

**JCOMM/CHY COASTAL INUNDATION  
FORECASTING DEMONSTRATION PROJECT  
(CIFDP)  
SECOND STEERING GROUP MEETING**



Geneva, Switzerland, 20 – 22 September 2010

**FINAL REPORT**

JCOMM Meeting Report No. 81

## NOTES

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Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

#### **Regulation 43**

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

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## **GENERAL SUMMARY OF THE WORK OF THE SESSION**

### **1. OPENING OF THE SESSION**

#### **1.1 Opening**

1.1.1 The second meeting for the development of the Coastal Inundation Forecasting Demonstration Project (CIFDP) was opened by the Deputy Secretary-General, Jeremiah Lengoasa, at 0900 hrs on Monday, 20 September 2010, in the WMO Headquarters in Geneva, Switzerland.

1.1.2 On behalf of the Secretary-General of the WMO, Mr Lengoasa welcomed participants to the session, to Geneva in general and to the WMO in particular. He recalled that oceanic combined with hydrological phenomena have major impacts on the marine coastal environment and socio-economic activities in coastal regions, where a large percentage of population inhabits and often depend on coastal resources and the marine environment for their livelihood. Mr Lengoasa emphasised that coastal areas are especially vulnerable to extreme events.

1.1.3 Mr Lengoasa noted that there were more challenges in the improvement of forecasting and warning systems that allow dedicated disaster prevention agencies to safeguard lives and mitigate damages on infrastructure in coastal areas. In this context, Mr Lengoasa informed the meeting that the WMO Executive Council, at its 60<sup>th</sup> session (June 2008), identified two high priority areas, namely:

- (a) The need for the provision of storm surge guidance information to Members exposed to these risks as a matter of priority, and therefore agreed that storm surge watch schemes (SSWS) attached to the tropical cyclone advisory arrangements would help to increase advisory lead-time and thus contribute to saving lives and properties;
- (b) The implementation of the recommendations from the First JCOMM Scientific and Technical Symposium on Storm Surges (Seoul, Republic of Korea, October 2007), including coastal inundation and linkages to storm surge forecast and warning operations in all relevant regions.

1.1.4 Mr Lengoasa concluded by expressing his sincere appreciation to the meeting for assisting WMO and the UNESCO/IOC to coordinate the transfer of forecasting products from research to operational systems, contributing therefore to the multidisciplinary efforts for management of Member/Member States losses to entities and people during natural hazards, and he recommended to build the Project upon the ongoing relevant initiatives such as the SWFDP. Lastly, Mr Lengoasa introduced Mrs Val Swail and Donald Resio, the Chairmen of the Steering Group, and assured participants of the full support of his staff and concluded by wishing everyone a successful meeting and an enjoyable stay in Geneva.

1.1.5 The list of participants is given in Annex I.

#### **1.2 Adoption of the agenda**

1.2.1 The Group adopted its agenda for the session based on the provisional agenda that has been prepared by the Secretariat. This agenda is given in Annex II.

#### **1.3 Working arrangements**

1.3.1 The Group agreed its hours of work and other practical arrangements for the session. Participants briefly introduced themselves, to facilitate future interactions.

## 2. THE FIRST CIFDP MEETING AND FOLLOW-UP

2.1 The meeting noted that the first CIFDP meeting decided that the project should develop an overarching framework. The meeting recalled that the identified priority countries for the implementation of the CIFDP are:

- (a) Bangladesh (Bay of Bengal);
- (b) Dominican Republic (Caribbean).

2.2 The meeting noted the ongoing development of interactions with associated projects, particularly for the following regions/countries:

- (a) Shanghai, China (RA II) – Multi-hazard Early Warning System (MHEWS) project;
- (b) Indonesia (RA V) – proposed project by *Deltares*;
- (c) RA I – Severe Weather Forecasting Demonstration Project (SWFDP); RA V Severe Weather Forecasting Demonstration and Disaster Risk Reduction Project (SWFDDP); and the Storm Surge Watch Scheme (SSWS);
- (d) West Africa – SWFDP and other initiatives in the region.

2.3 In addition, the meeting noted that existing initiatives in the Southern Africa region should be considered in the framework of the project implementation.

2.4 The Group noted that following the tragically destructive earthquake event in Haïti and damages caused to infrastructure and hydro-meteorological facilities, priority has been given in WMO to the reconstruction of meteorological centres to prevent another disaster during the hurricane season. In the context of the CIFDP implementation in Dominican Republic, the meeting agreed that the synergies should be developed between the two countries in a one-island approach to mitigate Hispaniola vulnerability to coastal hazards.

2.5 The meeting noted that during the Third Session of the JCOMM Expert Team on Wind Waves and Storm Surges (ETWS-III) in Toronto, Canada, 18 - 22 May 2010, the ETWS agreed to act as an advisory group for the CIFDP.

2.6 The meeting noted ongoing initiatives and related events in the Bay of Bengal and Caribbean regions that might be used for future interactions and discussions, including:

- (a) Third session of the JCOMM Expert Team on Operational Ocean Forecasting Systems (ETOOFS-III), Tokyo, Japan, 7 - 9 October 2010;
- (b) Technical Workshop for the development of Caribbean Regional Programme in MHEWS, Barbados, 1 - 5 November 2010;
- (c) RA IV TCP/JCOMM and Hurricane Committee Training Workshop on Storm Surge Forecasting, Santo Domingo, Dominican Republic, 6 - 10 December 2010;
- (d) Third International Conference on Water and Flood Management, Dhaka, Bangladesh, 8 - 10 January 2011;
- (e) Second UNESCO Advisory Workshop on Enhancing Forecasting Capabilities for North Indian Ocean Storm Surges, New Delhi, India, 11 - 15 February 2011.

### 3. PRESENTATIONS

3.1 The meeting was informed by delegates representing institutions and organizations with ongoing initiatives and interests related to the development of integrated systems for coastal inundation, including tropical cyclone, storm surge, wave and hydrological forecasting; flood; disaster risk management; and early warning systems for tsunamis, storm surges and coastal hazards, as follows:

#### 3.2 WMO Tropical Cyclone Programme Storm Surge Watch Scheme

3.2.1 The meeting was informed that establishment of the WMO Storm Surge Watch Scheme (SSWS) was recommended by the WMO Executive Council (June 2008) for the regions subject to tropical cyclones after a request made by the WMO Secretary-General in consultation with UNESCO/IOC. The WMO Executive Council urged Regional Associations concerned to incorporate a SSWS in the tropical cyclone advisory arrangements and in the Tropical Cyclone Programme (TCP) Regional Operational Plans/Manuals. The Tropical Cyclone Programme (TCP) in partnership with the Marine Meteorology and Oceanography Programme (MMOP) is leading the implementation of the SSWS with an objective of covering all the areas prone to tropical cyclones. Actions have been taken by all five WMO regional tropical cyclone bodies under the initiative of Regional Specialized Meteorological Centres (RSMC) with Activity Specialization in Tropical Cyclones. In the North Indian Ocean, RSMC New Delhi started to provide storm surge advisories to the Members of the Panel on Tropical Cyclones in 2009. In the Western North Pacific, RSMC Tokyo is preparing for storm surge forecast charts to be distributed to Typhoon Committee Members in 2011. The SSWS Task Teams were set up in RA I and V Tropical Cyclone Committees.

3.2.2 The meeting noted that TCP and MMOP, with the support of JCOMM, have been promoting capacity building on storm surge and wave forecasting and warning for years. In particular, the meeting appreciated the organization by TCP and JCOMM of five workshops on storm surge and wave forecasting, and the annual attachment training in IIT Delhi in the previous ten years. The meeting informed that a workshop on storm surge and wave forecasting is planned to be held in Dominican Republic in December 2010. The meeting noted that further workshops on storm surge and wind wave forecasting are planned in 2011 in the Western North Pacific in 2011, in the North Indian Ocean and the Southwest Indian Ocean regions, respectively.

3.2.3 The meeting recognized that the SSWS is an important component of the coastal inundation advisory and warning mechanisms contributing to the improvement of storm surge forecasting and warning products at the regional level. The meeting therefore agreed that the CIFDP implementation should be closely coordinated with the relevant tropical cyclone regional bodies. In this context, the meeting decided that the CIFDP should liaise closely with the regional coordination of storm surge warning services. The meeting requested the WMO Secretariat to conduct a discussion during the workshop in Dominican Republic to facilitate coordination between CIFDP and SSWS activities.

**Action: WMO Secretariat, organize preliminary discussions with Dominican Republic NMHS during the TCP/JCOMM Training Workshop on Storm Surge and Wind Waves Forecasting**

#### 3.3 UNESCO/IOC Pilot Project on Enhancing Regional Capabilities for Coastal Hazards Forecasting

3.3.1 This project was initiated following the recommendations of the First JCOMM Scientific and Technical Symposium on Storm Surges on enhancing regional capabilities for storm surge prediction. The objectives of this project are; 1) to support scientific and technical development for enhancing regional capabilities for coastal hazards forecasting, and 2) to link regional community/activity with global framework. Key members of the JCOMM Expert Team on Waves and Storm surges (ETWS) lead the process, in partnership with the modeling experts of IIT Delhi.

The 1st phase was launched for the North Indian Ocean that is the most surge-prone region in the world, with financial contribution from the government of Korea and with institutional partnership with the government of India. The first advisory workshop (New Delhi, India, July 2009), <http://www.icomm.info/SSindia> reviewed the performance of the currently operating storm surge model in the region (IIT-D model), and agreed on the three-year work plans to upgrade the model predictability. The second workshop is planned on 11-15 February 2011.

3.3.2 The meeting agreed that this project was closely relevant to the CIFDP, and the two projects should continue interacting through the process. It was agreed that the outcome of this project should be introduced and discussed within the CIFDP, particularly in the context of reviewing the current operating system in the NIO region and making comparison with (the storm surge component of) other models under consideration. The Meeting also noted the importance of involving regional experts to the design and implementation of the CIFDP, and requested that the WMO and IOC Secretariats should ensure communication between the key experts of two projects

**Action: WMO and IOC Secretariats, ensure communication between the experts of CIFDP and IOC Project on Enhancing Regional Capabilities for Coastal Hazards Forecasting**

### **3.4 WMO Hydrology and Water Resources Programme: Integrated Flood Management and Coastal Flooding**

3.4.1 The meeting presented with the good practices on flood mapping and with community flood management developed in Bangladesh in the framework of the activities of the Associated Programme on Flood Management (APFM). The meeting discussed the necessary involvement of local institutions and communities in the CIFDP and agreed that the institutions should be involved in the Project at a national scale to ensure the long-term sustainability of the socio-economic benefits. The meeting noted the possibility to implement a series of pilot projects involving communities based on the experience gained during the Community Based approach to Integrated Flood Management (IFM) held in Bangladesh by APFM. The meeting noted that the Guidelines on Flood Mapping are on finalization and should be published by WMO Secretariat by March 2011.

3.4.2 The meeting recognized that the publication of the Guidelines on Flood Mapping and the Integrated Flood Management activities should be coordinated with the CIFDP implementation, in particular for the preliminary assessment of hazard, vulnerability and risk, as well as for determining end-users requirements at an early stage of the project preparation. The meeting further recognized that the experience developed during the previous Community based approaches to flood management in Bangladesh should also be taken into consideration to put in place effective preparedness, response and recovery measures in areas prone to coastal flooding.

