River to cope with 18 000 m^3/s, and the Meuse River with 4 600 m^3/s, must be completed.

81. Rijnmond: A very large flood gate that is able to be opened and closed is recommended for dealing with flood protection, fresh water supply and urban development. The natural tidal dynamics in the Rijnmond region will need more room.

82. Ijsselmeer region: The higher water level in the Ijsselmeer Lake of maximum 1.5 m, which discharges into the Waddern Sea, should be kept as long as possible without

pumping. This will help maximize flexibility of the fresh water supply. Leading up to 2050, measures to facilitate water level rise can be implemented gradually.

83. Political-administrative, legislative and financial aspect: Political and administrative measures of water safety should be reinforced. Financing for flood protection and fresh water security measures should be guaranteed for the Delta Act to embed political and administrative measures and to secure funding within the present constitutional system and current legislation.

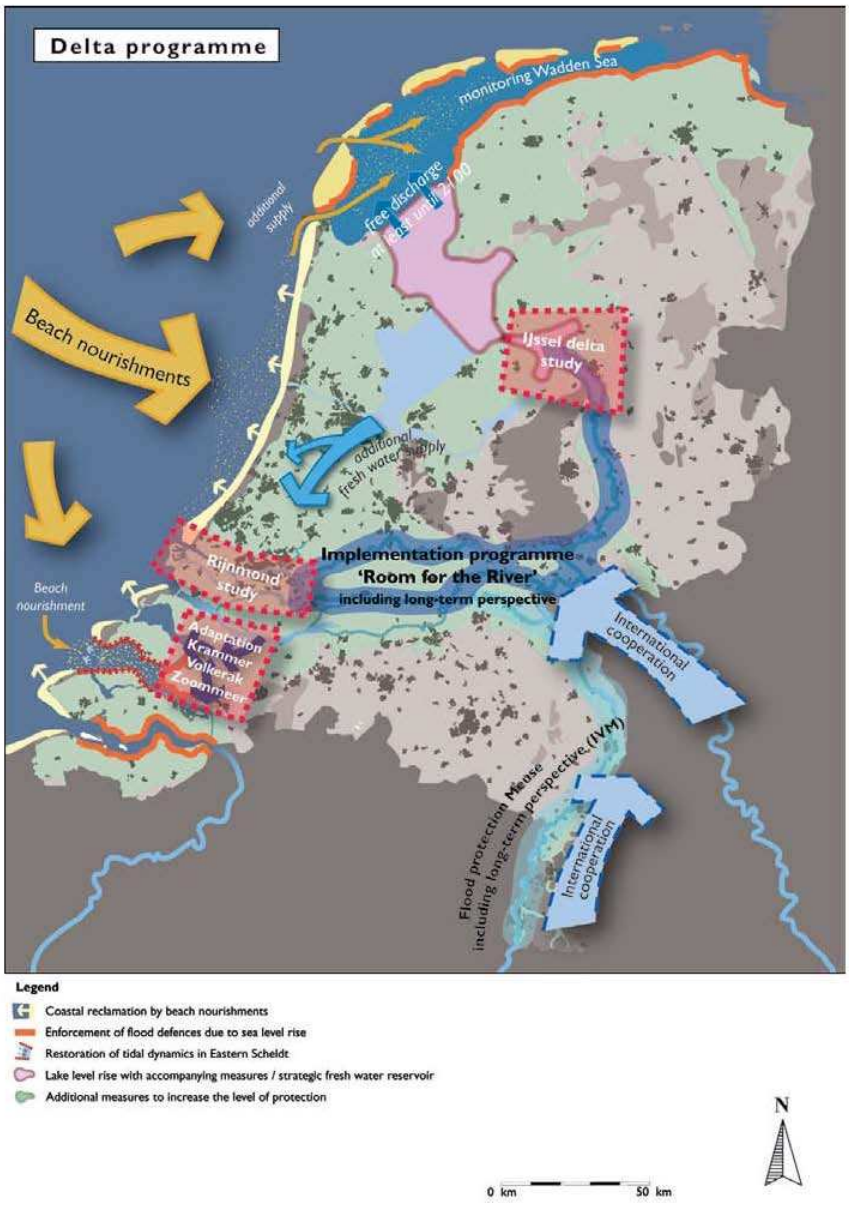


Figure 5. Activities in the framework of the Delta programme
(source: http://www.deltacommissie.com/doc/deltareport_full.pdf)

84. Implementation of the Delta Programme until the year 2050 involves a cost of €1.2 billion to €1.6 billion per year, and from 2050 to 2100, €0.9 billion to €1.5 billion per year.

85. The Netherlands also has an adaptation strategy for spatial planning. The National Programme for Spatial Adaptation to Climate Change was launched in 2007 (ARK). The objectives of this programme are as follows (Ministry of Housing, Spatial Planning and the Environment and others, 2007):

Raise awareness, form networks and develop strategies;

Develop and disseminate knowledge, and develop a common view;

Develop instruments, and provide advice on measures and implementation.

6.1.2 Implementation of Climate Change Adaptation Strategies

River improvement

86. In 2006, the Dutch Cabinet drew up the Spatial Planning Key Decision “Room for the Rivers.” Three objectives are as follows:

By 2015, the Rhine River branches will safely cope with an outlet capacity of 16 000 m^3/s;

The measures implemented to achieve the above will also improve the quality of the environment of the river basin;

Rivers will be provided with the extra space needed in the coming decades owing to expected climate changes (Ministry of Transport, Public Works and Water Management, 2006).

Figure 6. Location of measures and alternatives of the Room for the River Programme
(source: http://www.ruimtevoorderivier.nl/media/19174/factsheet_uk.pdf)

6.2 Legal and institutional role in climate change adaptation

87. The Delta Committee recommended strengthening political and administrative measures. This will be achieved by unifying national direction and regional responsibility for its implementation. Reinforcement of political and administrative measures include:

Appointment of a Ministerial Steering Committee, comprising at a minimum the Ministers of Transport, Public Works and Water Management; Agriculture, Nature and Food Quality; Finance; and Housing, Spatial Planning and Environment, to be chaired by the Prime Minister;

Appointment of a steering committee responsible for decision-making, direction and horizontal and national coordination;

Strengthening the role of the Minister of Transport, Public Works and Water Management, who bears ultimate responsibility for the programme, for the national goals for flood protection, and for securing the fresh water supply;

Appointment of a steering committee with a secretary and a Delta Director, who will report to the Ministerial Steering Committee and (thereby) to the Cabinet and Parliament;

Appointment of a Delta Director who translates national tasks for the coming century into regional tasks for the next 25 years;

Appointment of (regional) administrator(s) who are each responsible for the planning and performance of individual regional tasks. According to the nature of the task, the administrator(s) may be chosen from the local or provincial government, or the water boards. This administrator could count on the Delta Director as a central government partner;

Appointment of a Delta Director who takes a collective, national view of all regional tasks (including their planning and progress) collectively, guiding their direction where necessary; the Director should facilitate the process, encourage developments and decision-making, and bring together the parties and their knowledge as needed. If necessary, the Director uses designated authority to take decisions;

Appointment of a permanent Theme Committee in Parliament, thus assuring close parliamentary involvement.

