



**Workshop on the Strategy and Action Plan of the
WMO
Flood Forecasting Initiative**

**WMO Headquarters
Geneva, 8 – 10 December 2009**

FINAL REPORT

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Background and objectives

Developed in 2003, the WMO Flood Forecasting Initiative (FFI) is based on the analysis of weaknesses of current forecasting systems and with a focus to enhance the ability of National Hydrological and Meteorological Services (NMHSs) to cooperate in an effective manner to provide improved flood forecasting services. The objective of the initiative is to: "Improve the capacity of meteorological and hydrological services to jointly deliver timely and more accurate products and services required in flood forecasting and warning and in collaborating with disaster managers, active in flood emergency preparedness and response".

Based on a series of eight regional workshops and one global conference in November 2006, a Strategy and Action Plan had been developed as a means to achieve the objective of the WMO Flood Forecasting Initiative. The Fifteenth Congress of WMO in 2007 had endorsed the "Strategy and Action Plan for the Enhancement of Cooperation between National Meteorological and National Hydrological Services for Improved Flood Forecasting". Subsequently, in its Resolution 3, the Commission for Hydrology (CHy) during its thirteenth session in 2008 (CHy-XIII, 2008) decided "To supplement the Strategy and Action Plan on the Flood Forecasting Initiative with a detailed activity plan that will assist Members in establishing flood forecasting systems."

The principal objective of this workshop was therefore to develop a detailed, region-specific Activity Plan based on the Strategy and Action Plan of the WMO Flood Forecasting Initiative.

This had been achieved by a series of presentations, guided group discussions and writing sessions. Principal results of the workshop were the adoption of an Activity Plan, and guidance to implement the Activity Plan to achieve the objective of the Strategy and Action Plan (SAP) of WMO's Flood Forecasting Initiative (FFI).

Welcome remarks by representative of WMO and opening of the workshop

Welcoming participants of the workshop, Dr Grabs outlined the objectives and expected results of the workshop, highlighting the necessity to mainstream the Strategy and Action Plan of the WMO Flood Forecasting Initiative into actual implementation. Basis for the implementation would be the Activity Plan, developed on the basis of the Strategy and Action Plan. He expressed satisfaction over the fact that not only a good number of participants had contributed in earlier events in the development of the Strategy and Action Plan but also that the workshop showed gender balance and good representation from WMO regions. He informed participants that the Final Report of the workshop together with all presentations will be available under the following URL: http://www.wmo.int/pages/prog/hwrf/flood/wmo_FFI_StrategyActionPlan.html.

The workshop was attended by 13 participants from 13 member countries (annex 9) and was chaired by Mr Julius Wellens-Mensah from Ghana.

The WMO Flood Forecasting Initiative (FFI): Overview of the Strategy and Action Plan

The FFI is based on the understanding that an improved cooperation between National Meteorological and Hydrological Services (NMHSs) is essential to provide better flood forecasting services to decision-makers and the general public that can be quantified in terms of improved accuracy and reliability of flood forecasting services and improved timeliness, update cycle and extended forecasting times beyond 48 hours. The SAP serves as a guide to the Technical Commissions and the WMO Secretariat in all activities related to improving flood forecasting capabilities worldwide.

The SAP identifies a number of Action Domains that need to be addressed to improve the overall chain of hydrological forecasting. These have been at the core of discussion at the workshop for the development of the Activity Plan. Further, the SAP promotes the preparation of national

implementation plans and suggests the implementation of demonstration projects at various levels (country-specific, sub-regional and regional projects).

At the regional level, the SAP advocates the establishment of a framework under which partnerships and development assistance could be provided and coordinated amongst the Members and the various contributing agencies while taking advantage of existing regional and international arrangements. The SAP also addresses requirements of well-established flood forecasting and warning systems for their further improvement.

An overview of the SAP is provided in annex 1 and the full SAP document can be downloaded from: <http://www.wmo.int/pages/prog/hwrp/documents/FFInitiativePlan.pdf> .

Discussion of key features of the SAP

Participants recognized a number of key challenges for hydrological services including

- Capacity Building
- Observation networks and telecommunication
- Integration of hydrological & meteorological data and information
- Data management and forecast modelling
- Modernization of services and effectiveness of forecasting procedures and products

Based on the Action Domains of the SAP, implementation plans are to be developed on national, sub-regional and regional levels. To demonstrate the validity of different approaches to address key challenges for hydrological services and the technical and institutional feasibility of proposed actions, the SAP proposes a number of demonstration projects. The SAP also proposes the development of a Flood Forecasting and Warning International Support Committee (FFWISC) as an overall coordination and support platform for the implementation of the SAP. Cooperation and Technical Assistance could then be undertaken under an overall framework within the scope of the SAP endorsed by WMO Congress and the WMO Technical Commission for Hydrology (CHy).

Implementation Status of the WMO Flood Forecasting Initiative (FFI)

Participants were informed that, based on the results of eight regional workshops, and a global conference, the Commission for Hydrology (CHy) in 2007 had decided to supplement the Strategy and Action Plan (SAP) on the Flood Forecasting Initiative (FFI) with a detailed Activity Plan that will assist Members in establishing flood forecasting systems. Based on the SAP and the detailed Activity Plan, the CHy further decided to explore the possibility of establishing an Inter-Commission Task Team comprised of representatives of CHy, and the following Technical Commissions of WMO:

- Commission on Basic Systems (CBS)
- Commission for Climatology (CCI) and the
- Commission for Instruments and methods for Observation (CIMO)

This Inter-Commission Task Team should then support the implementation of FFI.

An important component of the FFI is the planning and implementation of the project: “Flash Flood Guidance System” The overall goal of the project is to contribute to reducing the impacts from flash floods in different regions by providing the operational capacity for flash flood warnings. The project is currently funded by USAID and will eventually be implemented region-wise. Currently, FFGS has been implemented in Central America and is in various stages of implementation in the Mekong river basin (since 2008) and the Southern African Region (since 2009). It is also planned to implement it in the Black Sea and Middle East Regions (starting in 2010) with other regions to follow.

Implementation Status of the Strategy and Action Plan of the FFI

Until November 2009, the following achievements were communicated to participants of the workshop:

- Eight regional meetings held
- About 58 countries have participated with over 300 participants from National Meteorological and Hydrological Services;
- Since 2005, a network of meteorologists and hydrologists has been formed and is active covering regions WMO Regions III and IV (South and Central America),
- 86 countries have participated in a survey to identify main flood forecasting capabilities and shortfalls;
- A global conference as been organized in November 2006 to formulate a Strategy and Action Plan for Flood Forecasting.
- A Strategy and Plan of Action had been developed and endorsed by WMO Congress in 2007
- The WMO Commission for Hydrology (CHy) in 2008 decided “To supplement the Strategy and Action Plan on the Flood Forecasting Initiative with a detailed activity plan that will assist Members in establishing flood forecasting system”;
- A project “Flash Flood Guidance System with Global Coverage (FFGS)” has been developed in 2008 together with NOAA, HRC and USAID that is implemented in different regions since 2009;
- Development of an Activity Plan to supplement the SAP for its implementation

Participants noted that the implementation of the SAP includes country-specific, sub-regional and regional activities that should be implemented through demonstration projects (annex 2). Participants also noted the importance to recognize different capacity levels of National Meteorological and Hydrological Services (NMHSs) in tailoring activities as a means to implement the SAP. The categorization of different capacity levels of NMHSs are documented in annex 3.

Region/country - specific issues

Participants discussed regional issues and reiterated that the implementation of the SAP needs to be tailored towards specific conditions in different regions and institutional as well as technical situations of the National Meteorological and Hydrological Services. Participants reviewed a document providing a summary of main regional conclusions/issues emerging from the regional workshops held earlier. Participants saw merit in this table attached as annex 4, to document regional specific issues. In presentations made by participants from WMO regions I, II, III, IV and VI the following common issues were identified:

Amongst the most prominent challenges are:

- Inadequate professional capacity at the working and the institutional level;
- Obsolete or dysfunctional hydrological information systems including station networks and communication facilities;
- Fragmented forecasting services;
- Insufficient cooperation between meteorological and hydrological agencies;
- General lack of adequate quality management controls in forecasting; and
- Low level of integration of forecasting services in natural risk management and disaster reduction management.