**Action: WMO Secretariat, coordination with IFM activities and publication of the Guidelines on Flood Mapping**

### **3.5 Deltares: Flood Early Warning System (Delft-FEWS)**

3.5.1 Delft-FEWS is an open forecasting system that enables flexible interaction between data, models and Forecasting/Warning products. The system is fully configurable by users enabling short cycle from research to operations. The system is operating system independent, and is very scalable. It can run as a distributed (country-wide) as a 24/7 system or as platform for operational research on a single machine (PC). The system is based on Java, PostgreSQL/Oracle, Jboss, XML and the software is freely available and is focused on the central role for the user community for further development of the system. The idea behind the open system is to share knowledge and best practices on:

- Probabilistic/flood risk forecasting;
- Uncertainty quantification & reduction in forecasting;

- Forecast verification;
- Training for dealing with extreme events (Serious Gaming);
- Provide a platform to carry out Joint Research to extend the application to: Drought forecasting & reservoir management, (Extreme) surge & tsunami forecasting, inundation forecasting, water quality forecasting (e.g. harmful algae bloom).

3.5.2 The meeting noted that the system can now already communicate (“plug and play”) with over 70 models through generic model and data adapters, and that it can access various data formats. The meeting further noted that the system has now been implemented in a large number of flood forecasting centres and met-services world wide, such as the National Flood Forecasting System (United Kingdom), Dutch River and coastal forecasting for Rijkswaterstaat and water boards, Po River and Adriatic Sea for ARPA (Italy), Mekong River for (Mekong River Commission), PUB (Singapore), Community Hydrologic Prediction System and National River Forecasting System for National Weather Service (USA) and the Bureau of Meteorology (Australia).

### **3.6 WMO Disaster Risk Reduction Programme: Caribbean Regional Programme in Multi-Hazard Early Warning Systems with National Capacity Development**

3.6.1 The Caribbean Multi-Hazard Early Warning Systems (MHEWS) Programme will be developed with a 6-8 years vision starting in 2010. The priorities include the strengthening of operational forecasting capacities for hydro-meteorological and marine-related hazards and stronger coordination with the tsunami warning system. In the roadmap for the development of the Caribbean Regional Programme in MHEWS, a Technical Workshop is co-organized by WMO in Barbados, 1 - 5 November 2010, in coordination with the Caribbean Disaster Emergency Management Agency (CDEMA), the Caribbean Meteorological Organization (CMO) and its Caribbean Institute for Meteorology and Hydrology (CIMH), UNDP and other international and national institutions involved in disaster risk reduction in the Caribbean.

3.6.2 The meeting agreed that the forecasting system development in the framework of the CIFDP should be closely coordinated with the national and regional disaster management agencies involved in the Caribbean MHEWS Programme.

**Action: WMO Secretariat, engage preliminary discussions with the regional and national disaster management agencies during the Technical Workshop for the development of the Caribbean MHEWS in Barbados**

### **3.7 U.S. Army Corps of Engineers (USACE): Surge Forecasting, Risk Assessment and the Effects of Rivers**

3.7.1 This presentation covered differences in requirements for inundation information utilized for forecasting and for planning/risk-assessment. Forecast surges include a very large component of uncertainty from the error distribution in forecast storm track, intensity, speed, etc., consequently, the accuracy requirements for the modeled surges from individual storms are somewhat reduced – provided that the surge levels are not under-predicted. On the other hand, accuracy requirements for planning and risk assessment are much more stringent, since design and planning guidelines often involve critical thresholds. Because of this, models that are optimal for forecasting may not be suitable for planning/risk-assessment and vice versa. The presentation also discussed the impact of river discharge on surges travelling within the river. It was shown that, for the Mississippi River, variations in discharge from a median flow during summer months to double that flow could change the upstream surges by a metre or more. Finally, the presentation stressed the need to recognize critical differences in the relative roles of direct wind forcing and

wave set-up on surges in the two areas selected for demonstration projects, Bangladesh and the Dominican Republic.

### **3.8 UNESCO/IOC: Global coordination of end-to-end regional tsunami early warning system**

3.8.1 The meeting noted that the tsunami unit of UNESCO/IOC in 2005, based on the experience in the Pacific in operating to basin wide tsunami warning system (TWS), established three more intergovernmental coordination groups (ICG) to coordinate regional TWS in the Indian Ocean (ICG/IOTWS), the Caribbean (ICG CARIBE EWS) and the NE Atlantic and Mediterranean (ICG/NEAMTWS). The meeting further noted that all regional coordination groups started to work in a broader "coastal inundation" framework coordinated by IOCs Working Group on Tsunamis and other Ocean related Hazards Warning and Mitigation Systems (TOWS - WG) which ensures participation and membership of JCOMM and WMO.

3.9 All presentations in PDF format are available at the JCOMM website (see <http://www.jcomm.info/CIFDP2>).

## **4. REVIEW OF PROJECT PLAN AND FINALIZATION OF IMPLEMENTATION STRATEGY AND ACTIVITIES**

4.1 The meeting discussed the project framework. The meeting decided to revise the Implementation Plan submitted prior to the meeting, based on a phased approach, as described in paragraph 4.5.

4.2 The meeting noted that a general agreement at the national level in both Bangladesh and Dominican Republic is a key starting point required for the project implementation.

**Actions: WMO Secretariat, arrange a general agreement at the national level to ensure the commitment of the relevant institutions in Dominican Republic and Bangladesh, respectively.**

4.3 The meeting agreed that the Project Plan should be extended with sub-project specific annexes as soon as the system specification activities have been endorsed at the national level.

4.4 The meeting decided that the focus of the project is on the integration of existing forecasting components into an operational end-to-end forecasting system, allowing adaptation of the ongoing forecasting components and the continuous integration of available products. The development of hydrodynamic models can be considered as required by the systems specification following the initial workshops with stakeholders.

4.5 The meeting defined the Project Plan in a phased approach as follows:

- **Phase 0, Project preparation phase:** National agency(ies) agreement and commitment to the development of a long-term sustainable forecasting system;
- **Phase 1, Information gathering:** Infrastructure (organization and responsibilities); user requirements; data inventory; model inventory; hazard and vulnerability maps; system specification; revision of the organic Project Plan; endorsement of the specified project from the national government;
- **Phase 2, Project implementation:** Forecasting system integration (model adapters, hardware infrastructure), output communication plan, test of historical storms and verification, initial capacity building, ongoing review and evaluation by forecast producers;

- **Phase 3, Pre-operational testing and technical capacity building:** capacity building among forecasters during the tropical cyclone season, simulated multiagency exercise with involvement of pilot communities;
- **Phase 4, Operational evaluation:** Way forward; enhancements of the forecasting system; capacity building on developed products; development of hazard and vulnerability maps towards implementation of risk mapping; evaluation of the end-to-end system and demonstration workshop for stakeholders and media partners.

4.6 The Project Plan is given in Annex IV.

## 5. IMPLEMENTATION PLAN IN BANGLADESH

5.1 The Project Steering Group defined the timelines and the overall activities/actions for the implementation of the CIFDP in Bangladesh, taking into account the relevant activities that are planned in the Region II. The overall timeline with planned activities is given in Annex IV, with the following outline:

- **Phase 0: November 2010;**
  - Formal arrangements at the national level;

**Action by Secretariat: see paragraph 4.2**

- **Phase 1: December 2010 - May 2011;**
  - First technical and stakeholders workshop (23 – 30 March 2011);

**Actions: PSG and WMO Secretariat, draft Bangladesh technical and stakeholders Workshops programmes**

- Formal national commitment to the detailed Project Plan;
- Endorsement of the system specification and Sub-Project plan during the First Meeting of the Sub-Project Implementation Team (May/June 2011);
- **Phase 2: mid-May 2011 – November 2011;**
- **Phase 3: December 2011 – mid-April 2012;**
  - Incorporation of end-users input into process for better communication of the message and verification of the implemented package;
  - Evaluation by forecast producers (May 2012);
- **Phase 4: May 2012 – September 2013;**
  - Operational evaluation phase during the Tropical Cyclone season and enhancement of the system (May 2012 – September 2012);
  - Evaluation workshop with stakeholders and media partners (September 2013).

5.2 The meeting noted the Third International Conference on Water and Flood Management, Dhaka, Bangladesh, 8 – 10 January 2011. The Meeting agreed to use this opportunity for preliminary discussions.

**Action: WMO Secretariat, PSG and Consultant, organize preliminary discussions with flood forecasting and disaster management institutions in Bangladesh during the 3<sup>rd</sup> International Conference on Flood and Water Management in Dhaka**

## **6. IMPLEMENTATION PLAN IN DOMINICAN REPUBLIC**

6.1 The Project Steering Group defined the timelines and the overall activities/actions for the implementation of the CIFDP in Dominican Republic, taking into account the relevant activities that are planned in the Region IV. The overall timeline with planned activities is given in Annex IV, with the following outline:

- **Phase 0: December 2010;**
  - Formal arrangements at the national level;

**Action: WMO Secretariat, see paragraph 4.2**

- **Phase 1: December 2010 - July 2011;**
  - First technical and stakeholders workshop (April/May 2011);

**Actions: PSG and WMO secretariat, draft Dominican Republic technical and stakeholders Workshops programmes**

- Formal national commitment to the detailed Project Plan;
- Endorsement of the system specification and Sub-Project plan during the First Meeting (July/August 2011) of the Sub-Project Implementation Team;
- **Phase 2: August 2011 – February 2012;**
- **Phase 3: March 2012 – July 2012;**
  - Incorporation of end-users input into process for better communication of the message and verification of the implemented package;
  - Evaluation by forecast producers (June 2012);
- **Phase 4: August 2012 – December 2013;**
  - Operational evaluation phase during the Tropical Cyclone season and enhancement of the system (August 2012 – December 2012);
  - Evaluation workshop with stakeholders and media partners (December 2013).

6.2 The meeting noted that the RA IV TCP/JCOMM and Hurricane Committee Training Workshop on Storm Surge Forecasting is planned in Santo Domingo, Dominican Republic, 6 - 10 December 2010, and that the Technical Workshop for the development of Caribbean Regional Programme in MHEWS is planned in Barbados, 1 - 5 November 2010. The meeting agreed to use these opportunities for preliminary discussions.

## **7. FINALIZATION OF THE PROJECT PLAN**

7.1 Based on the discussions the Meeting agreed to endorse the modifications on the Project Plan according to the phased approach described in the paragraph 4.4 and requested the Secretariat to finalize the Project Plan, given in Annex IV.

**Action: WMO Secretariat and consultant, finalization of the Project Plan**

7.2 The meeting revised the project organisation chapter in the Project Plan (Annex IV), including PSG membership, PSG terms of reference and the link to other WMO, JCOMM, regional and national initiatives.

7.3 The list of action items is given in Annex V.

**8. CLOSURE OF THE SESSION**

8.1 In closing the meeting, Swail expressed his appreciation to all participants for their very positive input to the development of the Project Plan. The Chairman noted the upcoming phase of project preparation and highlighted the need for the PSG to work closely with the Secretariat. Swail concluded by thanking, on behalf of all participants, the Secretariat for their ongoing support.