88. Financing for flood protection and fresh water security measures should be guaranteed. This will be achieved by:

Setting up a Delta Fund;

Supplying the Delta Fund with a combination of loans and deposits from (or part of) natural gas revenues;

Allowing the national government to make funds available for measures and to draft rules for withdrawing from the Fund.

89. Finally, a Delta Act draft needs to embed political and administrative measures and ensure funding within the present constitutional system and current legislation.

90. The new Delta Act must contain the following at a minimum:
Institution of a Delta Fund, including conditions for deposits and withdrawals;
Delta Director's tasks and authorities;
Provision for a Delta Programme to be drafted;
Regulations for strategic land acquisition, and compensation for damage.

91. The Delta Act draft should also include loss of financial advantages occurring as a result of measures under the Delta Programme (Delta Committee, 2008).

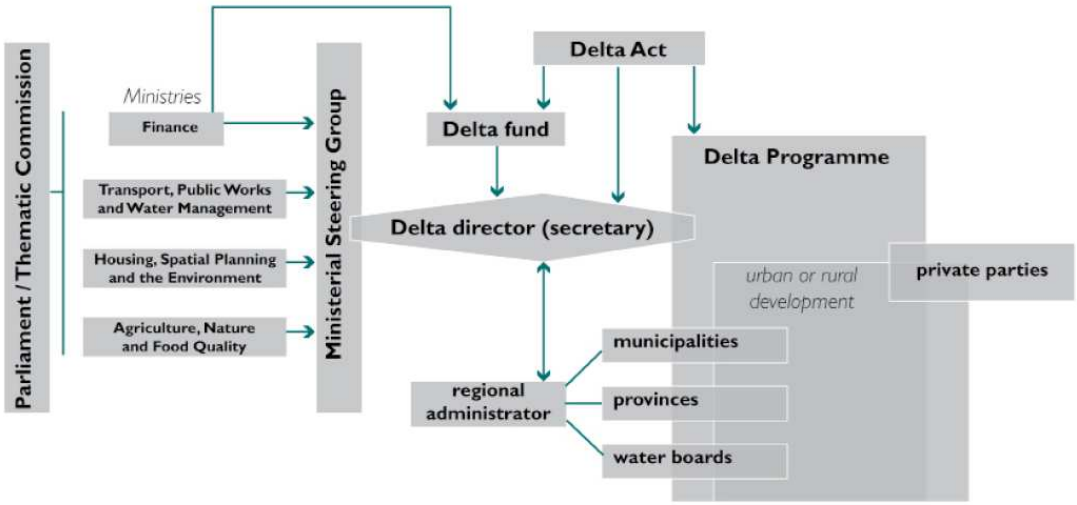


Figure 7. Administrative/political/legislative structure of the Delta Programme
(source: http://www.deltacommissie.com/doc/deltareport_full.pdf)

6.3 Risk assessment for climate change adaptation strategy

92. About 60 per cent of the territory of the Netherlands is prone to flooding. 95 of its so-called dike-rings protect polders from being flooded from the North Sea, rivers or lakes.

93. Under the Law of Disasters and Major Accidents, the Dutch Government needs to inform the population about potential disasters and major risks. As part of flood risk assessment to deal with residual risks, the government has published flood hazard maps on the Internet to satisfy the Disasters and Major Accidents Act, which gives local authorities the responsibility of informing the population of risks involved. Maps show flood prone areas as defined by more than one metre of flooding depth with 4 000-year flood.

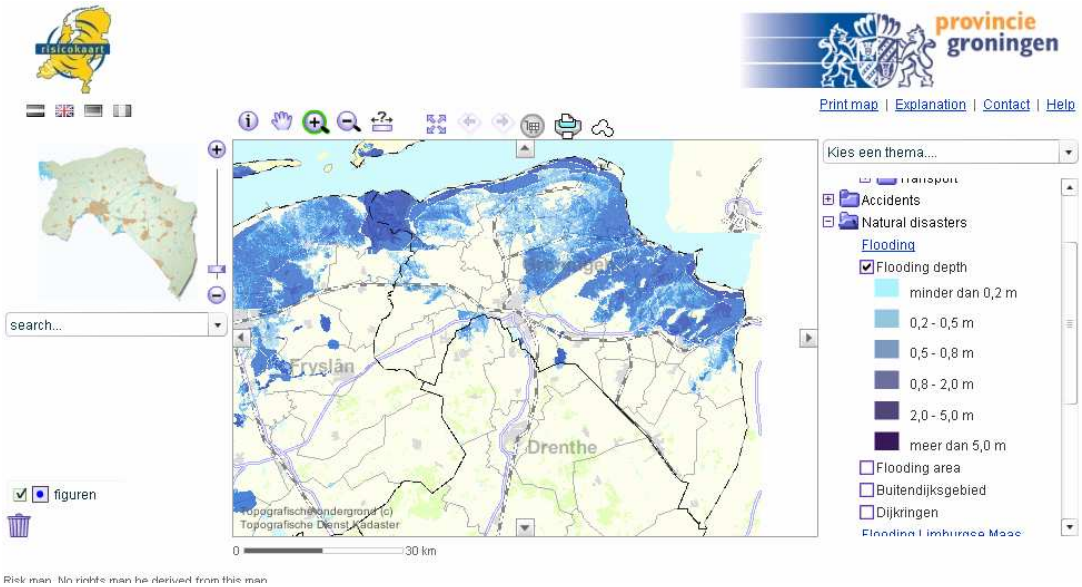


Figure 8. Flood hazard map in the Groningen province
(source: http://risicokaart.provinciegroningen.nl/)

7. JAPAN

94. In Japan, the River Law stipulates that the national government is charged with river administration of large water systems (class A rivers), which are especially important from the point of view of land conservation and the national economy. Prefecture governments, on the other hand, are responsible for administration of other water systems (class B). Officials who are responsible for river administration are called river administrators. River administrators determine the design flood discharge and other matters, providing the basis for basic river management policy of river works and river maintenance for improvement of the river. Administrators also establish river improvement plans according to the basic river management policy. Under policy implementation, the river improvement plan is designed to enable integrated administration of rivers, considering specifically measures necessary to prevent and mitigate damage to those areas where disasters frequently occur owing to precipitation, topography, geology and other conditions (APFM, 2006).

7.1 Adaptation strategy and implementation to climate change in flood management

95. The Government of Japan has established a subcommittee on climate change adaptation for flood control under the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The subcommittee was originally established to analyse and assess climate change-induced changes in characteristics, such as frequency and scale of floods; sediment-related, storm surges and other disasters; and their impacts on society. The subcommittee was also established to review adaptation strategies. While discussion progressed, however, subcommittee members emphasized the need for conducting investigations not only from a contracted viewpoint of conventional flood management but also from various angles. The

subcommittee decided to discuss and clarify the basic directions and contents of overall adaptation to water-related disasters from a wide scope of perspectives.

96. Because it is difficult to provide total protection from the effects of floods, sediment-related disasters, storm surges, which are likely to intensify in terms of frequency, magnitude and duration as a result of climate change, the subcommittee emphasizes that adaptation strategies for climate change need to define clearer goals, that is, aim for “zero victims.” In areas such as the Tokyo metropolitan area, where key functions are concentrated, intensive efforts to protect state functions from paralysis and to minimize damage should be made by setting priorities.