The following paragraphs summarize key issues of the presentations made:

WMO Region I (Africa)

Nile Basin Initiative

The Flood Preparedness and Early Warning Project (FPEW I) is under implementation as one of the fast track projects through the Eastern Nile Subsidiary Action Program (ENSAP). The Eastern Nile Technical Regional Office (ENTRO) established the Regional Flood Coordination Unit to facilitate the project implementation. The FPEW I project established a new National Flood Forecasting Center in Ethiopia and enhanced the existing Flood Forecasting Centers in Sudan and Egypt. The Regional Flood Coordination Unit is located in Eastern Nile Technical Regional Office (ENTRO) at Addis Ababa. The following activities have been conducted or are ongoing:

- Capacity building training in Numerical Weather Prediction (NWP) using ETA and MM5 models conducted;
- Development and calibration of Flood Forecasting Model using HEC models (HEC-HMS, HEC-RAS, etc.) in Ethiopia and Sudan (A.A. & Khartoum Universities);
- Flood Risk Mapping & Community Flood Preparedness Action Plans for Pilot areas in Ethiopia and Sudan
- Enhancing satellite precipitation estimate and hydrological models in Egypt;
- Two annual flood forums are conducted in Khartoum, and Cairo the third is planned for January 2010 in Ethiopia.
- International study tour to India and Bangladesh for sharing experience in flood forecasting and community flood preparedness.

Main challenges include lack of good quality hydrological (flow) data for model calibration in Ethiopia and Sudan; establishing and operating real time gauging stations and data communication system & data sharing between agencies & countries.

In addition there is very short lead forecasting time (in hours) in Ethiopia, questions on the sustainability of flood forecasting systems in Sudan and Ethiopia, general lack of capacity to predict short period rainfall data (NWP); and institutional and professional capacity building in flood forecasting & the use of hydrological models including correct interpretation of model results.

Ghana

Ghana experiences both urban and rural/widespread flooding. Likewise, Ghana also experiences flooding from dam spills in upstream country. These spills are beneficial for filling up reservoirs for hydropower generation, but causes severe flooding on way to the reservoirs. This requires synchronization of spilling with conditions in downstream channels that in turn requires timely communication of scheduled, controlled and phased spilling from upstream dams and reservoirs.

Ghana uses streamflow forecasting models for inflows into dams and reservoirs for management of hydropower, potable water supply and irrigation reservoirs; however with challenges related to inadequate infrastructure, instruments and equipment to collect and transmit hydro-met data in real time mode including radars for rainfall forecasting, there is no comprehensive Flood Forecasting System, except for ad hoc warnings based on levels in rivers.

There is the urgent need to develop end-to-end flood forecasting systems taking advantage of state-of-the art observing systems, data transmission, modeling (eg. using NWP inputs), transmission of flood warnings, generation of flood impact scenarios and related response measures that, amongst others require delineation of flood plains in relation to flood magnitudes, duration and inundation depth.

WMO Region II (Asia)

China

The flood forecasting system of the Changjiang (Yangtze) River was presented as an example.

Major input into the short-term flood forecasting system is Quantitative Precipitation Forecasting information. In this system, accuracy of flood forecasting information is largely depending on the accuracy of precipitation forecasts. Information processing is based on an interactive flood forecasting platform, and the short-term hydro-meteorological forecasts plays a vital role in a comprehensive Decision Support System for flood management purposes.

Large reservoir and multiple reservoirs operation in the river basin require longer time forecasting capabilities. Consequently this requires improvements related to meteorological forecasting technologies and middle to long term hydrological forecasting technologies, including new models. Especially the influence of dams and reservoirs on the river system requires close monitoring of the river hydraulics and necessitates frequent re-calibration of models.

Challenges include

- Lack of reservoir operation information – currently the national and regional flood management headquarter are promoting coordination (with hydropower firms) and cooperation on such issue;
- Integrated reservoir operation is important for water resources redistribution and management – which requires longer lead time, thus
 - (1) Middle-long term flood forecasting accuracy needs urgent improvement;
 - (2) Need to improve Quantitative Precipitation Forecasting accuracy.

Thailand

The Mission of the Thai Meteorological Department (TMD) is

- To supply weather forecasts for the entire country and publicize disaster warnings
- To build the people's awareness toward natural disasters and reduce effects from natural disasters.
- To become the meteorological IT data and service center at the national level for users in any ventures,
- To improve and develop the Departments research works

Functions and responsibilities include

- Operation and maintenance of 24 hydro-meteorological stations and 1,178 automatic rain gauge stations using a real-time telemetering system
- Provision of flood forecasting and warning information and services
- Analysis of the hydrometeorological data of the hydrometeorological and rain gauge stations nation- wide, including the Bangkok Metropolis and its vicinity.

A special characteristic of flood forecasting and warning services in Thailand is that several governmental organizations provide sector-oriented flood forecasting services. All of these use weather information from TMD however. Different organizations including Royal Irrigation Department, Department of Water Resources, amongst others, cover several of the 25 major river basins in Thailand. For the general public, it is TMD that provides authoritative flood forecasting services. TMD makes use of state-of-the-art weather observations (terrestrial as well as satellite and radar systems) and modeling systems including NWP system to provide accurate flood forecasting services.

WMO Region III (Latin America)

PROHIMET

PROHIMET is the Ibero-American Network on monitoring and forecasting of hydrometeorological phenomena. It is designed as a thematic network, of Ibero-American scope, which gathers specialists, of several disciplines, especially worried about the topics of floods and droughts, although they also cope with the problems related to climate change. Capacity building and the conduct of pilot projects for transferring knowledge and technology and strengthening international cooperation are amongst key activities of PROHIMET.

As examples, characteristics of a pilot project in Colombia are:

- Led by a (hydropower production & water supply) government company that has installed a hydrometeorological system
- Multipurpose goal
 - Improve reservoir operation
- Short response time of the hydrological system
 - Civil protection
- Main problems to be solved
 - Weather forecast
 - Coupling NWP and hydrological forecasting models
 - Hydrometry & new technology
 - Rainfall estimation

Main objectives of the project are

- To prevent flood disasters;
- To improve the reservoirs operation and to avoid possible failure of the dams;
- To plan economical activities in function of the available water resources;
- To support emergency actions.

Results up to 2009 include

- Hydrological and meteorological studies: calibration of Hydro-Estimator, calibration of ETA model, improvement of previous calibration of HBV model and evaluation of the present hydrometeorological stations net.
- Adding new capabilities to institutions, example: new team of meteorology applied to hydrology;
- New technology for the hydrometeorological stations, a new telemetry system and a new system of reception of satellite images.
- New system for the automatic review of the quality of the hydrometeorological information and their transmissions.
- Capacity building;
- Inter-institutional relationships: Agreement between National Institute of Meteorology and Hydrology (IDEAM) and EPM

Characteristics of a pilot project in Uruguay are:

- Long response time of the hydrological system
- Led by a university under the supervision of the central water administration
- Main goal
 - Reinforce local civil protection services emergency actions
- Main problems to be solved
 - Hydrometry
 - Hydraulics
 - Rainfall estimation

Objectives include

- Reinforcement of the actions performed by the civil protection service (CECOED);
- Preparation of a geographical information system (GIS);
- Support the operation of the CECOED and for urban planning;
- Advance towards linking meteorological information with hydrologic models.

Argentina

The Hydrological Alert System for the La Plata Basin and the Parana in Argentina is developed and implemented in the National Water Institute (*Instituto Nacional del Agua* - INA). It is a user-oriented system focusing on national and bilateral institutions since the La Plata basin is a transboundary basin. Using geographical information systems for product generation (analyses, maps...), both meteorological data and information including satellite based precipitation estimates are used together with hydrological and hydrodynamic information. Main objectives are the real-time monitoring of the hydrological status of the basin and to produce tailor-made hydrological forecasts for specific locations of interest. A specific aspect is the refinement of forecasting products on the basis of close interaction with the user communities.