8.2 The meeting closed at 15.30 hours on Wednesday, 22 September 2010.

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## AGENDA

### 1. Opening of the meeting

- 1.1 Adoption of the agenda
- 1.2 Working arrangements for the meeting

### 2. Report of the CIFDP-I and follow-up

### 3. Presentations and guest speakers

- 3.1 Introduction
- 3.2 WMO Tropical Cyclone Programme Storm Surge Watch Scheme
- 3.3 UNESCO/IOC Pilot Project on Enhancing Regional Capabilities for Coastal Hazards Forecasting
- 3.4 WMO Hydrology and Water Resources Programme: Integrated Flood Management and Coastal Flooding
- 3.5 Deltares: Flood Early Warning System (Delft-FEWS)
- 3.6 WMO Disaster Risk Reduction Programme: Caribbean Regional Programme in Multi-Hazards Early Warning System with National Capacity Development
- 3.7 U.S. Army Corps of Engineers (USACE): Surge Forecasting, Risk Assessment and the Effects of Rivers
- 3.8 UNESCO/IOC: Global coordination of end-to-end regional tsunami early warning system

### 4. Implementation strategy and activities

### 5. Implementation plan in Bangladesh

- 5.1. Estimated time schedule
- 5.2. Sub-project potential partners and regional opportunities

### 6. Implementation plan in the Dominican Republic

- 6.1 Estimated time schedule
- 6.2 Sub-project potential partners and regional opportunities

### 7. Finalization of the Project Plan

### 8. Closure of the meeting

### ACRONYMS AND OTHER ABBREVIATIONS

CAS	Commission for Atmospheric Sciences (WMO)
Cg	Congress (WMO)
CHy	Commission for Hydrology (WMO)
CIFDP	Coastal Inundation Forecasting Demonstration Project (JCOMM, CHy)
DMCPA	Disaster Management and Civil Protection Agencies
DRR	Disaster Risk Reduction (WMO)
EC	Executive Council
ESCAP	Economic and Social Commission for Asia and the Pacific
EWS	Early Warning System
HWR	Hydrology and Water Resources (WMO)
IHO	International Hydrographic Organization
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
M&E	Monitoring and Evaluation
MHEWS	Shanghai Multi-hazard Early Warning System Project
NMHS	National Meteorological (and Hydrological) Service
PIP	Project Implementation Plan (CIFDP)
PSG	Project Steering Group (CIFDP)
PWS	Public Weather Services (WMO)
RA	Regional Association (WMO)
RSMC	Regional Specialized Meteorological Centre (WMO)
SSWS	Storm Surge Watch Scheme (WMO)
SWFDDP	Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project
SWFDP	Severe Weather Forecasting Demonstration Project
TBD	To Be Decided
TCP	Tropical Cyclone Programme (WMO)
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNITAR	UN Institute for Training and Research
UNOSAT	UNITAR Operational Satellite Applications Programme
WMO	World Meteorological Organization

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**COASTAL INUNDATION FORECASTING DEMONSTRATION PROJECT**  
**PROJECT PLAN**

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## **1 Background**

### **1.1 Introduction**

Storm surges and wind-induced waves associated with severe cyclones, and their combined effect with river flooding, leading to coastal inundation, stand out as natural hazard with extreme impact potential including significant loss of lives and livelihoods. Recognizing this extreme vulnerability of coastal areas to storm surges and coastal inundation/flooding due to Tropical Cyclones (TC), there is a strong need for the development and implementation of comprehensive forecasting and warning systems, which allow dedicated disaster prevention agencies to safeguard lives and mitigate damages to infrastructure in coastal areas. An important factor of the system is the provision of flood risk maps that provide information on flood risks to be used by decision makers and the public.

WMO Fifteenth Congress (May 2007) requested the Secretary-General to “coordinate the collection and dissemination of information on meteorological, hydrological and climate-related hazards and their impacts, when possible and available”. Furthermore, in response to a request of the WMO Executive Council, at its 60<sup>th</sup> session (June 2008), WMO has initiated, through the joint efforts of Tropical Cyclone Programme (TCP) and JCOMM, the development of Storm Surge Watch Schemes (SSWS) in regions subject to tropical cyclones. Finally, WMO, through its Hydrology and Water Resources (HWR) Programme, is contributing through the improvement of tools and methodologies for flood hazard and risk analysis.

Additionally a comprehensive coastal inundation forecasting and warning system depends on the cooperation of different scientific disciplines and user communities. An integrated approach to river flow, storm surge, wave and flood forecasting will be the strategy for building improved operational forecasts and warnings capability for coastal inundation<sup>1</sup>.

Key players for operation of the forecasting services are the National Meteorological and Hydrological Services (NMHSs) of affected states. At present, the number of NMHSs globally that run storm surge, wave and hydrological models, coupled coastal forecasting systems is fairly limited and almost non-existent in developing countries. Hence, the Coastal Inundation Forecasting Demonstration Project (CIFDP) will work with NMHSs to support them in utilizing forecast products operationally and linking them to coastal flood management programmes and related activities. This requires substantive training in the use of these products, under different hydro-meteorological and risk situations.

As many sectors are involved, this requires an integrated approach that is embedded in an overall framework of coastal risk management. Other key players include national and local institutions responsible for disaster prevention, international organizations and centres of excellence in research and application of storm surge and coastal inundation mapping, modelling and forecasting.

The goal of the CIFDP is to show how coastal inundation forecasting products can be improved and effectively coordinated with warning services provided by the NMHSs. This process will be facilitated primarily by technical commissions, in particular JCOMM and CHy, in cooperation with a consortium of experts and related institutions of excellence in the field of storm surge, wave and coastal flooding.

A related goal of CIFDP is to contribute to the improvement of the interaction of NMHSs with Disaster Management Agencies (DMA), through an integrated coastal management strategy,

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1. Beside the development of tools, the development of guidelines for the maintenance of common database structures, metadata is essential. For these reasons, WMO and its partners have embarked on a project to develop Guidelines on Flood Mapping covering pluvial, fluvial and coastal flooding processes. The draft guidelines are expected to be available in spring 2011.

including the development of preparedness, response and management strategies of storm surges and waves associated with coastal inundation. These strategies will be built on the basis of hazard and vulnerability maps and related information by developing scenarios, for the use of DMA. These scenarios will be the

basis for disaster preparedness, and will provide valuable assistance to national partners involved in recovery and reconstruction activities.

CIFDP should provide an example of cooperative work as a strategy for building improved operational forecasts and warnings capability for coastal inundation.

## **2. Scope and Deliverables of CIFDP**

### **2.1 Project Initiation**

During the first CIFDP meeting, held in June 2009 in Geneva, Switzerland, various existing and developing storm surge, wave and hydrological models and integrated systems for coastal inundation forecasting were considered. (Australia, Bangladesh, India, Netherlands, Germany, UK and USA)<sup>2</sup>. This present version of the Project Plan has been developed during the second Project Steering Group Meeting in Geneva, 20 – 22 September 2010<sup>3</sup>.

The main focus of the CIFDP will be to facilitate the development of efficient warning systems for coastal inundation based on robust science and observations. The CIFDP should:

1. Support informed decision-making on warning issuance and dissemination (that includes information on land-use and planning);
2. Transfer and translate science and technology to communities (technology development and transfer);
3. Provide a framework for Coastal Flood Management;
4. Facilitate the development of a comprehensive Storm Surge Watch Scheme (SSWS) in basins subject to tropical cyclones, storm surges and (fluvial) flood events;
5. Facilitate the development and implementation of warning services;
6. Provide improved science to forecasters;
7. Support risk assessment, hazard and risk mapping;
8. Identify and support end-user needs. In this context, full engagement of the stakeholders and partners in the CIFDP from early stages is critical for the successful development and implementation of this project.

### **2.2 Goals and Expected Outcome**

The major goals and expected outcomes of the CIFDP are as follows:

1. Identification of stakeholders and user requirements in the areas where CIFDP will be implemented;
2. Technology development and transfer, including training, which would enhance the capabilities of NMHSs to produce and provide storm surge forecasting, coastal inundation

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<sup>2</sup> All presentations in PDF format are available at the JCOMM website (see <http://www.icomm.info/CIFDP>).

<sup>3</sup> see <http://www.icomm.info/CIFDP2>

forecasting and warning services, through the provision of tools for coastal inundation forecasting and warning services, and risk assessment;

3. Communication platform and training, which would improve interactions of NMHSs with stakeholders and partners (Government, Disaster Management and Civil Protection Agencies, media, etc) for better understanding of user requirements, effective communication of the message, and user feedback.

### **2.3 Overall Project Setup**

The project will be implemented in a phased approach, which provides opportunity to adjust the scope of the next phases to fit the prevailing requirements. At the end of each phase the status of the project will be reviewed by PSG before starting the next phase.

A detailed description of the phases is discussed in Chapter 3.

### **2.4 Focus Areas**

During the first CIFDP meeting, regional assessments/requirements for coastal inundation prone-areas in the different WMO Regions were presented. In particular the regional aspects in West Africa (RA I); South China Sea with focus on Shanghai area (RA II); Bay of Bengal (RA II); Caribbean (RA III/IV); Indonesia (RA V), and South Pacific Ocean and Storm Surge Watch Scheme (RA V) were discussed.<sup>4</sup>

On the bases of the assessments/requirements and the existing capabilities, the meeting agreed that there were six potential regions where the CIFDP should be implemented as a demonstration. The meeting noted that there were/ are other initiatives in place where the CIFDP could be seen as an integrating framework. These include the Shanghai Multi-Hazard Early Warning System (MHEWS) project and the Severe Weather Forecasting Demonstration Project (SWFDP).

Taking into account the limited resources available and the required time for the implementation of the CIFDP, priority for the initial implementation of the CIFDP is given to Sub-Projects in the following countries and regions:

- (a) Bangladesh (Bay of Bengal);
- (b) Dominican Republic (Caribbean).

However, the overall project concept for each of this Sub-Project should not be limited to the country itself but approached regionally.

At the same time, it was concluded to develop modalities for interactions with and input from associated projects, particularly for the following regions/countries - projects:

- Shanghai, China (RA II) – Multi-hazard Early Warning System (MHEWS) project;
- Indonesia (RA V) – proposed project by Deltares;
- RA I and RA V – Severe Weather Forecasting Demonstration Project (SWFDP) and the Storm Surge Watch Scheme (SSWS);
- West Africa – SWFDP and other initiatives in the region.

### **3. Organization**

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<sup>4</sup> All presentations are available at the JCOMM website (<http://www.jcomm.info/CIFDP>).

### 3.1 Overview

Implementation of CIFDP is governed by a Project Steering Group (PSG) with appropriate expertise for the development and implementation of the project, comprising met-ocean, hydrological and social experts. The Terms of Reference and membership of the PSG was defined (see following sections).

The task of software development (configuration of the front-end and back-end of the system), model implementation will be carried out by a consultant. The forecast system will be implemented at a national agency that is to be appointed by WMO in consultation with the selected countries. This agency will be the owner of the system, with a responsibility to maintain its daily operation.

The consultant and local and international experts appointed by PSG will co-ordinate the model development, calibration and validation efforts. In view of the usual difficulties in getting access to bathymetric data, which is critical for storm surge and flood forecasting, and hydrographical/ sea level data for evaluation and calibration of the model applications, it was decided that the WMO Secretariat establish agreements with the selected countries and with the International Hydrographic Organization (IHO) in order to facilitate the access to these required data.

The meeting also recognized the valuable contribution of the data available through the UNOSAT in identifying past events and in providing the associated data required for evaluation and calibration of models.