97. If precipitation in the future is projected to increase, design flood peak discharges need to be raised further if present flood safety levels are to be maintained. Construction of structures, however, usually takes considerably long time to complete. Because of social and other constraints including environmental considerations, it is sometimes difficult to construct such structures, including river improvement and flood control structures, which can accommodate increased discharges.

98. To deal with these issues, multi-layered flood management policies should be implemented. These policies consist of not only traditional flood control within the river corridor mainly through structural measures, but also flood management to secure safety in whole basins (basin-wide adaptation strategy) for possible increase of floods that exceed design floods (see Figure 9). Multilayered flood management policies would be effective in flexibly coping with possible floods of different magnitudes in each basin. Implementation of a basin-wide adaptation strategy requires raising awareness of possible risk among local communities and inhabitants and their involvement in its management.

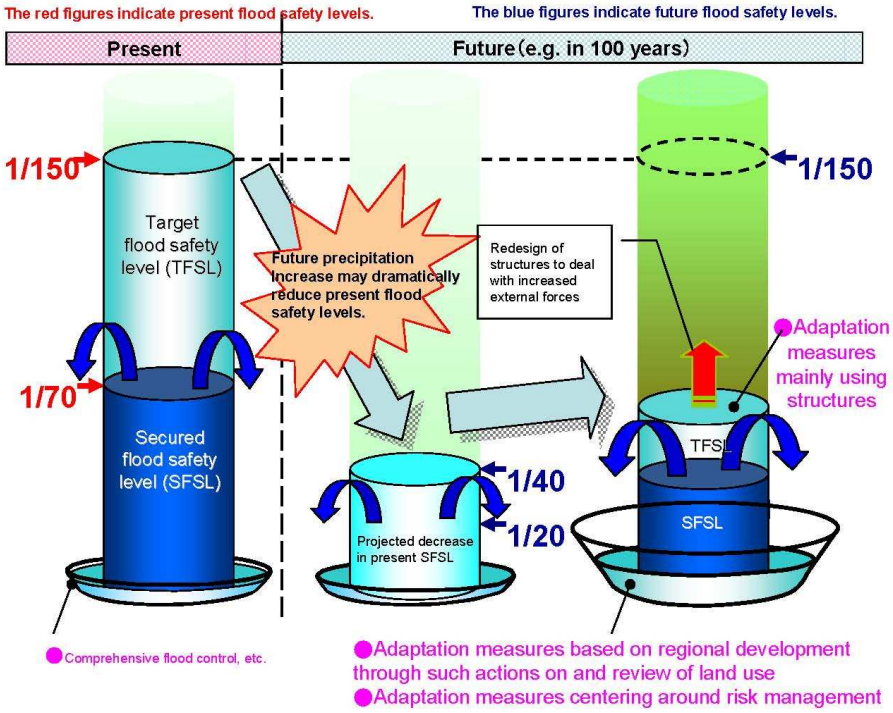


Figure 9. Multilayered flood management policies (Adachi, 2008)

99. Adaptation strategies to mitigate damage from flood, sediment-related, storm surges and other disasters are categorized as follows: “Adaptation strategies using structures”, “Adaptation strategies in relation to community development” and “Adaptation strategies based on crisis management” (MLIT, 2008).

100. *Adaptation strategies using structures*: New protection structures aim to reduce construction costs , and enhance structural strength. Maintenance and improvement of the safety of existing structures is a persistent requirement. Existing structures also have to be, managed in a sophisticated manner and/or put into multi-use by current and innovative technologies. In floodplains, structures such as secondary levees, ring levees, retarding ponds, and so forth, can be developed or maintained to reduce damages caused by flooding.

101. *Adaptation strategies in relation to community development*: Land-use regulation can enhance the effectiveness of prevention measures. Designation of disaster risk zones based on a legal code can prohibit further development or promote flood proofing in the area. A new concept for urban development, aiming towards more compact built-up of urban areas makes flood protection measures more effective, on the one hand, and more effective in energy consumption, on the other. Regulations, such as city codes and subsidies, should promote implementation of facilities for rainwater storage, infiltration and runoff control in an integrated manner at the (urban) basin scale.

102. *Adaptation strategies based on crisis management*: Preparation for sudden, large-scale disasters is important in achieving the “Zero Victims” objective. Development of nation-

wide disaster relief systems and organization of cross-district disaster mitigation networks by the national government is required to better manage disaster risks and respond to actual disasters. Management of non-structural measures should be thoroughly reviewed based on not only conventional scenarios but also new scenarios that consider changes in frequency and timing of external forces and/or social vulnerabilities, such as ageing communities. Effectiveness of flood fighting, evacuation and emergency restoration in disaster management depends highly on reliability of flood forecasting and warning. It is therefore necessary to enhance forecasting/warning technologies through improvement of observational systems and runoff forecasting technologies.

103. As MLIT adaptation policy emphasizes international contribution, MLIT developed a practical guideline on Strategic Climate Change Adaptation Planning, which describes a standard procedure for developing adaptation measures for water-related disasters caused by climate change based on experiences, strategies and technologies accumulated in Japan. The guideline aims at supporting countries that face the following conditions: 1) socio-economic development and urbanization owing to population growth; 2) living and production areas situated in an alluvial plain; and 3) flood control measures that are underdeveloped (MLIT, 2009).

7.2 Risk assessment for climate change adaptation strategy

104. According to data provided by the Japan Meteorological Agency (JMA), an increase in flood occurrence can be readily observed. In particular, there was a significant increase during a 106-year period (from 1901 to 2008) in number of days with daily precipitation ranging from 100 mm or more to 200 mm or more. There has been an increase in short-time heavy rainfall as well (from 50 mm or more per hour to 80 mm or more per hour).

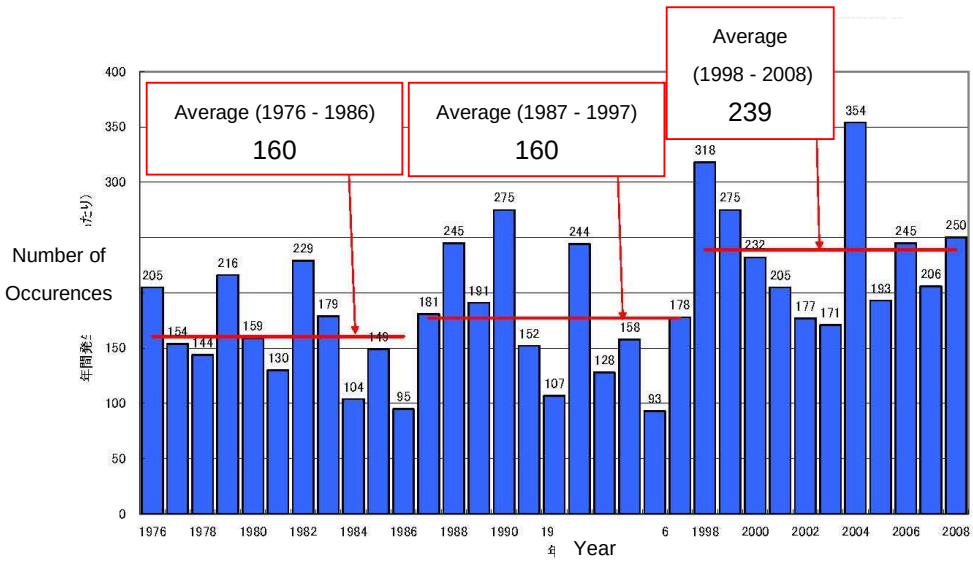


Figure 10. Number of occurences of hourly precipitation of 50mm or more (JMA, 2009)

105. Japan is vulnerable to climate change risk because about half of its population and three-fourths of total property are located in alluvial plains, which account for only 10 per cent of total area. MLIT has tentatively assessed the impact of climate change from a perspective of reduction of flood safety levels in existing flood control plans for 82 major rivers. According to studies using downscaling models and high-resolution global models (GCM20), which can precisely simulate phenomena around Japan, regional increase rates of annual maximum daily precipitation in 100 years is about 1.1 to 1.3 times the current value and 1.5 times the highest value under A1B and A2 scenarios[2] used in the IPCC 4th Assessment Report. To assess further impacts on discharge, medians of increase rates of annual maximum daily precipitation in 100 years were used in 11 regions of Japan.