WMO Region IV (Central and North America)

An overview of working towards a regional flood warning system in WMO Region IV was provided. The evaluation of the existing flood warning system(s) needs to include determination of weaknesses in existing components, identifying the gap between existing system and a future desired system and to then develop a Strategic Plan to fill the gap. A number of measures are proposed to strengthen hydrometeorological observations from conventional terrestrial networks and satellite-based observation platforms. These measures include:

- Design river and rainfall network
- Consider satellite rainfall estimates
- Develop/expand on Radar networks
- Use all hydrometeorological data sources available and seek partners in sharing data

A high-priority programme is the establishment of a flash flood warning system that will include the following initial steps, amongst others:

- Select/Implement a software tool for hydrologic modeling
- Acquire historical hydrometeorological data
- Acquire GIS/Link to modeling system for calibration
- Modeling system must be flexible to data availability

According to Mr Planos, challenges in the development of a regional flood warning system in WMO Region IV include

- Insufficient knowledge of hazards and risks;
- High vulnerability of the existing observation networks;
- Many Meteorological and Hydrological services cooperate inadequately;
- Difficulties with the access to the necessary technology;
- Problems with the national capacity to maintain operational systems;
- Poor relationship among the hydrological and meteorological services with the civil defense agencies;
- The data and information are not free;
- Capacity building

USA

The US National Weather Service (NWS) has adopted Deltares (formerly Delft Hydraulics Lab) Flood Early Warning System (FEWS) as the basis for its Community Hydrologic Prediction System (CHPS). CHPS will provide a flexible environment for operations and the ability to introduce research performed by third parties into NWS operations in a straightforward manner. It will also facilitate researchers' worldwide easy access to NWS observational databases. Basic characteristics of CHPS include:

- Use of gridded environmental forcings.
 - Precipitation.
 - Temperature.
 - Freezing level.
 - Potential evapotranspiration.
- Use of a sequence of models.
 - Many components have been migrated from NWSRFS.
 - HEC-ResSim added for reservoir operation simulation.
 - HEC-RAS added for hydraulic routing.
- Supports ensemble simulations.
- Provides a variety of notification options.

Recognizing the importance of coordinated operation of integrated observing systems at region and wider scales, and highlighting the key role of information systems to achieve this integration and improve forecasting services,

- The United States collectively with other WMO RA-IV Members has identified the WMO Information System (WIS) and the WMO Integrated Global Observing System (WIGOS) as key priorities for the Region.
- The RA-IV Management Group set up a Task Team to coordinate implementation activities for WIS and WIGOS.
- RA-IV WIGOS implementation will cover the full range of observation requirements but will place priority on exchange of RADAR data early in the process of implementation recognizing that RADAR data supports tropical cyclone and hydrological forecasting including flash flood and storm surge.
- Within RA-IV, NOAA/NWS has begun development of a WIS Discovery, Access and Retrieval (DAR) service that will be a part of a Washington Global Information System Center (GISC), a central WIS hub.
- RA-IV Members will provide information through other WIS data centers within the Region to meet collective requirements including those for Flash Flood Forecasting.

Capacity building is viewed by US agencies as a cross-cutting theme that involves all mission areas relevant to weather, water, and climate forecasts and warnings. NOAA/NWS and the U.S. Army Corps of Engineers promote the establishment of observing networks which leads to collaboration through data sharing. This includes

- Establishment of centers to collect, process, and share data;
- Promotion of standardization in observing equipment, data formats, forecasting methods, and service delivery;
- Encouraging new research and training in hydrometeorology to assist in international collaboration activities including in projects.

WMO Region VI (Europe)

General presentation on the European Flood Alert System (EFAS)

Building on experiences in the development of a European Flood Forecasting System since 1999,

the European Commission further engaged in 2003 in the development of a European Flood Alert System (EFAS). EFAS will be capable of providing medium-range flood simulations across Europe with a lead-time between 3 to 10 days. Being in a testing phase for operational use at the Joint Research Centre (JRC) of the European Commission, the advantages of EFAS for the European Commission are

- Overview of current flood situation in Europe for European Commission services
- Comparable results across Europe;
- Fostering harmonized exchange of hydrological data and information in Europe;

The advantages of EFAS for the National hydrological Institutes will include:

- Additional information on possible flood situations more than 3 days in advance based on different weather forecasts;
- Interpretation of flood ensemble prediction system forecasts based;
- Increased exchange on flood forecasting issues and EPS research between the different institutes participating in EFAS.

France

Building on integrated working procedures between hydrological and meteorological services, the Rainfall-Flood Vigilance system is in operation since December 2007. Basically, the system produces both meteorological and hydrological vigilance maps that are supported by local knowledge and real-time observations. Depending on the forecasting period of up to 10 days, a number of forecasting and decision-making tools have been successfully developed on the basis of various types of hydrological models for flood forecasting; including flash flood models.

Current challenges and areas of on-going developments are:

- To improve the existing system with regard to data networks (more complete and diverse), data assimilation in hydrologic and hydraulic models, communication during and post flood events;
- Linkage with similar systems developed by local communities;
- To coordinate financial and technical programmes of the 22 regional services in France;
- To enlarge forecasting to new areas including real time forecasting of flooded areas, forecasting in small watersheds;
- Integrate main urban alert systems;
- Develop warning systems in La Réunion island and Guyana;
- Using Flood Forecasting models for climate change scenario assessment;
- To enlarge partnership networks with regard to technical and sectoral cooperation as well as international cooperation.

Sweden

Forecasters in the domains of meteorology, hydrology and oceanography work at the forecasting division of the Institute of Meteorology and Hydrology of Sweden (SMHI). The forecasting division gets IT-support from SMHI's own IT-division. The Hydrological Forecasting System in Sweden is based on the Ensemble Prediction System of ECMWF and produces flood probability maps for exceeding a certain flood threshold. The system is operational since 2007.

Specialized training courses for specialized end-users (risks management) are offered to promote

- Basic knowledge on MHO (meteorology-hydrology-oceanography);
- MHO-forecasting and MHO-forecasting products;

A new warning system based on CAP-standard (Common Alerting Protocol) is under development. This system

- Follows international standards;
- Is a common system for MHO warnings;
- Provides possibility for end-users to administrate the warning information by itself (each end-user has the possibility to configure into their own profile which warnings they want to have and at which thresholds)

Access to flood forecasting models

Participants discussed the availability of flood forecasting tools, software and guidance in support of flood forecasting services especially in developing countries. In a presentation, Dr. Scharffenberg provided information on this topic related to the Hydrologic Engineering Centre (HEC): HEC is part of the Institute of Water Resources in the U.S. Army Corps of Engineers and as such is designated as a "Center of Expertise" for hydrology and closely related areas. The HEC mission it to take the state-of-the-art research in water resources and make it usable by practicing engineers. Most of HEC's products are software with supporting documentation. Selected software include:

- HEC-HMS for hydrology.
- HEC-RAS for one-dimension hydraulics.
- HEC-ResSim for reservoir simulation and operation.
- HEC-FDA for risk-based project evaluation.
- HEC-FIA for real-time damage impact estimation.
- HEC-EFM for environmental impacts due to flows.
- HEC-SSP for statistical analysis of flow data.
- HEC-WAT for integrated project planning.
- HEC-RTS for integrated flood forecasting.

With regard to access to and availability of this software and guidance materials, he outlined that all software is designed primarily for the U.S. Army Corps of Engineers. However, all software and documentation is available online with no fee or charge, ready for download at www.hec.usace.army.mil . Although there is no technical support function available from HEC, any question about a suspected error in the software will be answered.

In terms of capacity building, HEC has an extensive schedule of training courses on the use of the software products. These courses are offered for the U.S. Army Corps of Engineers, but extra space is available to anyone. Potential students should begin planning in advance in order to coordinate international travel requirements. Recently trainers from HEC have gone to other countries to provide courses for students. Some examples include: Afghanistan, Ethiopia, Guyana, Hungary, Iraq, and Kenya.