### 3.2 Links to Other WMO, JCOMM, Regional and National Initiatives

Modalities for interactions with and input from associated projects will be developed by PSG, particularly for the following regions/countries - project:

- Multi-hazard Early Warning System (MHEWS) project in Shanghai, China (RA II);
- Proposed project by *Deltares* in Indonesia (RA V);
- Severe Weather Forecasting Demonstration Project (SWFDP) in RA I, RA II and RA V;
- Storm Surge Watch Scheme (SSWS), cf. Figure 3. and Regional Specialised Meteorological Centre for Tropical Cyclones (TC) forecasting (i.e RSMC New Delhi and RSMC Miami);
- WMO Disaster Risk Reduction (DRR) Programme: Caribbean Regional Programme in Multi-Hazard Early Warning Systems (MH-EWS) with National Capacity Development;
- UNESCO/IOC (i.e. the pilot project on “Enhancing Regional Capabilities for Coastal Hazards Forecasting” in the North Indian Ocean).

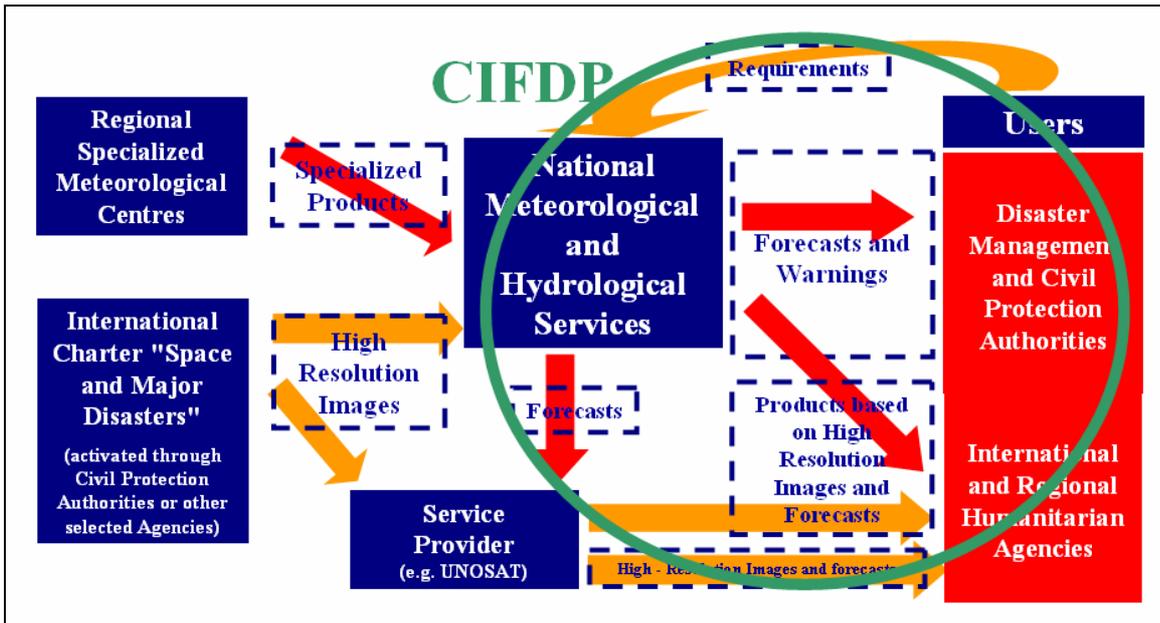


Figure 3.2 A concept for a Global Storm Surge Watch Scheme (WMO, 2009) and the position of the proposed CIFDP within it.

### 3.3 Stakeholders Commitment

The Consultant and PSG experts, together with national and regional relevant agencies, will define during the first national workshops the operational framework for the project and agree on resources allocation for the Sub-Projects, in particular the funding structure, the experts' contribution and the data management aspects. The first Sub-Project workshops with stakeholders and technical users will define the Sub-Projects' scope and prepare the agreements between stakeholders before starting the System development phase.

The stakeholders of each Sub-Project are the members of NMHS and other governmental, UN or disaster management related agencies involved in the national and regional achievement of the goals of the CIFDP, as described in §2.1. The stakeholders will constitute with the NMHS and consultant the Sub-Projects National Implementation Team (NIT) and the National Advisory Group (NAG) for development of the CIFDP tools and follow-up of the project evolution with regard to the end-user requirements, under supervision of the PSG.

### 3.4 Project Organization

PSG, supported by the WMO secretariat, has the task to review and approve the CIFDP Project Plan and its implementation.

The Sub-Project National Technical Implementation Team (NIT) will collaborate with the national operational meteorological and hydrological agencies for the implementation of the Forecasting and Warning System in close coordination with the PSG. The Consultant, a local institute, and a pool of experts nominated by the PSG and JCOMM/CHy, will join in a Sub-Project National Technical Implementation Team (NIT) that will be responsible for the development and implementation of the system until its transition to operational use. The NIT will also be responsible for the system maintenance and for data management aspects, in close coordination with the relevant Regional Specialized Meteorological Centres (RSMC). The Consultant has the task to coordinate and contribute to the activities, and to coordinate the reporting to PSG in close collaboration with WMO and IOC. NIT jointly reports to PSG for approval of the Project Plan at each phase of the implementation (see Figure 3.)

The National Advisory Group (NAG) will be constituted with representatives of the Sub-Project stakeholders and disaster managers from the national and international institutions involved in disaster risk reduction and disaster response, in coordination with UNOSAT and the regional ongoing initiatives. The NAG advises the National Implementation Team (NIT) in assessing and summarizing the end requirements of the potential end-users of the Forecasting and Warning System. The NAG will be responsible for the continuous end-users feedback to the NIT and PSG, including the final evaluation of each Sub-Project. The NAG will therefore contribute to build communication platforms between forecasters and meteorological products for users communities and develop a framework for an Integrated Coastal Flood Management approach.

The NIT will set-up the Forecasting and Warning System as will be specified with the NAG during the initial workshop and follow-up joint meetings.

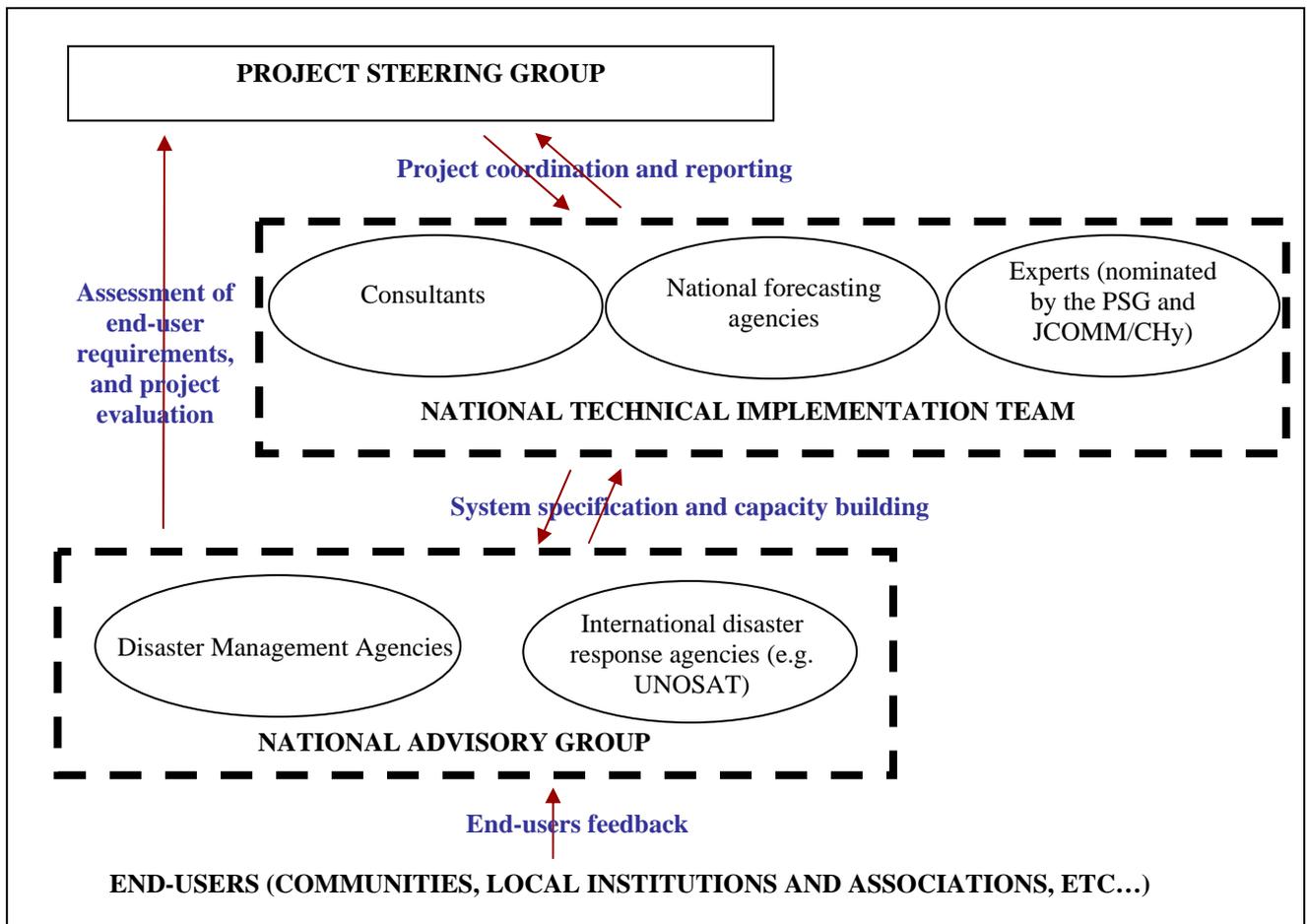


Figure 3.4 CIFDP Organigram

## 4 Approach to Project Implementation

### 4.1 Introduction

The aim of the project is to integrate cross-cutting scientific modelling software into an open forecasting environment in the purpose of improving/ expanding/ developing the forecasting and warning systems for:

- a. Tropical Cyclone landfall impacts on coastal areas;
- b. Storm surges;
- c. Hydrological response to heavy rainfall and Tropical Cyclone landfall on delta/estuary areas
- d. Tsunamis and related severe coastal events.

The project will focus on integrating the forecasting models already in operational use as 'plug-and-play' modules. The modelling components will be developed and adapted to fit in an open, flexible and easily extendable forecasting system: the future CIFDP system. The new system is expected to underpin a significant improvement of flood disaster management in coastal areas.

The project will be implemented in a phased approach that leaves scope for adjustment in the next phases to fit the prevailing requirements. The following phases were identified:

- Phase 0: Preparation**
- Phase 1: Information Gathering**
- Phase 2: System Implementation**
- Phase 3: Pre-Operation Testing and Capacity Building**
- Phase 4: Live Running and Evaluation**

The project phases are described in more detail in the following sections. Description of the phases and activities will become more detailed as the project progresses. Please note that the phases and tasks described below do not need to run strictly in parallel in the chosen countries (initially Bangladesh and Dominican Republic).

## **4.2 Preparation (Phase 0)**

Before the actual start of the CIFDP, National Agreements should be prepared. These National Agreements will be based on a high level definition of the operational scope for the national Sub-Projects in the chosen countries as described in this Project Plan.

In this phase, the Sub-Project National Implementation Team (NIT) will be identified. Within the NIT the National Hydrological and Meteorological Services (NHMS) – assisted by the WMO Experts and the Consultant - will be responsible for project implementation at national level. The national agreements will provide a national commitment to the Sub-Projects at the political level and will ensure a long-term coordination between the national agencies within the respective NIT and NAG.