106. The degree of reduction of flood safety levels was provisionally estimated based on regional changes in annual maximum daily rainfall in 100 years, projected using the GCM20 model. Changes in flood safety levels in 100 years are expressed in exceedance probability[3] under the current climate according to the regions and flood safety levels of the present plans. Estimations show that a probability of once in 200 years may be reduced to once in 90 to 145 years; once in 150 years to once in 22 to 100 years; and once in 100 years to once in 25 to 90 years, indicating that the occurrence of extreme events is likely to increase. In particular, the northern area (Hokkaido and Tohoku regions) shows higher rainfall increase rates, suggesting that extreme events would occur more frequently and thus, their flood safety levels would be lower to a greater degree. A similar case can be applied to small and middle-sized rivers, meaning lower flood safety levels. These projections show that future precipitation increase will sharply lower the flood safety levels of the present plans, and clearly suggest that risks of inundation and flooding will increase.

[2] For more information about A1B and A2 scenarios, see IPCC Special Report on Emission Scenario, 2000 (available at http://www.ipcc.ch/ipccreports/sres/tectran/index.php?idp=0) and IPCC Fourth Assessment Report: Climate Change 2007 (AR4) available at http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm

[3] Annual probability of exceedance: An annual probability of exceedance is a rate showing that a certain event occurs once every so many years. For example, when the annual probability of exceedance for a certain scale of precipitation is one-tenth, it means that such a rainfall will occur at a rate of once every ten years.

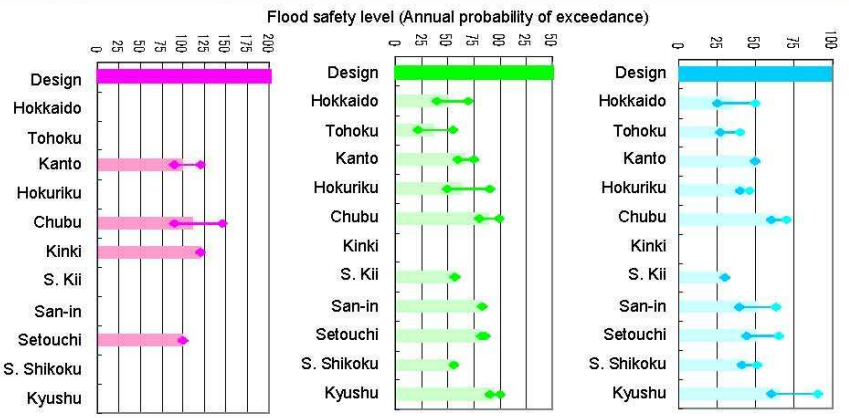
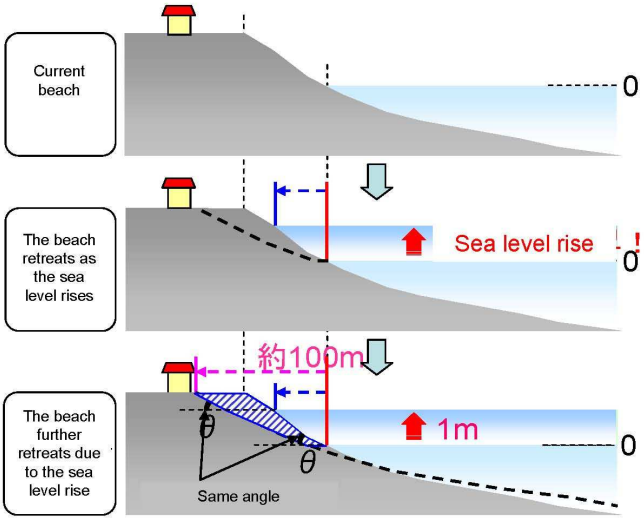


Figure 11. Predicted impacts on flood safety level (Adachi, 2008)

107. Lower basin areas and coastal zones in Japan, where low lands and areas below sea level spread, have intensified the problems of associated with higher short-time rainfall intensity, typhoon activity, storm surges and increased sea levels. Flood waters from the middle reaches are likely to cause more frequent inundation and flooding events due to levee breaches. Urbanization in low lands and below-sea-level areas has caused larger discharges, making proper drainage difficult. Thus, river flooding and flash flood induced sediment disasters and storm surges are likely to occur more frequently and with higher intensities over time. Particularly in areas below sea level located along three major bays (Tokyo, Ise and Osaka Bays), the mean sea level would increase by 59 cm, which is the extreme projected in the IPCC 4th Assessment Report. In this scenario, greater damage by storm surges is also projected. In many cases, lower basin areas and coastal zones show highest numbers of population density and urbanization. Because these three megacities (Tokyo, Nagoya and Osaka) serve as centres of social and economic activity, floods, and storm surges will affect not only the lives and property of their population, but will impact national and global activities. Coastal erosion is also advancing in some coastal zones. Further sea level rise and intensified typhoons may accelerate coastal erosion.



Sea level rise (m)	0.3	0.65	1
Ave. beach retreat (m)	30.55	65.4	101.04
Eroded area rate	56.6	81.7	90.3

Figure 12. Image of coastal erosion (Adachi, 2008)

108. The impacts that water-related disasters due to climate change imposed on society and its economy need to be presented to the public and related organizations in an easy-to-understand manner. It is increasingly important to keep the population informed of the vulnerabilities of land and social systems through risk assessment. The selection of appropriate adaptation strategies will be possible only after individuals understand completely those vulnerabilities. Results of the assessment need be presented visually, for example, through the development of risk maps (Figure 13). Assessment is important not only for showing current vulnerabilities visually, but also for showing the differences that the introduction of adaptation measures can make (MLIT, 2008).