Discussing Action Domains of the Strategy and Action Plan

With the document "Action Domains of the Strategy and Action Plan" as reference (annex 5), participants discussed key issues under each of the action domain areas. In the discussion, several of the original action domain areas were combined. This session served as preparation for the development of the Activity Plan of the SAP. Under each of the Action Domains, participants suggested a number of issues that need to be addressed in the implementation of the SAP and in defining specific activities. These are documented below:

Strengthening of Observation and Information Systems

- A legal framework to establish proper coordination at the National and Trans-boundary level is needed to collect data from other Non-Meteorological/Hydrological Services (hydropower sector, universities, local communities, etc.).
- Private observation Networks should be encouraged to adapt to the national standardization of data collection
- An assessment of the existing networks should be done by each Country
- Maintenance of existing automatic data collection stations is essential to guarantee continuous data collection
- Exchange of Hydro-meteorological data should be ensured between NHSs and NMSs via internet/e-mail
- It is important to have an integrated information system to access data for emergency situations. The observation network should be sustainable in terms of operation and maintenance
- International cooperation should be enforced in a cooperative way to develop observation networks in countries where these networks are not developed yet, and assist in maintenance of the networks.
- Methodologies for localization of observing stations should be established and implemented to avoid redundancies and overlapping with existing networks.
- Community awareness of importance of data collecting stations should be increased to avoid vandalism of stations.
- Awareness of importance of data collecting stations should be increased also at the decision-making level, taking into consideration transboundary issues and new technologies such as radar or satellite-based observation networks
- Making use of new technologies for data collection and transmission is crucial, keeping an eye on the sustainability of operation and maintenance of these stations
- Data collection and transmission in mountain areas should be further developed with the appropriate technologies
- The number of observation stations should be optimized to reach the right balance between benefits derived from data collection and costs of maintenance of the network
- Cooperation and collaboration with scientific sectors should be increased, as well as between different Agencies/WMO programmes/International projects
- Encourage the transfer of responsibility of the observation stations to the local communities in order to avoid/decrease vandalism
- Review the quality of existing hydro-meteorological data and upgrade some of the stations to real-time especially in flood-prone areas
- Ensure that international network with long range of data is established and increased for future needs. Updating of rating curves is also needed.
- Data collection should be focusing not only on precipitation/streamflow, but also to other hydro-meteorological variables such as soil moisture, snow cover and melting, ET.
- Develop an automatic system for review of the quality of collected data and their transmission
- Metadata and information should also be properly collected

Improvement of Hydro-Meteorological Forecasting Practices and Products

- Limitations of the forecasts (errors, uncertainty) should be considered
- Risk should be taken into account in the forecasting process (from deterministic to stochastic approach)
- Uncertainty in hydrological modelling are not easily identifiable, therefore an inter-comparison of the results of various hydrological models is suggested
- End-users need stable forecasts (especially during extreme events) to make the right decision in emergency situations.
- To push for the development of real-time hydro-meteorological products

- Develop and improve the quality (increase lead time and improve the reliability) of numerical forecasts for estimating QPE and QPF for flash floods from satellite/radar data
- More participation of the hydrological sector in the development of meteorological forecast (THORPEX/HEPEX are two examples).
- Encourage joint bulletins to forecast hydrological and meteorological information.
- Initiate national consultation processes to determine hydrological requirements for meteorological information for flood forecasting (and vice versa).
- Limitations of meteorological forecasts (especially in downscaling) should be fully understood by the hydrological sector
- Terminology and standards should be compatible between hydrological and meteorological communities
- Rationalize data requirements (principle of parsimony) for models
- Seasonality should be included in the forecasting models, encouraging the use of numerical forecasting products
- Identify and quantify the needs of the end-users for specific forecasting products
- To improve data assimilation technology a.k.a. updating procedures to improve hydrological forecasting accuracy
- Use of global data sources such as DEM and other satellite data
- Forecasting to be extended to include flash floods
- Training to calibrate mesoscale models
- Joint use of satellite and ground-based data in forecasting models
- Promote integrated operation of reservoir and legal framework to regulate operation of reservoirs taking into account the impacts downstream
- Encourage dissemination of forecasts through reports considering uncertainty of the forecasts
- Community awareness of importance of forecasting and early warnings
- Including local knowledge (empirical knowledge based on thresholds) in the forecasting and early warning process
- Develop an easy guide on advantages/disadvantages of available forecasting models (technical document on intercomparison of forecasting models) and setting criteria for the selection

Strengthening Institutional Coordination, Cooperation and Integration between NMSs and NHSs and between Countries in issues related to Flood Forecasting

- Share information about problems related to the issue and latest solutions available (discussion platforms, fora)
- Memorandum of Understanding (twinning arrangements) between NHSs and NMSs for a joint cooperation to provide data sharing and flood forecasting tools
- Share methodologies through seasonal technical meetings between NHSs and NMSs
- Creation of working groups to solve common problems (coordination)
- Elaboration and definition of protocols and responsibilities
- Promote virtual forum involving different countries to analyze the different meteorological and hydrological systems
- Reservoir and dams managers should be involved in the coordination and cooperation
- Memorandum of Understanding on data sharing at the transboundary level, and well defined protocols for flood waves and dams spills, through identification of National Focal Points to be contacted in case of transboundary communication
- Develop formal and informal contacts between NHSs and NMSs at operational, technical and scientific level
- In formulation and development of projects there is the need of joint cooperation between hydrologists and meteorologists from the concept to the implementation stages
- Initiate river basin coordination/working groups
 - Invite representatives from all regions adjacent to the river

- Share experiences, knowledge and ideas about how collaboration and coordination can be improved
 - Discuss, agree, and set up responsibilities and working routines
- Stronger coordination between WMO and UNESCO programmes to reflect at the operational level the latest contributions from universities in modelling (pilot project)
- NHSs and NMSs to issue joint flood early warning statements during the flood season
- Create political will to share data for humanitarian reasons
- Support at international level all transboundary activities and development of joint methodologies
- Set up large scale or basin scale sharing of experiences and trainings
- EXCIFF (http://exciff.jrc.ec.europa.eu/downloads/exciff-related-documents/EXCIFF_guide.pdf) and EXIMAP (set up by European Water Directors) were created to facilitate sharing of experiences of operational centres and could be revived and expanded out of Europe
- Coordination between NHSs and NMSs should be on a day-to-day basis

Promoting Training and Capacity Building in NMHSs and Formulating Technical Documentation and Guidelines related to Flood Forecasting

- Set up an institutionalized training programme for defined skill sets on yearly basis for staff of NMSs and NHSs (technical and professional levels) as well as other institutions dealing with water resources (e.g. reservoir operators)
- Update regularly technical documentation (special focus on software)
- Operational manuals for flood forecasting and warning
- Encourage sharing of experience of operational activities through programme formation
- Set up international large scale exercise on flood forecasting to improve capacity building
- Set up international curriculum for flood forecasters
- WMO to take a leading role to standardize methodologies for flood forecasting so that countries can adjust to the system
- Develop general check lists, especially for emergency situations and compare the existing ones to improve them
- Joint trainings for meteorologists and hydrologists on flood forecasting
- Make use of WMO regional training centres to building capacities on flood forecasting
- To promote joint research between meteorologists and hydrologists for modelling and flood forecasting
- Training on use of NWP/EPS and estimate of rainfall products for flood forecasting
- Set up a responsible team in charge of flood forecasting
- Pilot projects are a good opportunity to train and acquire hands-on experience for the people involved and for creation of capacities at the host services
- Operational hydrological services need to coordinate closely with National Services in situations of flash floods and extreme events
- Translate available manuals in local languages
- Develop E-learning and distance learning programmes and assess the existing ones (UNESCO, ICHARM)
- Encourage gender sensitivity in participation to training courses
- Collect existing guidelines from Member countries as reference for the development of flood forecasting guidance
- Collect flood events on video to use them as training materials
- Encourage flood forecasting centres to develop case studies

Supporting Disaster Management

- Regular community training: How to use early warning systems; preparedness and response
- Improve linkage between Hydro/Met services and disaster management centres, including civil protection agencies, clear guidance, instructions, procedures (i.e. evacuation etc)
- Develop and provide flood risk maps also to demonstrate areas at risk for disaster managers. Need for vulnerability and use of satellite information on flooded areas
- Risk maps should be taken into account in the land use planning
- Encourage disaster management exercises and simulation before flood season
- Define specific products in cooperation between hydrological, meteorological, and disaster management sectors (e.g. contingency plans)
- NHSs and NMSs should start a dialogue with disaster managers and increase their visibility, setting up working routines and responsibilities during flood events
- WMO should assist in increasing the visibility of NHSs and NMSs
- NMHSs in conjunction with disaster managers should develop a communication strategy targeted at communities at the most appropriate level
- Decision-makers should be assisted by scientific/technical counsellors to advise them on the steps necessary to face flood disasters in the proper way and to link them with NHSs and NMSs
- Education and public awareness of flood forecasting usefulness
- Improve/develop coordination between disaster managers to share experiences and be updated about latest developments in technologies/procedures
- Explain and present uncertainty related to flood forecasting for support of decision makers and insurance companies
- Involve and train mass media to transmit the right message and the benefits/uncertainties of flood forecasting

Addressing Climate Variability and Change in the Light of Extreme Events (Focus on Floods)

- Variability and extreme events
- WMO should continue to support research for El Niño and La Niña and other regional climate phenomena, and the different effects they have on the affected places
- WMO should encourage countries to develop research related to the local impacts of climate change, and to reanalysis of long time series of data
- Guidance on Water and Adaptation to Climate Change http://www.unece.org/env/water/publications/documents/Guidance_water_climate.pdf
- IPCC Technical Report VI – Climate Change and Water http://www.ipcc.ch/publications_and_data/publications_and_data_technical_papers.htm
- WMO should coordinate with IPCC for development of research on uncertainty related to downscaling of climate models
- NMSs should disseminate outputs and results obtained from models implemented in Climate Centres for use in the countries

Demonstrating the value of meteorological and hydrological data, information and products for disaster management

- Make a demonstration of flood forecasting using past events, in order to demonstrate lead time of the forecast
- Guidance material and case studies on how to value flood forecasting systems
- Use of mass media for advocacy on flood forecasting
- The private sector should support data collection for flood forecasting

Development of demand-driven integrated weather, climate and hydrological information products for forecasting

- Improved flood forecasting services through the use of integrated forecasting information systems (reference was made to the WMO Information System (WIS))
- Availability and use of meteorological forecasting tools for hydrological forecasting
- Suitability of currently-used hydrological forecasting models to include meteorological observations;
- Access to meteorological data and information for flood forecasting purposes;
- Information required/available for flood probability estimates based on climate information
- Identification of pathways for the development of integrated products based on actual sector-specific requirements.