Task responsibility: WMO.

## **4.3 Information Gathering (Phase 1)**

### **4.3.1 Initial Assessments**

The national capabilities in fields of coastal flood risk, inundation forecasting and related disaster management structures will be assessed and described. A high level inventory of the institutional end-users' information and communication needs for disaster management during extreme coastal flood events will be made. Combining assessments of both technical capacities and end-users requirements (gap analysis) will demonstrate where the CIFDP could provide added value.

Task responsibility: NHMS

### **4.3.2 Stakeholder Workshops**

The stakeholder workshops will be organised in each of the CIFDP Sub-Project countries:

- End-user workshop with organisations playing key roles in disaster and coastal hazards management (National Advisory Group);
- Technical workshop with the relevant forecasting agencies and operational centres (National Implementation Team).

The national stakeholder workshops will be a key activity in this phase of the project. The goals of these workshops are the wider introduction of the CIFDP, information collection on stakeholder needs and requirements, and obtaining agreement and commitment on the project objectives. Preparatory discussions will be held with the workshop participants direct prior to workshops. Both workshops will be held at the same time and will last one week. Both workshops will exchange information and results towards the end of this week in a joint session.

During these workshops interaction with and input from UNOSAT, RSMC and other relevant data producing agencies will be actively sought for and encouraged. The Workshops will be concluded with Recommendations for the Sub-Project implementation.

Task responsibility: WMO / PSG / NHMS.

#### 4.3.3 Information Collection and Implementation Specification

Following the stakeholder workshops a full information collection should be undertaken. In addition the national approach to the CIFDP implementation and the specification of technical systems and information products, and end user requirements will be undertaken.

The end user requirements include:

- Inventory of end user requirements;
- Specification of forecasting model components, forecasting system and hardware requirements;
- Definition of organisational setting - assessment of responsibilities structure & personnel capacity (training requirements, technical implementation approach);
- Inventory of vulnerability mapping data and products and practices in Coastal Flood Management.

Furthermore, special attention will be given to the information collection:

- Assessment of existing marine meteorology, hydrology and tropical cyclones forecasting capacities in the chosen countries, with the focus on compatibility with open source modelling software packages;
- Assessment of the availability of met-ocean, atmosphere and hydrology data in the chosen country(ies), including access to real-time observations, bathymetry, DEM, GIS and data related to coastal inundations past events;
- Data collection and establishment of a storm surges/coastal floods events database, in coordination with storm surge climatology initiatives.

Task responsibility: NHMS and NIT / NAG.

#### 4.3.4 Project Plan update and Sub-Project Implementation Plan

Based on the workshops outcomes, the Project Plan will be updated with the Recommendations for the Sub-Project implementation within 2 weeks after completion of activity 4.3.3. The recommendations from the Stakeholders and Technical Workshops should describe the technical and organisational aspects of the Sub-Project, the detailed working arrangement and the selection of the forecast components for CIFDP System.

Task responsibility: Consultant.

#### 4.3.5 Definitive National Agreements

Based on the updated Project Plan and Recommendations from the Stakeholders and Technical Workshops, a definitive commitment is to be obtained from National Government and from the National Agencies to carry out the following phases of the CIFDP.

Task responsibility: WMO.

#### 4.3.6 Project Phase Review and approval from PSG

The updated Project Plan will be presented to PSG for reviews, discussions and approval to start the next phase of the project. At this stage a definitive commitment from the National Government and National Agencies must already be in place.

This approval involves the technical and organisational aspects of the Sub-Project and the selection of the forecast components for CIFDP System that allows integration of different modelling software packages in a 'plug and play' mode, manages input and output data and provides standardized options for data analysis and presentation.

Task responsibility: WMO with support from Consultant.

### 4.4 System Implementation (Phase 2)

System implementation in Phase 2 will be the responsibility of the national agencies and the Consultant. Experts appointed by the PSG and by JCOMM/CHy will be involved at relevant moments in the implementation process while the PSG will be regularly updated on the progress of the work.

#### 4.4.1 Implementation Specification Kick-off Meeting

Prior to implementation, a kick-off meeting will be held to confirm the system implementation approach and the forecasting system setup as defined in the updated Project Plan. The specifications will be updated and detailed (i.e. describing concretely the links to data, software, models, hardware, communication platforms) if required.

All key stakeholders at national level should participate in the workshop and agree on the Sub-Project working arrangements, including the membership and terms of reference of the NIT and NAG, the meetings timeline and the reporting structure. End point of the Kick-off Meeting will be the generally accepted Sub-Project Implementation Plan.

Task responsibility: NIT.

#### 4.4.2 Model & System Development

##### 4.4.2.1 Forecasting Models

Atmosphere (hurricane, rainfall), ocean and hydrological forecasting prototype models in coastal areas will be selected or developed for the CIFDP focus areas. New models, if any, will be based on open-source modelling software. The models may be developed individually but serious attention must be given to the model interconnectivity and inter-changeability of the models for later integration of the models into the forecasting system.

Task responsibility: NIT.

#### 4.4.2.2 *Forecasting System*

The prototype forecasting system will be built up for an operational run integrating the forecasting models. The national forecasting system will be build through configuration of an existing open forecasting system framework (like Delft FEWS). In addition some software development may be required to connect models that do not yet have 'plug and play' interfaces (adapter) to the forecasting system.

As part of the system implementation, set-up of formalized communication platforms for data management (see example in Figure 3.) and project coordination will be worked out.

Technology transfer and on-the-job training will be an imported element of this task. The system implementation will be carried out by the Consultant with support from the technical experts of the national agencies to build local experiences and capacity.

Task responsibility: NIT.

#### 4.4.2.3 *Hardware setup*

Following the hardware specifications developed in Phase 1 of CIFDP, a hardware platform will be set up to run the forecasting system including the forecasting models. Where possible co-hosting may take place with existing systems.

The hardware platform should be available in an early stage of Phase 2 to allow operation and testing of initial versions of the forecasting system. On-the-job and some formal training of system managers will be part of this task.

Task responsibility: NMHS with support from Consultant.

#### 4.4.2.4 *System Testing*

System testing will include functional, performance and operational tests during the system implementation phase. Prototype versions of the forecasting system will be tested from an early stage in the implementation phase onwards of the using historical events. Based on simulation and hindcast of several characteristic historical events (e.g. tropical cyclones, storm surges, floods) the performance of the forecasting system including the forecasting models will be tested and demonstrated.

As part of this task, an acceptance testing plan will be prepared for testing in Phase 3 of the CIFDP. Further validation and improvement of the forecasting system will be carried out in operational testing phase during the tropical cyclone season in coordination with forecasters from the NHMS.

Task responsibility: Consultant with support from the NHMS.

#### 4.4.3 *End User Products*

An iterative approach will be followed for (web based) forecasting product development and related communication procedures to ensure a good and practical connection to end-user needs. Feedback from end-users and forecasters will be obtained on regular basis.

Development of coastal inundation scenarios (based on flood risk mapping) will be carried out in collaboration with DMCPA, disaster response and risk reduction institutional partners following an Integrated Flood Management approach, and guidelines provided by the WMO/HWRP. Interaction with UNOSAT will also take place.

Task responsibility: NAG

#### 4.4.4 Capacity Building and Training

Capacity building for the NMHS and key stakeholders will take place throughout the system implementation phase through on-the-job training, implementation workshops and some formal training for NMHS professionals will be undertaken by the system developers on setting of CIFDP technology.

More extensive formal training will be undertaken in Phase 3 of the CIFDP (see 4.5.2).

Task responsibility: Consultant with support from JCOMM/CHy Experts.

#### 4.4.5 Project Plan Update

Based on the results from the implementation of the prototype of the forecasting system the Project Plan will be updated and detailed for the remaining phases of the CIFDP.

The update is expected to include:

- Acceptance testing plan;
- Plan for the operational system set-up;
- CIFDP communication plan (dissemination of project results to wider audience);
- Human resource development and training plan.

Task responsibility: NIT/NAG.

#### 4.4.6 Project Phase Review and approval from PSG

The CIFDP deliverables including the updated Project Plan will be discussed amongst NIT members, including WMO experts, followed by a presentation to PSG for reviews, discussions and an approval to start the next phase of the project.

Task responsibility: WMO with support from Consultant.

### **4.5 Pre-Operation Testing and Capacity Building (Phase 3)**

The objective of Phase 3 of the CIFDP is to transfer the new technology and methods developed in the previous phase to an operational Forecasting and Warning System. This phase will include development of operational procedures, development of Coastal Flood Management tools, acceptance testing and capacity building. A major event in this phase of the project is the simulation of an extreme flood event using the CIFDP technology involving all key stakeholders from the forecasters to the end users at local level. CIFDP Phase 3 will be concluded with the CIFDP Forecasting System going live at national level.

#### 4.5.1 System User Guidelines

This task will focus on developing procedures to use the new CIFDP technology and allow an effective use of inundation forecasts for flood warning and disaster management. This new CIFDP technology will focus as well in developing new Coastal Flood Management tools. Such flood warning strategy will take into account forecasts – and the uncertainties in these forecasts - of flood risks resulting from combinations of surges due to storms and tropical cyclones, river floods and heavy rainfall.

This task should provide a basis for embedding the CIFDP technology in the national and local flood disaster management procedures.

Task responsibility: National agencies with support from Experts and Consultant.

#### 4.5.2 Further Training and Capacity Building

An important part of the capacity building for the NA and key stakeholders has taken place in the system implementation phase through on-the-job training and implementation workshops. This task will focus on formal training of NMHS professionals and other key stakeholders at national and local level. The training will focus on the operation, maintenance and further development of the CIFDP technology and the use of the forecasting products in flood disaster management procedures.

The training will pay attention to the set-up, strengthening and adaptation of marine meteorology and hydrological forecasting modelling skills, forecasting system handling, maintenance and related operational capacity. User and support documentation will be completed as part of this task.

Task responsibility: NIT.

#### 4.5.3 Acceptance Testing

A formal acceptance procedure will be followed to test whether the CIFDP technology is ready to be used operationally ('go live'). Defects identified during acceptance testing will be resolved and may require some retesting. The acceptance test procedure has been specified in task 4.4.2.4.

At the end of this task the CIFDP system should be ready to be used in the next task: an end-to-end forecasting simulation event.

Task responsibility: NIT.

#### 4.5.4 End-to-End Forecasting Simulation Event

A full end-to-end forecasting simulation event should demonstrate that the CIFDP system is ready to be used operationally in national and local disaster/hazard warning and flood management procedures. This major event includes a multi-agency test that includes the simulation of an extreme flood event using the CIFDP technology. The test will involve all key stakeholders from the forecasters to the end users at national and local level.

Task responsibility: NAG.

#### 4.5.5 Handover and going live

The final step in this phase will be the formal hand-over of the CIFDP system to the national agencies responsible for its operational use. This event may be used for promoting the CIFDP achievements at nationally and internationally. The current idea is to organise one day festive handover and media event.

Task responsibility: National agencies with support from WMO.

### 4.6 Live Running & Evaluation (Phase 4)

The CIFDP system is operational in this phase of the project. Realistically, some additional user requirements and change requests will become apparent when operating the system in real time. By giving room for some fine tuning, these requirements can be accommodated and will thereby contribute to the acceptance and appreciation of the new CIFDP technology. Also further training will contribute to this.