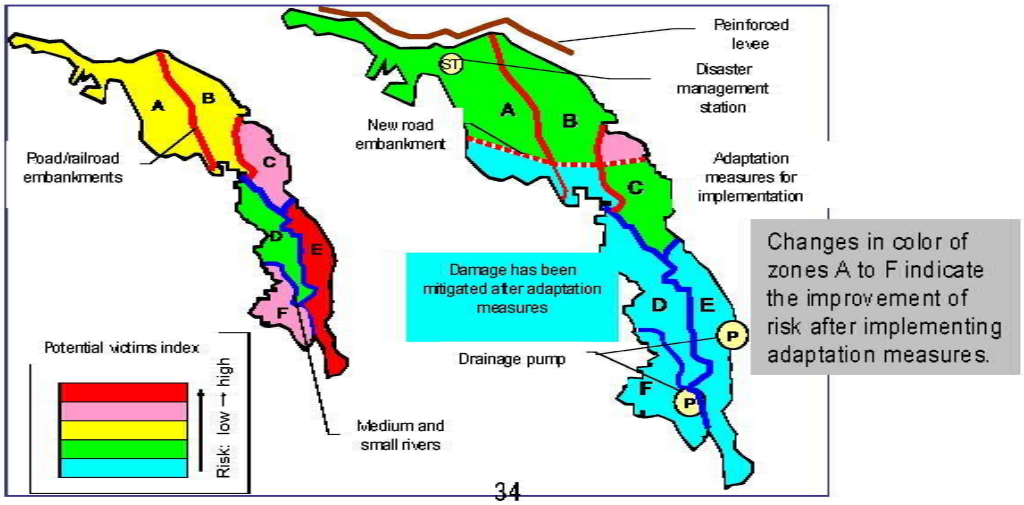


Figure 13. Example of risk assessment (Adachi, 2008)

8. PEOPLE'S REPUBLIC OF CHINA

109. In China, all rivers are owned by the national government. The national government assigns provincial governments the management and maintenance of their rivers. Large rivers are managed by river basin organizations composed of delegates from provinces in the basin. Management plans of all rivers in China are prepared by the national government. The plans are implemented by national governments and/or local governments.

8.1 Adaptation strategy and implementation to climate change in flood management

110. China has formulated the National Climate Change Programme (CNCCP), outlining objectives, basic principles, key areas of action, as well as policies and measures to address climate change for the period up to 2010 (National Development and Reform Commission, 2007).

111. In the CNCCP, three domains of adaptation strategy for water resources management are mentioned:

112. *Enhancing water resources management*:

- Converting farmland back into lake or river courses, removing polder dikes for flood ways, and dredging river channels and lakes.
- Rehabilitating and protecting rivers from serious ecological problems while strengthening dike construction and key water control projects.
- Enhancing unified management of water resources through basin-wide integration of water resources planning, allocating, saving, protecting, and optimizing water resources.

113. *Strengthening infrastructure planning and construction*:

- Accelerating the South-to-North Water Diversion project.

- Generating a new pattern of optimized water resources allocation with three water diversion lines linking the Yangtze River, the Yellow River, the Huaihe River and the Haihe River.
- Enhancing construction and improvement of key water control projects and infrastructures in irrigation areas.

114. *Promoting the development and extension of technologies for water allocation, water saving, and seawater use:*

- Focusing research on the mechanisms of water exchange among atmosphere water, surface water, soil water and ground water.
- Developing technologies for optimizing water resource configuration, wastewater and rainfall use, and artificial rainfall enhancement.

8.2 Risk assessment for climate change adaptation strategy

115. In China, assessment of the impact of climate change is conducted by the Ministry of Science and Technology, Ministry of Environmental Protection, and the China Meteorological Administration. For assessment of impacts on China, output datasets of GCMs issued by the IPCC Data Distribution Centre (DDC) are used as well as simulated results of GCMs generated by Chinese scientists. The scenarios adopted tentatively are the A2 and B2 scenarios. For downscaling of the climate models, the Regional Climate Models (RCMs) developed by Chinese scientists are used. The discipline models used by Chinese scientists as assessment tools include hydrological models such as the Xin'anjian flood forecasting model, the monthly runoff dry model, the variable infiltration capacity model. (The People's Republic of China, 2004).

116. Climate change has already caused changes of water resources distribution in China. A trend in runoff has been observed during the past 40 years in the following six main rivers: Haihe, Huaihe, Yellow, Songhuajiang, Yangtze and Pearl. Meanwhile, there is evidence for an increase in frequency of hydrological extreme events, such as drought in the north and floods in the south. The Haihe River basin is the most vulnerable region to climate change, followed by the Huaihe River basin and the Yellow River basin. The arid continental river basins are particularly vulnerable to climate change. In future, climate change will have the following significant impacts on water resources in China (National Development and Reform Commission, 2007):

- In the next 50 to 100 years, and on the basis of available evidence, the mean annual runoff is likely to decrease in some northern arid provinces, such as the Ningxia Autonomous region and the Gansu province, whereas it will more likely increase remarkably in a few already water-abundant southern provinces, such as the Hubei and Hunan provinces, indicating an increase in flood and drought events due to climate change;
- The situation of water scarcity tends to continue in northern China, especially in the Ningxia Autonomous region and the Gansu province, where water resources per capita are likely to decrease further in the next 50 to 100 years;

- Water resources should be exploited and used in a sustainable manner; for most provinces, water supply and demand would be basically balanced for the next 50 to 100 years. The gap between water resources supply and demand, however, might be expanded to the following regions: Inner Mongolia Autonomous, Xinjiang Autonomous, Gansu, and Ningxia Autonomous.

117. At the research level, the probability distribution of precipitation has been simulated in the Yangtze River by the climate model in Figure 14 (Su Buda and others, 2008).

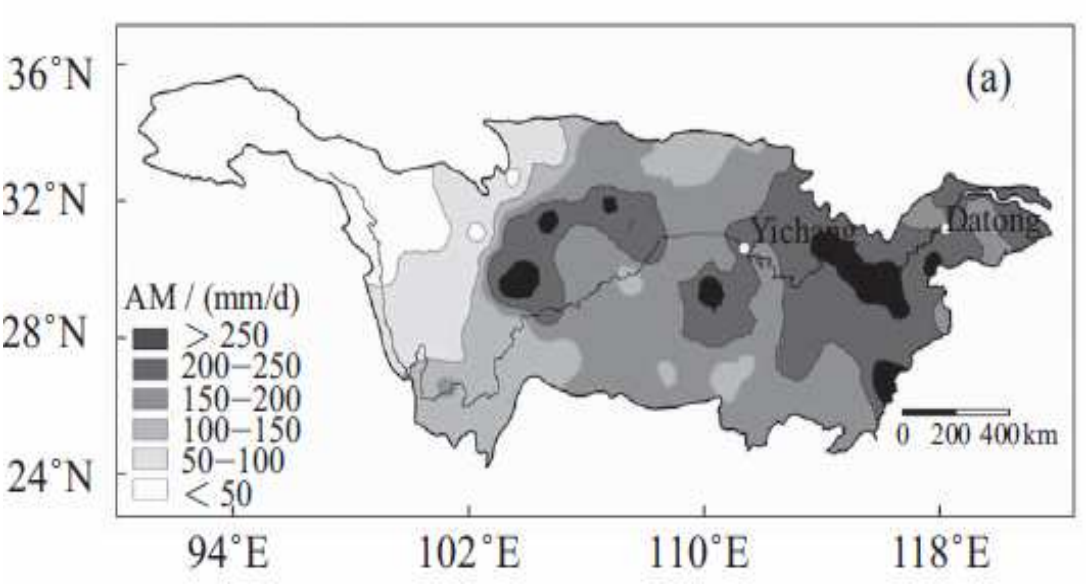


Figure 14. Spatial distribution of observed precipitation extremes over the Yangtse River Basin (mean Annual Maximum)
(Su Buda and others, 2008)

9. REPUBLIC OF KOREA

118. In the Republic of Korea (Korea), rivers designated by the River Law are categorized as national rivers (61 rivers comprising 2,981 km), regional A class rivers (52 rivers comprising 11,148 km) and regional B class rivers (3,772 rivers comprising 25,684 km). The remaining small rivers are administered under the Small River Law. Responsible institutions or governments for management of rivers vary by their categories; that is, national rivers are managed by the national government; regional A class rivers, which are close to urban development in the province, are managed by provincial governments; and regional B class rivers are managed by municipalities. According to the River Law, river management related to disasters is divided into two categories: construction, management and maintenance of river management infrastructures; and administrative management, which directs those activities that may cause changes in rivers. For the first category of flood management, the Ministry of Land, Transport and Maritime Affairs takes charge of the preparatory and normal phases. The Ministry of Public Administration and Security, on the other hand, takes charge of the latter's response phase. Projects for national rivers are financed by the national

government; and projects for regional rivers are financed by provincial governments or municipalities. There are five flood river control offices for the following five major rivers – Han, Nakdong, Geum, Seomjin and Yongsan.