Development of a detailed Activity Plan

During several consecutive sessions of the workshop, participants developed in three working groups a detailed Activity Plan (AP) for the Implementation of the Strategy and Action Plan (SAP) of the WMO Flood Forecasting Initiative (FFI). Under each Action Domain area of the Action Plan (annex 5), participants defined specific activities that make up the Activity Plan as documented in annex 6. However, under a few Action Domain Areas, no specific activities were recommended by the working groups, mainly in view of the highly specific matter that would require in-depth study of the options. The Activity Plan is to be seen as a systematic collection of proposed activities, based on the expertise present at the meeting. Together with the Strategy and Action Plan, the Activity Plan serves to provide guidance in the selection of activities in accordance to specific requirements of National Meteorological and Hydrological Services (NMHSs) in enhancing their cooperation with the objective to improve the accuracy and timeliness of flood forecasting services.

Adoption of the Activity Plan

After in-depth discussion in a plenary session, the Activity Plan was subsequently consolidated and adopted by the participating experts by acclamation.

Working arrangements for the promotion and implementation of the Activity Plan as part of the SAP of the WMO Flood Forecasting Initiative.

Participants discussed effective ways to promote and implement the Activity Plan. The items below represent a range of actions to be undertaken in this respect:

- Wide promotion of the Activity Plan – together with the Strategy and Action Plan - to NMHSs;
- Promotion of the Plan during national and regional events organized by WMO or suitable events where WMO has been invited;
- Facilitated national consultations to sensitize National Meteorological and Hydrological Services for an improved cooperation. WMO is seen as the lead agency to facilitate these consultations;
- Promotion of the Plan by members of the WMO Technical Commission for Hydrology (CHy);
- Integration of the Plan in Working Groups Hydrology of WMO's Regional Associations;
- Integration of the Plan in the hydrological domain of WMO's Tropical Cyclone Programme such as in the Working Group hydrology of the Typhoon Commission and the Hurricane Committee;
- On a selective basis, test the application of the Plan in NMHSs to gain experience and obtain lessons-learned in its practical application;
- Prepare a training module for the use of the SAP and Activity Plan in NMHSs;

- Fostering twinning agreements between NMHSs with the objective of sharing know-how and technology in improved cooperation and the development and use of advanced forecasting products and their dissemination.

Demonstration projects

The group saw an effective way to implement the SAP and the Activity Plan through demonstration projects aiming at specific aspects of the WMO Flood Forecasting Initiative. These demonstration projects had already been defined in the SAP.

Demonstration projects with a high visibility should demonstrate the value of the cooperation between meteorological and hydrological services and the use of advanced meteorological forecasting and prediction outputs. The SAP proposed to **undertake a limited number of demonstration projects, in areas of priority interest**. Participants reviewed the demonstration projects of the SAP and concluded that the following projects (I - VIII) should be further developed as outlined below:

- (i) *Standardized communications and operation terminology for meteorologists and hydrologists in flood forecasting and flood risk management (selected terminology) with a view to communicate to users.*
 - Caroline Wittwer to provide 3-4 pages as backbone for further development on terminology for meteorologists and hydrologists and on communication to end-users by end of February
- (ii) *The processing of hydrological relevant NWP information for flood forecasting in accordance to specific regional requirements.*
 - Eduardo Planos to provide a first draft by end of February
- (iii) *Common regional Internet websites for meteorology/hydrology information sharing for improvement of flood forecasting.*
 - Dora Goniadzki to provide concept ideas on how this could be done
- (iv) *Intercomparison of coupled forecasting models currently in use in the various WMO Regions, to help the countries in identifying the most suitable models to serve their requirements.*
 - Christina Edlund and William Scharffenberg are to work with Angel Luis Aldana to provide ideas of what could be the necessary steps in this process; a Task Team could be established at a later stage for further development and possible implementation.
- (v) *Joint research activities on flood forecasting systems and models in countries with similar regional characteristics.*
 - A small team composed by Huang Yan, Workaferahu Mulat and Cristina Edlund will develop a concept procedure on how to proceed with this task
- (vi) *Storm surge forecasting and warning services.*
 - JCOMM, WMO Marine Meteorology, WMO DRR, NOAA, Cuba, TMD, MeteoFrance will be consulted for ideas
- (vii) *Improved precipitation field forecasting as a requisite for an effective flood forecasting.*
 - Gloria Estela Marin Cortes and Sotharat Insawang to develop a first outline
- (viii) *Utilization of meteorological products from Regional Centres in flood forecasting.*
 - Dora Goniadzki, Gloria Estela Marin Cortes and Sotharat Insawang to contact Regional Centres to find out

Participants discussed the issue of coastal flooding (including deltas and estuaries) as a result of storm surges (and Tsunamis) and noted that this issue is insufficiently dealt with in conventional flood forecasting systems. Responding to the discussion and as a pathway to address this matter, Mr. Scharffenberg committed to find a specialist at NOAA with the necessary expertise to develop a white paper on a demonstration regional storm surge modelling centre.

Likewise, participants appreciated the stand of the U.S. Army Corps of Engineers to assist, in principal and within institutional and budgetary limitations, the promotion and capacity building of HEC forecasting models especially for use under different situations mainly in developing countries.

Framework for the assessment of service delivery capabilities of hydrological services in flood forecasting

Another way to implement the Activity Plan in an objective-oriented manner towards improving the efficiency of flood forecasting services was seen in the development of a framework for the assessment of service delivery capabilities of hydrological services in flood forecasting. The development of such a framework would entail the use of key elements of both the SAP and the Activity Plan. Several participants viewed the development and application of such a framework as a milestone to improve service delivery capabilities of hydrological services which, as a matter of fact, would require cooperation with meteorological services in workflow and sequence of processes and actions that are critical to improve flood forecasting efficiency.

The core of the assessment on a voluntary base is an evaluation exercise of the flood forecasting services of a hydrological service to provide flood forecasting based on an actual, historic event using historic data. Based on the outcome and in close cooperation with the staff of the respective hydrological service, a SWOT analysis is prepared and options for improvements of flood forecasting services discussed. The recommended actions are then integrated into the institutional development and capacity building process of the service.

Participants saw that amongst others, a critical issue in the development of an operational framework would be the identification of an objective set of criteria to qualify the term "flood forecasting efficiency" based on the operations of a hydrological service. The outline of the proposed framework is documented in annex 7 of the report.

General conclusions and closing session

Participants commented on the usefulness of the workshop and the conducive and productive atmosphere to achieve the expected results. There was general consent that the Activity Plan of the SAP needs to be widely distributed and actively promoted including through the promotion and implementation of the Activity Plan with the proposed activities as discussed during the meeting. Participants also felt that a close monitoring of activities by CHy would contribute to the effectiveness of the implementation of the SAP and the Activity Plan.

Closure of the meeting

The meeting adjourned on December 10th at 04:00 p.m.