The CIFDP will be completed a year after going live with an international conference presenting and evaluating the project impact and defining a future direction for the WMO in this field.

#### 4.6.1 System Updates, Support & Maintenance

The system support and maintenance organisation will be fine tuned at this stage of the project. Also forecasting system improvement scheme will be established including training on storm surge forecasting, facilitation of technology transfer from research to operations and continuous improvement of the numerical models, in coordination with TCP/JCOMM regional workshops on wind waves and storm surges forecasting.

Based on practical experience with live operation of the forecasting and warning system, end-users' needs will be identified for (early) warning system, disaster management and support to decision-making. System updates will be implemented where required.

Task responsibility: NAG/NIT.

#### 4.6.2 Follow-up training

Further capacity building will be done involving technical training in collaboration with SSWS and RMSC partners. Also disaster management training is expected to be initiated in collaboration with the Integrated Coastal Flood Management regional partners.

Task responsibility: NHMS with support from Consultant.

#### 4.6.3 Project evaluation workshop & international conference

Approximately one year following the CIFDP system going live, a project evaluation workshop will be organised. The workshop will be combined with an international conference on coastal inundation forecasting and flood disaster management in coastal areas.

This major international event should provide an outlook to future benefits and enhancements of the implemented CIFDP technology and strategy. It is expected to contribute to the WMO vision on future capacity building over different domains like operational marine and hydrologic forecasting, and flood management strategies.

The project evaluation will focus on the benefits on the CIFDP approach to coastal inundation early warning, risk analysis and coastal flood management. It is expected give direction for the integration of the CIFDP approach into national Multi-Hazard Early Warning Systems in collaboration with national/regional disaster risk management agencies.

Task responsibility: NAG and WMO.

#### 4.6.4 Project wrap-up

The project will be wrapped up by finalising a dedicated website for coordination and centralization of the project information, such as documentation of best practices and time schedule of capacity building events; and for linking to extreme coastal events database, distribution of open-source (model or system/framework) software, archiving and models inter-comparison studies.

A direction will be formulated for transition from the project demonstration phase to a global implementation phase coordinating ocean-related hazards systems with WMO Regional Associations, UN bodies and other partners involved in particular in the development of a comprehensive Storm Surge Watch Scheme.

Task responsibility: NAG and PSG.

## **5 Planning**

### **5.1 Effort Estimates**

The project, until phase 3, is expected to last 18 months for Bangladesh and 21 months for the Dominican Republic. The estimated duration for each of the phases is as follows<sup>5</sup>:

Phase 0: 2 (3) months;  
Phase 1: 4 (6) months;  
Phase 2: 8 months;  
Phase 3: 4 months;  
Phase 4: (operational and evaluation) will start after phase 3 is completed and is anticipated to last for a year.

### **5.2 Timeline**

Below two time lines, one for each of the Sub-Project, are presented below.

The time line for each of the country is drawn with the aim to deliver the pre-operational and operational system before the start of the tropical cyclone seasons. In Bangladesh the cyclone season starts in May and in the Dominican Republic in September. For the project in Bangladesh this means a very tight schedule and that the project must be started right away (October 2010). The Dominican Republic project has a same structure as the project time line of Bangladesh, with a time lag between 1 to 3 months.

Meetings, workshops and conferences that are important and relevant to the CIFDP project, in the first 4 months of 2011, are shown in the time lines as well as an overview of the milestones.

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<sup>5</sup> Numbers between brackets are valid for the project in the Dominican Republic

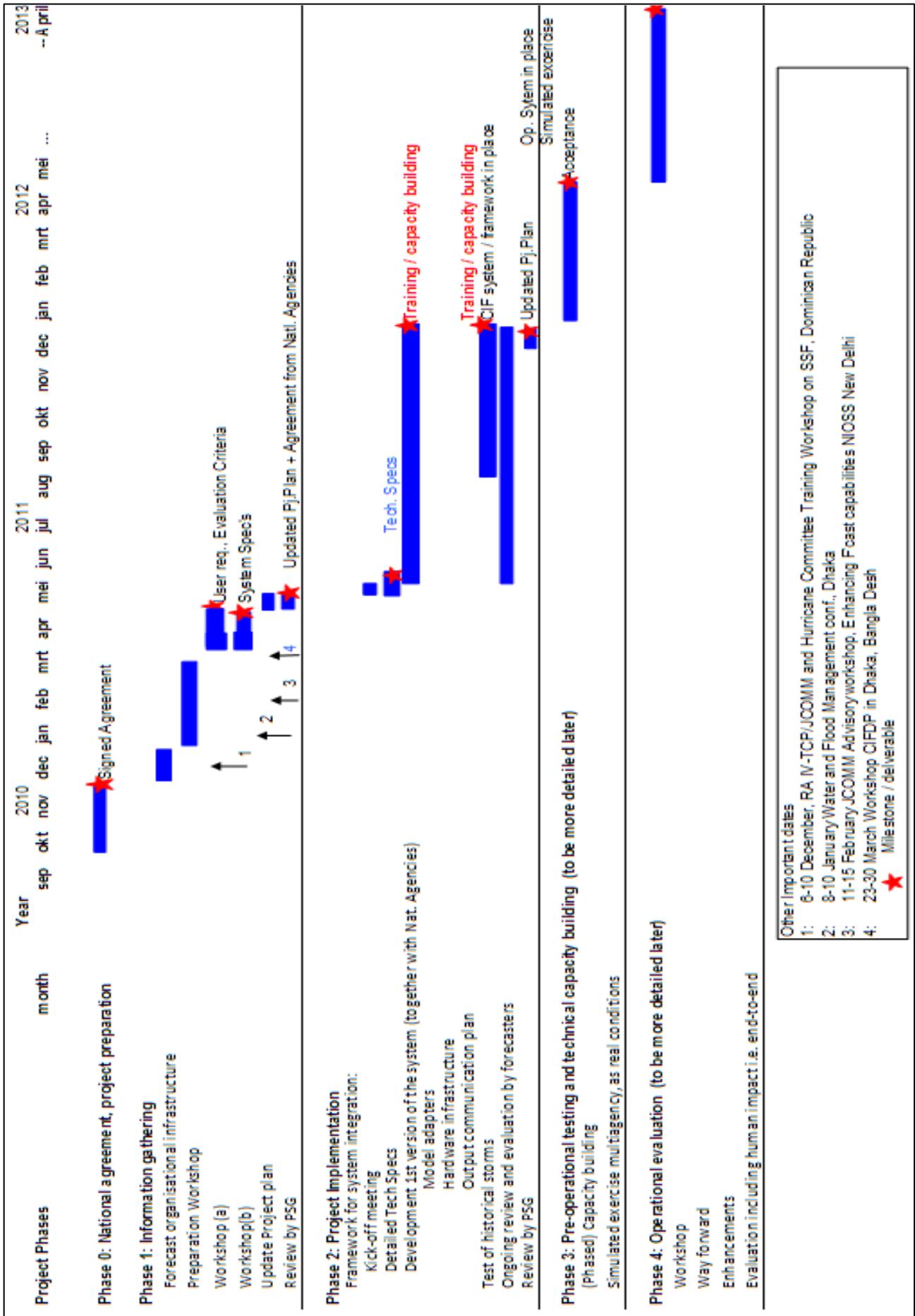


Figure 5.1 (a) Project timeline for Bangladesh

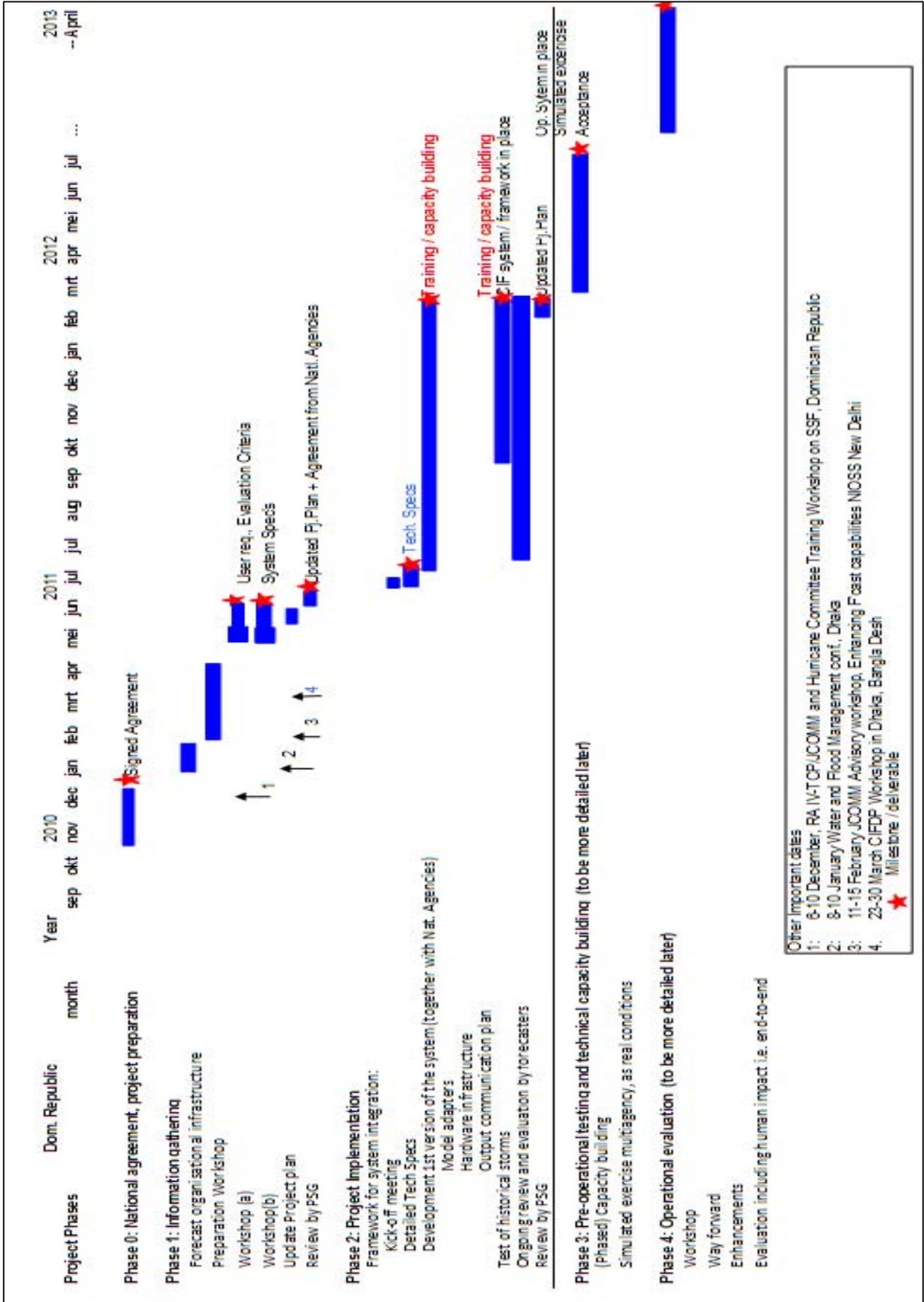


Figure 5.1 (b) Project timeline for the Dominican Republic

## **5.3 Milestones**

### **5.3.1 For Bangladesh project:**

#### Phase 0

December 2010: Signing of an agreement between the national agencies (BMD and FFC) approving, in principle, to the CIFDP initiative and willingness to co-operate and contribute in the preparation phase.