9.1 Adaptation strategy and implementation to climate change in flood management

9.1.1 Strategies for Climate Change Adaptation

119. In 1999, the Government of the Republic of Korea established the Comprehensive National Action Plan in three phases. The number of launched projects is as follows: 36 in the first plan period; 84 in the second plan period; and 91 in the third plan period (as of 1 August 2007). For water management, evaluation standards on the impacts of climate change on water resources are studied by the Ministry of Science and Technology. The Korea Environmental Policy and Evaluation Institute has established an efficient and thorough national adaptation policy framework based on the understanding of vulnerabilities, and has conducted a general analysis on the impacts of climate change in each field (Haeryong, 2007). The Third Governmental Comprehensive Plan on Countermeasures to Climate Change (2005–2007) [4] proposes the following adaptation strategies in water management:

- Integrated countermeasures for floods among ministries and government agencies,
- Increased efficiency of water resources management, and
- A systematic and accurate structure for early warnings of floods by the central government and local authorities to minimize the damage from disasters.

9.1.2 Implementation of Climate Change Adaptation Strategies

120. Korea has held very limited discussions on adaptation. Adaptation options have been identified, but at a fairly generic level – for example, measures such as crop switching, coastal protection, and so on, without reference to their specific context (see Table 4[5]). The four major rivers restoration project is establishing fundamental countermeasures against repetitive and increased damage of floods and droughts due to climate change. For flood management, proposals in the project included dredging sediment, reinforcement of old levees and construction of dams aimed at securing safety levels to deal with 200-year floods.

- Dredging sediment: By dredging around 5 700 million cubic metres of sediment, the highest water levels are expected to be lowered by 0.4 to 3.9 m.
- Construction of reservoirs: Around 500 million cubic metres of capacity for flood control would be secured by two reservoirs and four retention ponds.
- Reinforcement of old levees: 620 km of old levees would be improved and drainage gates would be constructed at levees near river mouths (KICT, 2009).

[4] Department of Environmental Cooperation, Ministry of Foreign Affairs and Trade. Korea's Vulnerability to Climate Change and its Adaptation Policies (http://www.ap-net.org/docs/16th_seminar/kim_session3.pdf)

[5] OECD, 2006, http://www.oecd.org/dataoecd/49/18/37178873.pdf

121. Restoration of the four mainstreams, such as dredging sediments and building reservoirs, would be completed by 2011; and projects for the branch streams would be completed by 2012 (McNally, 2009).

9.2 Risk assessment for climate change adaptation strategy

122. In Korea, assessment of impacts from climate change is being studied by the Ministry of Environment, Ministry of Agriculture and Forestry, and Ministry of Science and Technology. According to the Third Governmental Comprehensive Plan on Countermeasures to Climate Change, during the last century, the average temperature has risen by 1.5℃ (global average has risen by 0.6℃). Between 1912 and 2005, temperatures have risen from 12℃ to 13.5℃, even when excluding the effects of urbanization. This is an increase of 0.4℃ to 0.8℃ (a larger impact from ur banization rather than from global warming). During the past 20 years, annual rainfall and days with heavy rainfall have increased in the southern region of Korea as follows (Figure 15):

- Increase of annual rainfall by 7 per cent and days with heavy rainfall by 23 per cent;
- Decrease of annual number of rainy days by 14 per cent;
- Occurrence of extreme natural disasters, such as the heaviest snowfall in 32 years, the worst drought in history and the heaviest rainfall in 37 years, is rising in frequency and intensity.

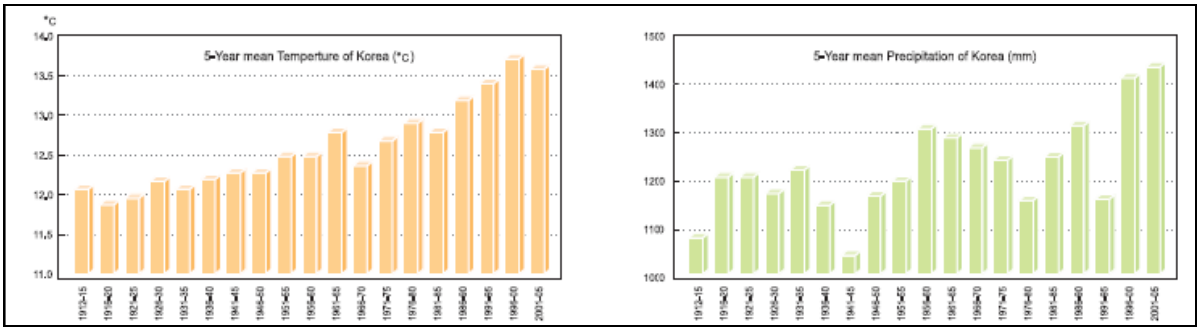


Figure 15. Trend in temperature (left) and precipiation (right) in the Korean Peninsula

123. According to the Meteorological Research Institute, the long-term A2 scenario based on the climate change model indicates that the average temperature is estimated to rise 1.2℃ by the 2020s; 2.4℃ by the 2050s; and 4.0℃ b y the 2080s. This rise in temperature will increase the threat of floods; thus, the concentration of rainfall during summers will increase damages due to floods[6].

[6] Meteorological Research Institute (http://www.metri.re.kr/metri_home/english/Laboratory/uClimateResL.jsp)

Table 4. Coverage of impacts and adaption in National Communications

(OECD, 2006)

		Climate change impact assessments			Adaptation options and policy responses				
		Historical climate trends	Climate change scenarios	Impact assessments	Identification of adaptation options	Mention of policies synergistic with adaptation	Establishment of institutional mechanisms for adaptation responses	Formulation of adaptation policies / modification of existing policies	Explicit incorporation of adaptation in projects
Early stages of impact assessment	Iceland		○	○					
	Portugal	○		○					
	Hungary			○					
	Latvia	●		○	○				
	Liechtenstein		○		○	●			○
	Germany		○					● German Strategy for Adaptation to Climate Change	
	Russia			○	○				
Advanced impacts assessment, but slow development of policy responses	Slovenia		○	●					
	Estonia		●	●					
	Mexico	●	●	●					
	Lithuania	●	●	●					
	Japan		●	●					
	Finland	●	●	●	○				
	Poland		●	●	○				
	Romania	●	●	●	○				
	Denmark	●	●	●	○				●
	Korea	●	●	●	○			● Comprehensive National action Plans	
	Greece	●	●	○	○				
	Czech Republic		●	●	○				
	Belarus		●	●	●				
	Bulgaria	●	●	●	●				
	Canada		○	◎	●				
	Croatia		●	●	●				
	Slovak Republic	●	●	●	●				
	Ukraine		○	●	●				
	Norway		◎	●		○			
	Sweden		●	●		○			
	Belgium		●	●	○	●			
	Ireland	●	●	●		●			
	Spain		●	●	●	●			
	Austria		●	●		●			
	France		●	●		●		● National Strategy on Climate Change	
	Switzerland	●	○	●	○	●			
	Italy	●		●	●	●			
Moving towards implementing adaptation	Netherlands		KNMI	KNMI				● National Programme for Spatial Adaptation to Climate Change, Delta Programme	●
	United States	●	●	●	●	●		● Climate Change and	