**Flood Forecasting Initiative as adopted by Fifteenth Congress of the World
Meteorological Organization (WMO), May 2007**

FLOOD FORECASTING INITIATIVE

**Cooperation between National Meteorological and National
Hydrological Services**

For Improved Flood Forecasting

Strategy and Action Plan

Executive Summary

General

1. Flood forecasting provides a valuable tool in reducing flood impacts, thereby contributing to national sustainable development. Advances in data collection, continual model development, calibration and verification, etc., contribute to improving the accuracy of forecasts. Recent enhancements in meteorological forecasting have made it possible to extend the lead-time for flood forecasting. A timely and reliable forecast helps greatly in disaster risk management responses. However, this requires a set of multi-disciplinary (meteorology, hydrology and emergency management) collaborative efforts.

2. At present many NMSs and NHSs do not have adequate means or the necessary know-how to provide extended forecasting services in flood critical situations and to communicate effectively with disaster management authorities. A strategic/coordinated approach is therefore needed for NMSs and NHSs to work closely together, making use of the state-of-the-art forecasting technologies, to improve hydrological forecasting products and provide better services.

Scope

3. Recognizing the need to improve the capacity of NMSs in detecting flood-critical situations and to improve the capacity of NHSs in using meteorological forecasting information, the WMO Flood Forecasting Initiative was launched in April 2003. The major activities within the scope of this initiative included an overall analysis of the strengths and weaknesses of current flood forecasting systems in the Member countries through a series of regional workshops (eight) organized for different Regions which were attended by hydrologists and meteorologists engaged in forecasting from 85 countries along with a number of regional and river basin organizations, technical institutions and experts.

4. As collaborative efforts between NMSs and NHSs will not only improve flood forecasting services in the countries but also other domains such as water resources assessment and use of climate prediction products in water management, the workshops provided a unique opportunity for meteorologists and hydrologists to exchange experiences and views on these issues, which came up strongly during some of the workshops. Similarly, lack of financial resources for the NHSs and NMSs also emerged as one of the major concerns in certain workshops, particularly involving countries from Region I (Africa).

Strategy and Action Plan

5. In order to fulfil the objectives of the Initiative, a *Synthesis Conference* was organized by WMO in November 2006 with the aim to analyse the key challenge areas that would need to be addressed as identified during the regional workshops. The conference resulted in the establishment of an agreed Strategy and Action Plan to improve national and regional capacities for flood forecasting. The Strategy and Action Plan (SAP) concentrates on the areas of collaboration between the NMSs and NHSs in the field of flood forecasting and other issues brought out in the workshops as mentioned in paragraph 4 above.

6. The SAP, once considered and endorsed by Cg-XV, would serve as a guide to the Technical Commissions and WMO Secretariat in all activities related to improving flood forecasting capabilities worldwide. In developing the Action Plan the diversity of conditions of levels of development, capabilities and status of NMHSs, the various possible user requirements and the possibilities of using advanced technologies were kept under consideration.

7. The SAP identifies the following areas of activities that need to be addressed to improve the overall chain of hydrological forecasting:

- (i) Strengthening of observing and information systems;
- (ii) Promoting data exchange at national and international river basin levels;
- (iii) Improvement of meteorological forecasting practices and products;
- (iv) Improvement of hydrological forecasting practices and products;
- (v) Strengthening of institutional coordination, cooperation and integration between NMSs and NHSs;
- (vi) Strengthening of cooperation and coordination of countries in issues related to flood forecasting and warning;
- (vii) Promoting training and capacity building in NMHSs;
- (viii) Formulating technical documentation and guidelines related to flood forecasting and warning;
- (ix) Supporting disaster management;
- (x) Addressing climate variability and change in the light of extreme events; and
- (xi) Demonstrating the value of meteorological and hydrological data, information and products (including forecasts).

Activities under (iii) to (viii) would form the core of the Flood Forecasting Initiative, while the rest would be mainly addressed under, and in cooperation with, other programmes.

8. The SAP promotes the preparation of national implementation plans. These would logically vary and have to be adapted in accordance with current national/regional flood forecasting capabilities, specific requirements and priorities of the corresponding NMHSs. Access to information, reliability of forecasts and public trust are critical issues to be addressed when developing a modern flood forecasting system.

9. The SAP suggests the implementation of demonstration projects at various levels (country-specific, sub-regional and regional projects). These would identify the technical and administrative difficulties in and showcase the value of an increased cooperation between NMSs and NHSs in flood forecasting. It is expected that the demonstration projects, at national level, would assist NMHSs in coping with their changing role in disaster risk reduction by means of a comprehensive suite of

activities for the upgrading, modernization and strengthening of their flood forecasting and warning systems.

10. At the regional level, the SAP advocates the establishment of a framework under which partnerships and development assistance could be provided and coordinated amongst the Members and the various contributing agencies while taking advantage of existing regional and international arrangements. Countries in a given region or river basin would be invited to collaborate on projects/ activities to be undertaken to strengthen collaboration between NMSs and NHSs for improved flood forecasting and warning.

11. The SAP also addresses requirements of well-established flood forecasting and warning systems for their further improvement through the development and use of new technology.

Implementation of the Strategy and Action Plan (SAP)

Resulting from different capabilities of NMHSs it is evident that for the development of the implementation plans due account will need to be taken of the fact that national flood forecasting and warning activities have significant differences as regards their levels of performance and outputs as a result of the technical and organizational capabilities of NMHSs. Thus, the implementation and activity plans will logically vary and have to be adapted in accordance with current national/regional flood forecasting capabilities, specific requirements and priorities of the corresponding NMHSs. Activities need therefore be classified under the following categories:

- I. country-specific activities required by a particular NMHS to address specific objectives;
- II. sub-regional activities, addressing objectives that are common to a number of countries with similar geographical, climatic or development conditions or those sharing a river basin;
- III. regional activities, addressing objectives that are common to an entire geographical region or a whole WMO Region, respectively or more generally would apply to all of its Members

As a means of more rapid implementation, the SAP proposes to ***undertake a limited number of demonstration projects, in areas of priority interest***. The priority demonstration projects as listed in the SAP are reproduced below:

- i. Standardized communications and operation terminology for meteorologists and hydrologists in flood forecasting and flood risk management (selected terminology) with a view to communicate to users.
- ii. The processing of hydrological relevant NWP information for flood forecasting in accordance to specific regional requirements.
- iii. Common regional Internet websites for meteorology/hydrology information sharing for improvement of flood forecasting.
- iv. Intercomparison of coupled forecasting models currently in use in the various WMO Regions, to help the countries in identifying the most suitable models to serve their requirements.
- v. Joint research activities on flood forecasting systems and models in countries with similar regional characteristics.
- vi. Storm surge forecasting and warning services.
- vii. Improved precipitation field forecasting as a requisite for an effective flood forecasting.
- viii. Utilization of meteorological products from Regional Centres in flood forecasting.

It had been proposed in the SAP that NMSs and NHSs, with the assistance of WMO, consider, plan, develop, outline, initiate and execute such demonstration projects.

The meeting may wish to review this list and make additional recommendations towards the implementation of these pilot projects.

Flood Forecasting and Warning Capabilities

Categorization of National Meteorological and Hydrological Services (NMHSs)

(based on 86 countries)

- **Level I** - Flood forecasting and warning services are limited or not operational, and a significant upgrading and strengthening of the basic data collection and transmission networks is required. In these cases there is insufficient network coverage and data exchange to enable a sufficient amount of data for hydrological forecasting. Generally, there is very limited coordination between NMSs and NHSs, as well as weak dissemination of warnings to users. Some countries issue only qualitative weather forecasts and only a simple warning system for the main river water levels is operational when these reach critical values. This system is usually based on simple statistical methods and forecasts, if available, are disseminated by phone calls or radio.
- **Level II** - The basic infrastructures for flood forecasting and warning services are in place. However, upgraded data management procedures and improved methodologies and models for flood forecasting are required. In most cases, there is little experience in operational practice of advanced hydrological simulation and forecasting models. Regression or other simple models are generally used to forecast the peak of the water wave and approximate time of transit. In many cases, the level of coordination between NMSs and NHSs still needs to be strengthened.
- **Level III** – These have well-established flood forecasting and warning services with high quality products and opportunities for further improvement through the use of new technology. The systems normally combine products and information from both meteorological and hydrological services. Different tools and methods are used to produce the flood forecasts and warnings (e.g. NWP, QPF, radar, satellite images, hydrological and statistical models and other approaches). Warnings generally are communicated through various media to Government and Civil Protection Agencies, industry and the public.