#### Phase 1

23-30<sup>th</sup> of March 2011: Workshop(s).

30<sup>th</sup> of April 2011: User requirements and system specification.

15<sup>th</sup> of May 2011: Approval of the updated plan by PSG before commencing phase 2;  
Agreement between BMD, FFC and relevant national agencies on the scope of the sub-project, by appointing the agency to operate it, and willingness to co-operate and contribute (by appointing forecasters) in the development and operational phase.

#### Phase 2

31<sup>st</sup> of May 2011: Sub-Project Implementation Plan for CIFDP in Bangladesh.

30<sup>th</sup> of December 2011: CIF-framework / system in place;  
Testing of past cyclones completed;  
Completion of 1<sup>st</sup> tranche of training / capacity building;  
Approval of the updated plan by PSG before commencing phase 3.

#### Phase 3

30<sup>th</sup> of April 2012: CIF pre-operational version completed,  
Simulated exercises completed,  
Completion of 2<sup>nd</sup> tranche of training / capacity building and  
Approval of the updated plan by PSG before commencing phase 4.

#### Phase 4

30<sup>th</sup> of April 2013: CIF operational version completed and implemented,  
Review / evaluation completed and,  
Recommendations for way forward.

### **5.3.2 For the Dominican Republic project:**

#### Phase 0

31<sup>th</sup> of December 2010: Signing of an agreement between the national agencies approving, in principle, to the WMO's CIFDP initiative and willingness to co-operate and contribute in the preparation phase.

#### Phase 1

15<sup>th</sup> of May 2011: Workshop(s).

20<sup>th</sup> of June 2011: User requirements and system specification.

30<sup>th</sup> of June 2011: Update CIFDP Project Plan and approval of the updated plan by PSG before commencing phase 3;

Agreement between national agencies on the scope of the Sub-Project, appointing the agency to operate it, and willingness to co-operate and contribute (by appointing forecasters) in the development and operational phase.

### Phase 2

15<sup>th</sup> of July 2011: Sub-Project Implementation Plan for CIFDP in the Dominican Republic.

30<sup>th</sup> of March 2012: CIF-framework / system in place,  
Testing of past cyclones completed,  
Completion of 1<sup>st</sup> tranche of training / capacity building and  
Updated CIFDP Project Plan and approval of the updated plan by PSG before commencing phase 3.

### Phase 3

15<sup>th</sup> of August 2012: CIF pre-operational version completed,  
Simulated exercises completed,  
Completion of 2<sup>nd</sup> tranche of training / capacity building and  
Updated CIFDP Project Plan and approval of the updated plan by PSG before commencing phase 4.

### Phase 4

15<sup>th</sup> of August 2013: CIF operational version completed and implemented,  
Review / evaluation completed and,  
Recommendations for way forward.

## **6 Cost Estimate and Financing**

### **6.1 Cost Estimates**

This section can only be completed after the financing structure is set.

### **6.2 Financing Structures**

WMO is providing support to the preparation phase of the Sub-Projects, in particular for the PSG meetings and for the initial stakeholders and technical workshops in the Dominican Republic. The financing structure of each Sub-Project will be developed in detail and agreed on the basis of the decisions taken during technical and stakeholders workshops at the national level.

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### **Appendices of the Project Plan:**

- A Members of the Project Steering Group**
- B Definitions and Abbreviations**
- C Technical Requirements**
- D Country Specific Considerations**
- E References**

## APPENDICES

### A Members of the Project Steering Group

The first CIFDP meeting nominated Mr Val Swail and Dr Donald Resio as co-chairpersons of the PSG, and agreed on its membership as follows:

- Dr Abu Saleh Khan - Bay of Bengal Modeling & Forecasting Expert
- Mr Fidel Perez - Caribbean Modeling & Forecasting Expert
- Dr Linda Anderson-Berry - Social Science Expert
- Dr Don Resio – Metocean Modeling & Forecasting Expert
- Prof Shishir Dube - Metocean Modeling & Forecasting Expert
- Dr Paul Davies – Hydrological Modeling & Forecasting Expert
- Ms Monika Donner or Prof Erik Pasche – Hydrological Modeling & Forecasting Expert
- Mr Deepak Vatvani - Consultant Representative

The Project Steering Group (PSG) will be supported by the JCOMM Secretariat.

### B Definitions and Abbreviations

#### B.1 Definitions

The words „model” or „system” are often used in different context with different meanings. To avoid misunderstanding the following definition will be applied in this document.

**Modeling software:** Software code used to solve certain hydrodynamic equations (equation solver). It is sometimes also referred to as Modeling Tools. Example: *HEC-RAS, ADCIRC, Delft3D MIKE21, SWAN, MIKE11, SOBEK.*

**Model (application):** Application for a specific area built using one of the modeling software mentioned earlier. Model application is defined by its input / output. Example: *Bay of Bengal storm surge model (application), Gulf of Mexico storm surge and wave model (application).*

**Forecasting system:** Software for coupling various model applications, with some intelligence and built in standard interfacing. Examples of such standard interfaces are: „plug and play” feature for various modeling software, telemetry data import archiving and client-server approach etc.). In case it is applied for specific purpose or for specific area, then the system requires (re-) configuration of the front- and back-end. Example: *NWS River Forecast System, CHPS forecast system, NFFS, FEWS Spain etc.*

## B.2 Abbreviations

BoM	Bureau of Meteorology (Australia)
DB	Database
DTM	Digital Terrain Models
CHPS	Community Hydrologic Prediction System
CIFDP	Coastal Inundation Forecast Demonstration Project
DHI	Danish Hydraulics Institute
DMCPA	Disaster Management and Civil Protection Agency
DRR	Disaster Risk Reduction (WMO Programme)
ECMWF	European Center for Medium-range Weather Forecast
FEWS	Flood Early Warning System (product of Deltares)
HWRP	Hydrology and Water Resources Programme
IHO	International Hydrographic Organization
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IFM	Integrated Flood Management
IWM	Institute of Water Modeling
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
MH-EWS	Multi-hazard Early Warning System
MMOP	WMO Marine Meteorology and Oceanography Programme
NAG	National Advisory Group
NIT	National Implementation Team
NMHS	National meteorological and Hydrological Services
NOAA	National Oceanic and Atmospheric Administration (USA)
NWP	Numerical Weather Prediction
NWS	National Weather Service (NOAA)
NWSRFS	National Weather Service River Forecast System
PSG	Project Steering Group
RSMS	Regional Specialized Meteorological Centre
SSWS	Storm Surge Watch Scheme
SWFDP	Severe Weather Forecasting Demonstration Project
TC	Tropical Cyclone
TCP	Tropical Cyclone Programme (WMO)
ToR	Terms of Reference
UK	United Kingdom
USA	United States of America
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOSAT	UN Institute for Training and Research (UNITAR) Operational Satellite Applications Programme
WMO	World Meteorological Organization

## **C Technical Requirements**

In this chapter are described how a forecasting system for coastal inundation could be developed for the achievement of the project activities and goals. These considerations will represent a basis for the assessment of the regional coastal inundation forecasting and warning capacities, identify gaps and provide an overview on the technical aspects for the definition Sub-Project specific Project Plan, as:

- a. Existing models and modeling capabilities;
- b. Communication / access to real-time data and quantitative forecast data;
- c. Bathymetry, DEM and GIS Data;
- d. Validation data;
- e. Organisational aspects.

### **C.1 Forecasting system and numerical models**

The following items should be considered:

- River models, wave models (offshore and coastal, including swell), storm surge models and flood models available;
- Local / regional capabilities to develop and maintain the models;
- Estimation of accuracy (in view of the model usage) of the existing models;
- Robustness of the models;
- Type of output available;
- Links to any existing forecast system

The river, wave and storm surge models, should in ideal case be coupled on-line (two way coupling). However, this will require huge computer power. Off-line coupling should be sufficient in the scope of system development activities, and could be improved during Phase 3 and 4 or in later system evolution depending of research applications opportunities.

#### **C.1.1 Forecasting system environment**

The forecasting system envisaged for CIFDP should have the following characteristics to support the aim of this project:

- the basic system can be implemented, with minor modifications, at different regions in the world;
- it is able to incorporate any numerical models (through so-called adapters);
- have standard capability to import data produced by various accepted Numerical Weather Prediction (NWP) models (e.g. ECMWF, NCEP);
- have a standard interfacing protocol to communicate between models and other components of the system;
- ability to run in real-time and produce forecast and warnings adapted to the operational NMHSs system
- easy to (further) develop / adapt and maintain without steep learning curve;
- new developments are shared with other CIF users in the world;
- based on open, non-proprietary system;
- robust and well tested;
- maintained properly;

The forecasting System will provide an-open source framework accepting plug-and-play modules, for example for observations data input or numerical models input. To illustrate some of the

possible information that is currently produced by existing forecast systems, a number of examples are presented below (copied from presentations given at the first CIFDP meeting in 2009).

#### C.1.2 Choice of atmospheric models

Some observations on the model aspects:

- Quantitative (local) rainfall models are not yet able to produce (long-term) forecasts with acceptable level of accuracy, especially during cyclone /hurricane events. This is also true for quantitative forecasts of rainfall in general, especially in (sub-) tropical areas. Rain gauges data and discharge gauges are extremely useful in this case;
- Local cyclone / hurricane model is required as NWP model(s) are usually not able to capture the hurricane winds with sufficient accuracy at a high resolution which is required by the storm surge and wave models.
- The Database shown in the figure above is different from the scenario database, which in the figure above is hidden behind the Decision Support System (DSS).

#### C.1.3 Choice of marine meteorology models

Wave propagation models in coastal areas (land) is not a trivial issue and development works has to be put into this issue to adapt exiting models, likewise, combined storm surge and river floods have to be looked at in a model environment.

Many coastal forecasting systems already available in the world have (in parts) integrated the entire train of numerical models mentioned earlier, as shown by the presentations given during the first CIFDP meeting ([see http://www.jcomm.info/CIFDP](http://www.jcomm.info/CIFDP)). However those systems lack some of the most important requirements mentioned above.<sup>6</sup>

#### C.1.4 Choice of integrated forecasting systems with hydrological and hydrodynamic/river models

For the (river) flood forecasting systems the situation is slightly better. Numerous forecasting systems that have been implemented fulfil the requirements mentioned above. Examples are:

- NFFS in UK - Environment Agency (that includes coastal inundation forecasting, <http://www.deltares.nl/en/project/101513/national-flood-forecasting-system-england-wales>),
- NWSRFS - USA that is currently being migrated to CHPS-FEWS, NWS / NOAA ([http://www.nws.noaa.gov/oh/hrl/chps/project\\_preparation.html](http://www.nws.noaa.gov/oh/hrl/chps/project_preparation.html))
- FEWS Australia – BoM Australia.
- Mekong River Forecasting System (based on FEWS), Vietnam

These forecasting systems have been developed using the approach that is well suited for the system that is envisaged for the CIFDP program. Initial development and pilot implementation of these systems was carried out by Deltares followed by transfer of technology. Further developments are carried out jointly by the agencies themselves with support from Deltares. Any new developments are shared with other users, reducing cost of implementation and maintenance.

It is envisaged that a similar development method is adopted here. This will guarantee consistency of the system and, at the same time, self reliance as far as maintenance and future developments are concerned.

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6. The coastal inundation forecasting system developed for the Andhra Pradesh state in India (funded by the World Bank) contains almost all of the models, but one (i.e. the wave model).