								Water Resources Management
	New Zealand		●	●	●	○	○	◎
	Australia		●	●	◎	○	●	○
	United Kingdom		UKCIP	UKCIP	●	●	●	Climate Change Act 2008, Climate Change Adaptation Strategy (2008-2011)

Coverage

	Extensive discussion
	Some mention / limited discussion
	No mention or discussion

Quality of discussion

●	Discussed in detail, i.e. for more than one sector or ecosystem, and/or providing examples of policies implemented, and/or is based on sectoral/national scenarios
○	Discussed in generic terms, i.e. based on IPCC or regional assessments, and/or providing limited details/no examples/ only examples of planned measures as opposed to measures implemented
◎	Limited information in NCs, but references to comprehensive national studies

Red character: revised parts based on the case studies.

References

Adachi, T., 2008: *Adaptation Measures for Climate Change in Japan* http://www.mlit.go.jp/river/basic_info/english/pdf/conf_01.pdf (accessed 9 February 2011).

Associated Programme on Flood Management (APFM), 2006: *Legal and Institutional Aspects of Integrated Flood Management Case Studies,* http://www.apfm.info/pdf/ifm_legal_aspects_casestudies.pdf (accessed 9 February 2011).

Brekke, L.D., J.E. Kiang, J.R. Olsen, R.S. Pulwarty, D.A. Raff, D.P. Turnipseed, R.S.Webb and K.D. White, 2009: *Climate change and water resources management federal perspective: U.S. Geological Survey Circular,* http://pubs.usgs.gov/circ/1331/ (accessed 9 February 2011).

Brent Cross Cricklewood Partners, 2008: *Brent Cross Cricklewood Planning Application, BXC16,* http://www.brentcrosscricklewood.com/bxc_planningapps/pdfdownloads/BXC16_STG2FLOOD.pdf (accessed 9 February 2011).

California Department of Water Resources, 2008: *Climate Change Adaptation Strategy for California Water,* http://www.energy.ca.gov/2008publications/DWR-1000-2008-031/DWR-1000-2008-031.PDF (accessed 9 February 2011).

———, 2009: *California Water Plan Update-2009,* http://www.waterplan.water.ca.gov/cwpu2009/index.cfm (accessed 9 February 2011).

Defra, 2008: *Who does what?,* http://www.defra.gov.uk/environment/flooding/who/index.htm (accessed 9 February 2011).

———, 2009: *Draft Flood and Water Management Bill,* http://www.official-documents.gov.uk/document/cm75/7582/7582.pdf (accessed 9 February 2011).

Delta Commission, 2008: *Working together with water,* http://www.deltacommissie.com/doc/deltareport_full.pdf (accessed 9 February 2011).

Department of Environment Cooperation Ministry of Foreign Affairs and Trade, 2006: *Korea's Vulnerability to Climate Change and its Adaptation Policies,* http://research.fit.edu/sealevelriselibrary/documents/doc_mgr/396/S._Korea_Vulnerability_&_CC_Adaptation_Policies_ppt_-_DEC_MAFT.pdf (accessed 9 February 2011).

Direction départementale de l'Equipement et de l'Agriculture (DDEA) de Seine et Marne, 2009: *Le risque inondation*, http://www.seine-et-marne.equipement.gouv.fr/article.php3?id_article=83 (accessed 9 February 2011).

———, 2006: P*lan de prévention des risques d'inondation - notice de présentation* http://www.seine-et-marne.equipement.gouv.fr/IMG/pdf/Notice_loing_cle7cd167.pdf (accessed 9 February 2011).

Enjolras, G., K. Erdlenbruch, F. Grelot, R. Kast and S. Thoyer, 2008: *Flood management at the basin level in France: Sustainability of local risk-sharing policies,* http://www.prodinra.inra.fr/prodinra/pinra/data/2009/01/PROD200920485bf1_20090129044554113.pdf (accessed 9 February 2011).

Environment Agency, 2008: *Climate Change Adaptation Strategy (2008–2011),* http://www.environment-agency.gov.uk/static/documents/Leisure/adaptation_strategy_2083410.pdf (accessed 9 February 2011).

———, 2009*a*: *Climate Change, Adapting for Tomorrow,* http://publications.environment-agency.gov.uk/pdf/GEHO0709BQBW-e-e.pdf (accessed 9 February 2011).

———, 2009*b*: *Flooding in England, a National Assessment of Flood Risk,* http://publications.environment-agency.gov.uk/pdf/GEHO0609BQDS-E-E.pdf (accessed 9 February 2011).

———, 2009*c*: *Investing for the Future, Flood and coastal risk management in England - A long-term investment strategy* http://publications.environment-agency.gov.uk/pdf/GEHO0609BQDF-E-E.pdf (accessed 9 February 2011).

Etablissement Public d'Aménagement de la Meuse et de ses Affluents (EPAMA), 2009: *Le Plan Meuse*, http://www.epama.fr/files_fr/epama_projets/epama6_planmeuse_intro.php4 (accessed 9 February 2011).

Etablissement Public Territorial du Bassin (EPTB) Saone et Doubs, 2007: *PAPI Allan-Savoureuse,* http://sites.google.com/site/eptbrapport20082009/le-papi-savoureuse (accessed 9 February 2011).

European Commission, 2007: *Floods DIRECTIVE,* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:288:0027:0034:EN:PDF (accessed 9 February 2011).

———, 2009: *White Paper Adapting to Climate Change,*

http://ec.europa.eu/environment/climat/adaptation/index_en.htm (accessed 9 February 2011).

Federal Emergency Management Agency, 1986: *A Unified National Program for Floodplain Management,* http://www.fema.gov/hazard/flood/pubs/lib100.shtm (accessed 9 February 2011).

———, 2009: *Risk Mapping, Assessment, and Planning (Risk MAP)*, http://www.fema.gov/plan/prevent/fhm/rm_main.shtm (accessed 9 February 2011).

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2002: *Federal Water Act,* http://bundesrecht.juris.de/whg_2009/ (accessed 9 February 2011).

———, 2005: *Act to Improve Preventive Flood Control,* http://www.bmu.de/english/water_management/downloads/doc/35456.php (accessed 9 February 2011).

German Federal Government, 2008: *German Strategy for Adaptation to Climate Change,* http://www.bmu.de/files/english/pdf/application/pdf/das_gesamt_en_bf.pdf (accessed 9 February 2011).