**STRATEGY AND ACTION PLAN FOR THE ENHANCEMENT OF COOPERATION BETWEEN
NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES FOR IMPROVED FLOOD FORECASTING**

Summary of Main Regional Conclusions/Issues emerging from the Regional Workshops

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
Need to establish or enhance flood forecasting, prevention and protection capabilities	Although there is recognition of the need for FF and political awareness, need to establish such activities particularly in LDC's of the Region since these countries are the most vulnerable to flood disasters	Need to improve flood forecasting products, which constitute an important corner stone for an accelerated socio-economic development. Strong interest of countries and donors to improve existing early warning and forecasting systems.	In general, there is need to strengthen the forecasting systems in Latin American countries.	Flooding issues and how they are addressed within the South-West Pacific vary considerably from country to country. Flash flood problem important for many countries in the Region.	Priority for the region
Established or existing flood-forecasting systems	In the majority of countries such systems do not exist or are very limited. Need to expand the mandate of NHSs to include such activities	Wide range of capabilities both between countries but also on national level between capabilities of the NMHSs	Flood forecasting systems have been established in many of the countries mainly on the main river basins. These are in various levels	In some countries flooding is a significant problem and some flood warning systems have been installed. These are in various	All countries have such systems. Significant differences in the level of performance and outputs exist

¹ Comprises West, Central and Southern Africa (SADC) countries of RA I

¹ Latin American countries of RAs III and IV

² No country reports or information available for a more in-depth analysis

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
			of operation and make use of a wide range of communication and modelling techniques.	states of operation.	
Upgrading of existing data collection and transmission networks	A large number of countries need significant upgrading and strengthening of their networks	Urgent need in a number of countries to expand the terrestrial observation hydrological and meteorological networks and to upgrade and improve the existing networks. Further development of established data quality control procedures..	The networks and hydrometeorological information systems are basic elements for an effective flood forecasting and warning. To ensure the feasibility and success of upgraded networks, special attention needs to be put on training of technicians and the maintenance costs of the system.	Many countries of the Region see improved real-time monitoring of rainfall as an immediate requirement.	Some countries need significant upgrading and strengthening of their networks New radar networks to be supported and existing ones upgraded
Strengthening the application of data management procedures and improved methodologies and models for flood forecasting	Need to strengthen the flood forecasting capacities of the countries, with the availability of real time communications / computing facilities and trained meteorological and hydrological personnel	NHSs need professional guidance in the selection, adaptation, calibration and use of rainfall-runoff models to suit operational requirements	Some countries are in the process of strengthening their flood forecasting methodologies and modelling activities.	Many countries require upgrading procedures and methodologies.	Some countries require upgrading procedures and methodologies
Improvement of well established flood-forecasting systems with high quality products		Ensemble prediction techniques are rapidly developing but need further refinement to	Some countries are taking steps to further improve their systems through the		Opportunities to be taken by a number of countries for further improvement through

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
		put these in operational use. NMHSs should be enabled to acquire the capacity to generate NWP.	application of new forecasting technologies.		the use of new technologies
Improvement of the forecast quality and better meeting the various requirements of the end users	Need identified in a number of countries of the Region	Detailed user requirements assessment necessary for improved user services.	Need identified in a number of countries of the Region		Need identified in a number of countries of the Region
Encourage data exchange, in particular meteorological data as input to flood forecasting models.	NHSs and NMSs to align their policies in this area to the WMO Resolutions 25 (Cg-XIII) "Exchange of hydrological data and products", and 40 (Cg-XII) "WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities".	Mechanisms needed for a more efficient exchange of hydrometeorological data and information both from different agencies nationally and also internationally. Communication systems need to be developed to allow inter-operability of present-day hydrological and meteorological data communication streams.	Data exchange mechanisms have been implemented mainly in a number of the international basins of the Region.		Data exchange mechanisms have been implemented mainly in a number of the international basins of Europe.
Limitation of financial resources	Need to demonstrate the economic value of hydrological and meteorological data and products to decision makers in		This problem is faced in a number of the countries, thus having to rely on international technical assistance.	Major problem facing countries with weak flood forecasting systems.	Major problem facing countries with weak flood forecasting systems

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
	order to increase the national budget allocations for flood forecasting activities				
Lack of specialized training on new technologies	Major problem facing countries with no or incipient flood forecasting systems.	Problem identified in a number of countries of the Region, particularly in specialized areas of meteorology and hydrological modeling.	This problem is faced by a number of countries of the Region, particularly in specialized areas of meteorology and hydrological modeling.	Major problem facing countries with weak flood forecasting systems.	Major problem facing countries with weak flood forecasting systems
Promotion of dialogue, cooperation and exchange of expertise between the meteorological and hydrological communities	Cooperation exists but only to a limited extent in certain countries	Needs to be encouraged in a number of countries of the Region	In some cases institutional difficulties are still an obstacle for the co-operation between the NMS and NHS	Co-ordination of water-related matters is considered a major issue in the region. NMSs and NHSs to make conscious efforts to further enhance cooperation at the national level.	Needs to be encouraged in a number of countries of the Region
Existence of multiple authorities issuing meteorological and hydrological information products Strengthen institutional cooperation between NMSs and NHSs	<i>Closer cooperation is required in a number of countries.</i> A legal framework needs to be put in place, and roles and responsibilities of required institutions defined.	Need for the issue of administrative reforms, as required, to institutionalised cooperation between NMSs and NHSs in terms such as: lines of responsibilities, sharing of specific data and information.	Institutional cooperation needs to be strengthened in a number of countries.		In a number of countries there is need for better coordination among the various suppliers of forecasting in order to ensure consistent information for end users.

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
Promotion of cooperation among countries, within countries and NHMS	The issue of data exchange and cooperation among NHSs with regional institutions needs to be examined in greater depth		Needs to be encouraged in the Region to contribute to enhance the quality of flood forecasting		Needs to be encouraged as needed in the Region to contribute to enhance the quality of flood forecasting, through dissemination of successful experiences, regular transfer of information, training and workshops.
Enhancement of technical capabilities	Need to enforce a training and capacity building programme for the meteorological and hydrological personnel, including managers, particularly on the modern trend in hydrological forecasting techniques with special emphasis on flood forecasting. Need for staff career development and retention schemes	Requirement of specialized training on modern methodologies.	Need to continue training and capacity building for the meteorological and hydrological personnel, particularly on modern trends in hydrological forecasting techniques with special emphasis on flood forecasting.	Most countries of the Region identified floods, as one of the three main subject areas requiring education and training. Technician training continues to be the highest priority in the Region.	Training on EPS, nowcasting and other modern methodologies is of high priority
Concerns in specific international river basins	The Niger Basin Authority provides hydrological forecasts for nine countries of the Niger river basin. The Senegal River Basin Authority provides forecasts to		Need to continue strengthening the Hydrological Information and Warning System in operation for the five countries of the Rio de la Plata Basin.		For the countries in the Sava River Basin (Albania, Bosnia and Herzegovina, Croatia, Serbia and Montenegro and Slovenia) the implementation of the

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
	three countries of the Senegal river basin.				Sava Initiative project is a tool to achieve a better quality of forecasts.
Impact of climate change on flood frequency and magnitude	Need to improve knowledge		Countries to continue studies on the hydrological effects of El Niño and ENSO.	NHSs need to ensure that water resources continue to be monitored on a long-term basis, so that a regional database is available for future climate change and variability studies and the hydrological effects of ENSO.	
WHYCOS and other regional and national projects	Very useful in strengthening the capacities of NHSs			Strong support for the Pacific-HYCOS as an excellent vehicle for effective capacity building for water resources assessment and management in the South-West Pacific.	WMO, with the countries concerned, to consider reinitiating the MED-HYCOS project
Application of the concept of IFM/IWRM for Flood forecasting.	Flood forecasting should be treated with a multidisciplinary approach taking into consideration environmental, economic, legal and social aspects		A pilot project underway for integrated flood management on the Cuareim/Quaraí river Basin (Uruguay-Brazil)		
Storm surge issues		Pose a major hazard to many countries in the region. A concerted effort		A number of countries identified storm surge modelling as an important need.	

MAIN REGIONAL CONCLUSIONS/ISSUES	WMO REGIONAL ASSOCIATIONS				
	I ¹	II	III-IV ¹	V ²	VI
		required to further develop and operationalize such systems as soon as possible.			