## C.2 Data management

### C.2.1 Hardware configuration

The ideal hardware configurations for a Coastal Inundation Forecast (CIF) system could be a-priori determined (see Figure below). However, not all components may exist or implemented at once. Prioritisation may be needed, so that ultimately the system can be developed in steps to meet the ideal requirements.

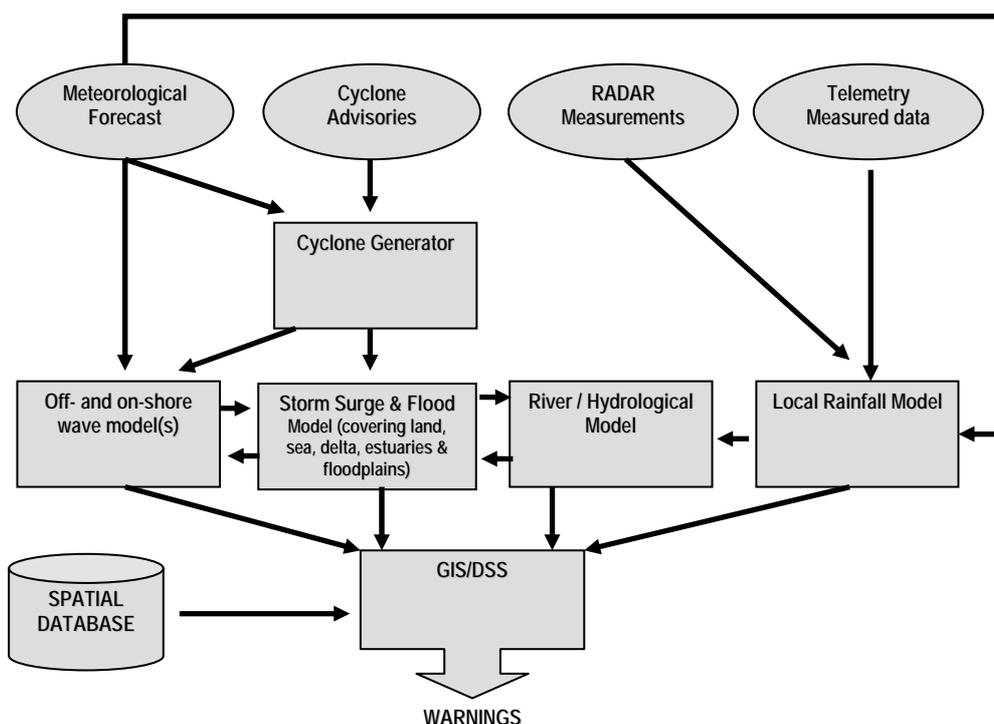


Figure C.1 Idealised model configuration for the targeted Coastal Inundation Forecast System

Detailed specification of each of the components will be provided only after the activities mentioned in 5.1 and 5.2 have been carried out / have produced results.

An example of web-based viewer / application for a real time Southern California Coastal Hazard (modelling) system, that partially could be applied in CIFDP case can be seen at <http://cosmos.deltares.nl/SoCalCoastalHazards/index.html>. Similarly one can also inspect the NWS site in USA: <http://www.weather.gov/forecasts/graphical/sectors/>.

An archiving sub-system (not shown in the figure) is an essential part of the hardware configuration. Selection criteria of events that need archiving must be developed to avoid overburdening the system.

Other items that should be considered here are:

- Resolution of the models (e.g. local wave models: approximately 100-200m, storm surge models: 200-500 m; inundation model: 25-100m);
- Model run times;
- Availability of data;
- System maintainability and extendibility.

### C.2.2 Bathymetry, DEM and GIS data

- Availability and access to GIS data (land use, population, shelters, building types, roads, electricity etc.);
- Availability of accurate DEM and bathymetry;

### C.2.3 Real-time data

Should be considered the communication / access to:

- Overall, spatial and temporal, atmospheric models (wind and pressure) and (quantitative) rainfall predicting models in real time;
- local atmospheric (wind and pressure, i.e. cyclone model) and (quantitative) rainfall predicting capabilities in real time;
- tide, wave and rainfall gauges in (near) real time.

### C.2.4 Validation data

In order to calibrate and validate the models and set-up the prototype, 3 to 4 official validation cases should be selected. Data that is required should cover the entire duration of the events:

- Rain gauge data (hourly, 3 hourly and daily);
- Wave height data (off and on shore);
- Water level data (Storm surge, tidal data, and if exists the mean sea level anomaly for fluvial and marine waters);
- Discharge/ flow data (discharges, inland runoff, flow velocities etc for estuaries, rivers, etc.)
- Observed wind data;
- Satellite pictures of cloud cover, cyclone positions;
- Cyclone/Hurricane tracks (forecast and actual) and parameters (maximum winds, gusts, pressure drop);
- Any hind cast wind and pressure fields from e.g. ECMWF, NCEP or any other sources;
- Off-shore wave field hind cast.

### C.2.5 Output of the system

The following issues are of importance:

- What kind of information is required (textual advisory, textual warnings, inundation maps, possible impacts on existing infra structure / population etc.);
- Who will be requiring the information above and for what purpose? ;
- Information update (e.g. every 6 hours 1 day before the expected event otherwise every 12 hours);
- Dissemination method;
- Off-line use of the system (flood hazard maps; coastal vulnerability) to assist the development of a Coastal Inundation Preparedness Plan (CIPP) and Standard Operational Procedure (SOP) that is to be followed in case of a threatening event;
- Communication platforms

## C.3 Organizational aspects

- Mandate of the forecast agency;
- Availability of qualified staff to run the system in 24x7 mode;

- Computer and communication infrastructure.

## D. Country Specific Considerations

### D.1 Bangladesh

Storm surge models for Bangladesh exist and have been applied on regular basis. Hydrological forecasting models for the entire country are already operational. Consequently, no new model development is anticipated for Bangladesh at this stage. Existing models will be integrated within the forecast system and tested to show that the results produced by the individual models can be replicated by the integrated forecast system. For integration within the forecast system, a 'plug and play' interface (adapter) will be required and provisions are made to provide such an adapter for this project.

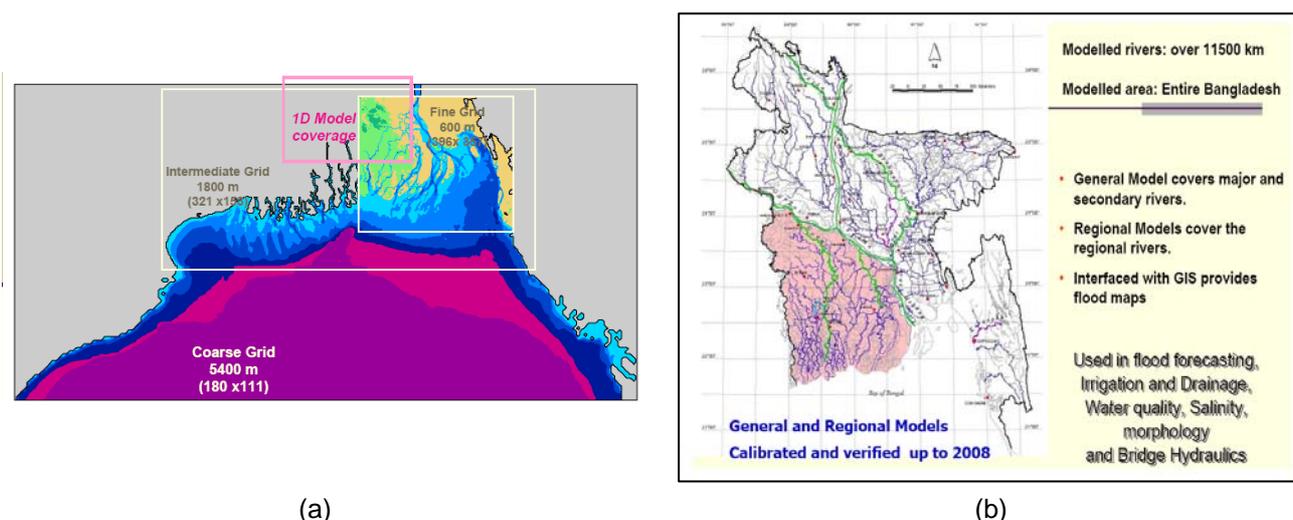


Figure C.2 Overview of the area covered by (a) the storm surge models and (b) hydrological models for Bangladesh  
(source: Prof. Abu Saleh Khan, IWM, Bangladesh)

In case that the development of such an interface will cause delay to the project a temporary solution will be sought, using a set of numerical models that already possess such an adapter. The temporary models used will be replaced by later by the actual models as soon as they are ready. Because of the status of the models, it is expected that the models need no calibration / validating as they have been carried out. Only fine tuning of the models may be required.

A special consideration for Bangladesh is the unique role and responsibility of the Flood Forecasting Centre (FFC) and Bangladesh Meteorological Department (BMD). FFC is responsible for the (inland) flood forecasting and BMD is responsible for the forecasting of the storm surge. In this project these two roles overlaps. Hence an agreement between these two national agencies on the role and responsibility for operational running of CIFDP is essential for a successful implementation of this project.

### D.2 Dominican Republic

In the Dominican Republic coastal inundation is caused primarily by storm surge and wave effects (in contrast to the Bangladesh situation). It is not yet clear at this moment whether relevant models for the region already exists and is operated by the regional RSMC. It is anticipated however, that local storm surge and wave models need to be developed under this project with the guidance from US and Canadian experts. Although the forecasting models will not be the same as the forecasting models in Bangladesh, but the forecasting system that is to be developed will make use of the same components as the system in Bangladesh.

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**LIST OF ACTION ITEMS**

Paragraph	Action	By whom	When/Target
3.2.3	Organize preliminary discussions with Dominican Republic NHMS during the TCP/JCOMM Training Workshop on Storm Surge and Wind Waves Forecasting	WMO Secretariat	6 - 10 December 2010
3.3.2	Ensure communication between the experts of CIFDP and NIO project	WMO and UNESCO / IOC Secretariats	Continuous
3.4.2	Coordination with IFM activities and publication of the Guidelines on Flood Mapping	WMO Secretariat	March 2011
3.6.2	Engage preliminary discussions with the regional and national disaster management agencies during the Technical Workshop for the development of the Caribbean MH-EWS in Barbados	WMO Secretariat	1 – 5 November 2010
4.2	Arrange a general agreement at the national level to ensure the commitment of the relevant institutions in Bangladesh	WMO Secretariat,	November 2010
4.2	Arrange a general agreement at the national level to ensure the commitment of the relevant institutions in Dominican Republic	WMO Secretariat	December 2010
5.1	Draft the programme of Bangladesh technical Workshop	PSG, WMO Secretariat	January 2011
5.1	Draft the programme of Bangladesh stakeholders Workshop	PSG, WMO Secretariat	January 2011
5.2	Organize preliminary discussions with flood forecasting and disaster management institutions in Bangladesh during the International Conference on Water and Flood Management in Dhaka	PSG, WMO Secretariat, Deltares	8-10 January 2011
6.1	Draft the programme of Dominican Republic technical Workshop	PSG, WMO Secretariat	January 2011
6.1	Draft the programme of Dominican Republic stakeholders Workshop	WMO Secretariat	January 2011
7.1	Finalization of the Project Plan	Deltares, WMO Secretariat	Mid-October 2010