Gestion et Impacts du Changement Climatique, 2009: *Presentation of the GICC programme*, http://www.gip-ecofor.org/publi/page.php?id=2&rang=0&domain=38&lang=en_GB (accessed 9 February 2011).

Haeryong, K., 2007: *Statement by Mr. Kwon Haeryong Deputy Director-General for International Economic Affairs At the Fourth Thematic Debate on Climate Change of the 61st Session of the General Assembly,* http://www.un.org/ga/president/61/follow-up/climatechange/statements/statementKorea.pdf (accessed 9 February 2011).

Her Majesty's Government, 2006: *Climate Change: The UK Programme,* http://www.decc.gov.uk/en/content/cms/what_we_do/change_energy/tackling_clima/programme/programme.aspx (accessed 9 February 2011).

Huisman, P., 2002: *How the Netherlands Finance Public Water Management* *http://www.ewaonline.de/journal/2002_03.pdf* (accessed 9 February 2011).

Jacobson, G.L., I.J. Fernandez, P.A. Mayewski and C.V. Schmitt (editors). 2009: *Maine's Climate Future: An Initial Assessment. Orono.* ME: University of Maine, http://www.climatechange.umaine.edu/mainesclimatefuture/ (accessed 9 February 2011).

Japan Meteorological Agency (JMA), 2009: *Report of observation of climate change 2008,*

http://www.data.kishou.go.jp/climate/cpdinfo/monitor/2008/pdf/ccmr2008_intro.pdf (accessed 9 February 2011).

KLIWA (Klimaveränderung und Wasserwirtschaft), 2008: *Our climate is changing Consequences-Extend-Strategies,* http://www.kliwa.de/download/KLIWA_en.pdf (accessed 9 February 2011).

———, 2009: *What is KLIWA?*, http://www.kliwa.de/ (accessed 9 February 2011).

KNMI, 2006: *KNMI Climate Change Scenarios 2006 for the Netherlands,* KNMI Scientific Report WR 2006-01 http://www.knmi.nl/klimaatscenarios/knmi06/WR23mei2006.pdf (accessed 9 February 2011).

Korea Institute of Construction Technology (KICT), 2009: *Master plan of the four major rivers restoration projects,* http://www.a-rr.net/jp/exchange/docs/4RiverRestoration_KOREA.pdf (accessed 9 February 2011).

McNally, M., 2009: *South Korea and the 4-Rivers Restoration Project/Grand Korean Canal background summary,* http://www.macaulay.ac.uk/hydroworkshop/4rivers.php (accessed 9 February 2011).

Meteorological Research Institute, Korea, http://www.metri.re.kr/metri_home/english/Laboratory/uClimateResL.jsp (accessed 9 February 2011).

Ministry of Housing, Spatial Planning and the Environment, Ministry of Transport, Public Works and Water Management, Ministry of Agriculture, Nature and Food Quality, Ministry of Economic Affairs, 2007: *National Programme for Spatial Adaptation to Climate Change,* https://www.maakruimtevoorklimaat.nl/fileadmin/user_upload/Documenten/PDF/Engelstalige_documenten/inter-admin_policy_paper_ENG.pdf (accessed 9 February 2011).

Ministry of Land, Infrastructure, Transport and Tourism of Japan (MLIT), 2008: *Climate Change Adaptation Strategies to Cope with Water-related Disasters due to Global Warming,* http://www.mlit.go.jp/river/basic_info/jigyo_keikaku/gaiyou/kikouhendou/pdf/draftpolicyreporttext.pdf (accessed 9 February 2011). http://www.mlit.go.jp/river/basic_info/jigyo_keikaku/gaiyou/kikouhendou/pdf/draftpolicyreportref.pdf (accessed 9 February 2011).

———, 2009: *Practical Guideline on Strategic Climate Change Adaptation Planning,* http://www.mlit.go.jp/river/basic_info/english/pdf/Practical-Guideline.pdf (accessed 9 February 2011).

Ministry of Transport, Public Works and Water Management of the Netherlands, 2006: *Spatial Planning Key Decision "Room for the River",* http://www.ruimtevoorderivier.nl/media/18566/brochureeng.pdf (accessed 9 February 2011).

National Committee on Levee Safety, 2009: *Draft: Recommendations for a National Levee Safety Program,* http://www.iwr.usace.army.mil/ncls/index.cfm (accessed 9 February 2011).

National Development and Reform Commission, 2007: *China's National Climate Change Programme,* http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File188.pdf (accessed 9 February 2011).

New York Department of Environmental Conservation, 2009: *Sea Level Rise Task Force*, http://www.dec.ny.gov/energy/45202.html (accessed 9 February 2011).

Observatoire National sur les effets de Réchauffement Climatique, 2007: *Stratégie nationale d'adaptation au changement climatique,* http://www.developpement-durable.gouv.fr/Strategie-nationale-d-adaptation.html (accessed 9 February 2011).

Office of Public Sector Information (OPSI), 2008: *Climate Change Act 2008,* http://www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080027_en.pdf (accessed 9 February 2011).

———, 2009: *Climate Change (Scotland) Act 2009-12-02,* *http://www.opsi.gov.uk/legislation/scotland/acts2009/pdf/asp_20090012_en.pdf* (accessed 9 February 2011).

Organization for Economic Co-operation and Development (OECD), 2006: *Progress on Adaptation to climate change in developed countries,* http://www.oecd.org/dataoecd/49/18/37178873.pdf (accessed 9 February 2011).

Sachsen-Anhalt Ministry of Agriculture and Environment, 2009: *Klimawandel,* http://www.sachsen-anhalt.de/LPSA/index.php?id=38016 (accessed 9 February 2011).

Su Buda, Marco Gemmer, Jiang Tong and Ren Guoyu, 2008: *Probability Distribution of Precipitation Extremes over the Yangtze River Basin,* In *Advances in Climate Change Research* 2008, 4 (Suppl.): pp. 27-31 http://www.climatechange.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=8534 (accessed 9 February 2011).

The Government of the Republic of Korea, 2003: *Second National Communication of the Republic of Korea Under the United Nations Framework Convention on Climate Change,*

http://unfccc.int/resource/docs/natc/kornc02.pdf (accessed 9 February 2011).

The People's Republic of China, 2004: *Initial National Communication on Climate Change,* http://unfccc.int/resource/docs/natc/chnnc1e.pdf (accessed 9 February 2011).

The Scottish Government, 2009: *Flood Risk Management (Scotland) Act 2009*, http://www.scotland.gov.uk/Topics/Environment/Water/Flooding/FRMAct (accessed 9 February 2011).

UK Government, Department of Communities and Local Government, 2006: *Planning Policy Statement 25: Development and Flood Risk,* http://www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement25.pdf (accessed 9 February 2011).

United Nations Economic Commission for Europe (UNECE), 2009: *Guidance on Water and Adaptation to Climate Change* http://www.unece.org/env/documents/2009/Wat/mp_wat/ECE_MP.WAT_30_E.pdf (accessed 14 September 2010).

United States Global Change Research Program (USGCRP), 2010: *USGCRP Scientific Assessments*, http://www.globalchange.gov/publications/reports/scientific-assessments (accessed 9 February 2011).

U.S. Congress, 2007: *Water Resources Development Act of 2007,* http://www.govtrack.us/congress/bill.xpd?bill=h110-1495 (accessed 9 February 2011).