**ENHANCEMENT OF COOPERATION BETWEEN
NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES FOR
IMPROVED FLOOD FORECASTING**

ACTION PLAN

**Action Domain I
Strengthening of Observing and Information Systems**

- a) Based on objectives-driven data requirements, develop and implement plans, including, as required, network re-design (rain gauges and river gauges) and appropriate real-time data transmission, to achieve a significant upgrade and strengthening of the *meteorological* and *hydrological* networks for flood forecasting. Integration with general purpose networks may be required.
- b) Plan the establishment of reliable and, if possible, redundant real or near real-time data transmission systems for flood forecasting purposes within a country, among institutions and agencies, and among countries as required, especially taking into account transboundary needs.
- c) Ensure that the instruments selected for equipping observing stations and for data communications are in compliance with WMO standards and regulations and are appropriate for and capable of being operated and maintained by the NMHSs and suitable for operation in the environment in which they are required to work. Ensure that adequate training of all staff is provided. Emphasis should be placed on the importance of ongoing station maintenance including the provision of adequate staffing of the operation of these stations.
- d) In the national context, recipient countries of externally funded projects need to ensure compatibility and inter-operability of appropriate technologies used in network operation, while donor countries should coordinate their actions through appropriate mechanisms and programs such as WMO's Volunteer Cooperation Programme (VCP).
- e) Periodic reviews, assessments and revisions of hydrological networks need to be included in operational and maintenance procedures to ensure that high quality measurements of the observed variables are available for flood forecasting purposes.
- f) Prepare and implement plans to evaluate the need for, and benefit of, establishment, and /or modernization or upgrade of meteorological radar networks, allowing for different information systems (radar and rain gauges).
- g) Encourage the development of improved techniques for the estimation of observed rainfall from satellites to provide improved observation coverage in remote and poorly instrumented river basins.
- h) Take steps to periodically assess, adapt and/or adopt new emerging observing technologies including the required training.
- i) In parallel with the upgrade of networks, put in place mechanisms to improve quality of measurement and accessibility of data, particularly during extreme events, and to implement or further develop established data quality control procedures.
- j) Promote and provide support to WHYCOS components and other regional and national projects geared to the strengthening of the national observing systems with flood forecasting as one of the application objectives.
- k) Take appropriate steps to ensure the continuous maintenance and sustainability of observing networks.
- l) Where necessary, there should be a close collaboration in the design of hydrometeorological networks.

- m) With the assistance of WMO Regional Associations where required, assess the possibility of donor support to establish a fund for network maintenance for those countries in need of such support. The benefits of support from appropriate technology providers (e.g. mobile telephone network operators) should be investigated.
- n) Countries should, as required, strengthen joint networks and national systems of hydrometeorological information by means of an adequate co-ordination at highest level between the NMSs and NHSs in their corresponding WMO Regions.

Action Domain II
Improvement of Meteorological Forecasting
Practices and Products

- a) NMSs should take into account the hydrologists' needs in terms of meteorological forecasts for a closer integration of meteorological inputs in flood forecasting. This may require meteorological training courses to include some elements of hydrological training.
- b) Develop or continue the development/improvement of meteorological techniques particularly for hydrological forecasting purposes, in particular those of QPE and QPF.
- c) Promote bilateral and regional arrangements to deliver derived NWP products for further use at local level.
- d) Promote the use of MRWF on an operational or semi-operational basis for hydrological forecasting purposes.
- e) Continue improvement of the meteorological models and now-casting products, both deterministic and probabilistic, particularly in relation to high intensity rainfall.
- f) Provide advice to NHSs, through specialized meteorologists in the field of forecasting, particularly in the following areas: radar and satellite image interpretation, use of forecast models in the field of now-casting, rainfall forecasts, both deterministic and probabilistic uncertainties and most frequent errors of meteorological models.
- g) Provide advice to NMSs and NHSs on aspects of downscaling, bias correction and calibration of NWP forecasts to specific locations and river catchments to assist hydrologists to obtain the best possible information from the limited skill of NWP models in QPF.
- h) Study and undertake downscaling of global models for areas of complex topography, aiming at improvement of the spatial and temporal location of the convective phenomena that produce large quantities of precipitation in very short time intervals.
- i) Continue further development of calibration techniques for radar and satellite derived rainfall data.
- j) Consider as required the application of tools of an international nature such as the software application of the Satellite Application Software (SAF) of now-casting from EUMETSAT, the TRMM satellites and others.
- k) WMO should promote and organize efforts including case studies to study the role of NMHSs in addressing the problems associated with forecasting of floods that result from snowmelt, ice jams, glacier lake outbursts and landslides. The International Polar Year (IPY) may provide one opportunity for such initiatives.
- l) Develop and make available state-of-the-art NWP products and techniques from meteorological services, RSMCs and other centres of excellence for application by NHSs.
- m) Continue the development of hydrological ensembles coupled with hydrological models for improving long-range hydrological forecasting and decision-making under uncertainty.
- n) Develop decision-support systems to assist local authorities, civil protection agencies, etc. in taking the necessary preventive measures.

- o) WMO include in its future plans actions to improve the capacities of NMSs for developing meteorological products for flood forecasting, particularly QPF and probabilistic Quantitative Precipitation Forecasting. [RAs I-VI]

Action Domain III
Improvement of Hydrological Forecasting Practices and Products

- a) Prepare detailed national consolidated requirements assessment as a basis to jointly develop NMS and NHS tailor-made forecasting products.
- b) Plan and implement improvements in flood forecasting systems through the use of new technologies with high quality estimation and forecast products.
- c) Take steps to strengthen or upgrade, as required, the application of data management and data assimilation procedures and improved methodologies and models for flood forecasting.
- d) Define and assess the NHSs' needs in terms of meteorological forecasts, with a view to integrate meteorological inputs in flood forecasting.
- e) Develop and adapt hydrological models that suit the user needs as well as the characteristics of the river basin and level of risk, as no single solution applies to all circumstances.
- f) Exchange software and data/information for hydrological forecasting and prediction.
- g) Provide professional guidance to other NHSs that are developing their flood forecasting abilities and skills in the selection, adaptation, calibration and use of hydrological models to suit operational requirements.
- h) WMO to promote the application, as required, of remote sensing information for flood forecasting.
- i) Undertake, as required, storm surge modelling activities, possibly in collaboration with other countries of regions that are similarly affected.
- j) Efforts should continue to be made to use the probabilistic forecasts from the ensemble prediction systems that will produce different scenarios such as: most likely scenario and extreme scenarios.
- k) Continue the development of meteorological ensembles coupled with hydrological models for improving long-range hydrological forecasting and decision-making under uncertainty. These should feed directly into decision support tools.
- l) Expand the forecast products' provision to include long-range hydrological forecasting through regional climate centres, noting the limitations of such products.
- m) Develop/improve hydrological modelling for extension and interpolation of hydrological data needs in areas where the networks are inadequate, recognizing that there will be limitations to our capabilities.
- n) Develop decision support systems to assist local authorities, civil protection agencies, etc. in taking the necessary preventive measures.
- o) Consider and ensure the participation and involvement of local communities in activities related to hydrological forecasting and warning.
- p) Promote steps in filling gaps in historical time series of hydrological and meteorological data and ensure rescue of historical data.
- q) Promote steps in using data assimilation in hydrologic models, including, amongst others, soil moisture and stage data.
- r) Promote the collection of real time data for flood forecasting purposes.

- s) Provide guidance for the development of performance monitoring of flood forecasting systems and floodplain mapping and for addressing specific issues such as flash floods and extreme events.
- t) Countries are encouraged, with WMO's support, to participate actively in the EUMETSAT SAF-Hydrology project to strengthen capabilities in the use of satellite technology. *[RAs I/VI]*
- u) WMO to include in its future plans actions to support development and outreach activities between NHSs on effective methods to incorporate probabilistic products into their hydrological forecasting, when possible.
- v) In the case of design and implementation of technical assistance projects with external funding for new or upgraded national flood forecasting systems, it should be ensured that the relevant characteristics of the basins are addressed, the actual capabilities of the receiving country are taken into account, that the training of staff and the maintenance costs of the system are adequately considered and, above all, that the project will be sustainable once the external funding has ended.

Action Domain IV

Strengthening of Institutional Coordination, Cooperation and Integration between NMSs and NHSs

- a) Review the issue of administrative and legal reforms required for improved institutional arrangements for flood forecasting and warning operations in a national context, in relation to: lines of responsibility, sharing of specific data, and provision of warnings and information and propose/develop guidance material on this topic for the use of NHSs and NMSs.
- b) Develop a checklist of common areas of cooperation between the NMSs and NHSs and establish areas of responsibility in terms for flood forecasting, as well as with corresponding civil protection agencies and others involved in disaster mitigation.
- c) Develop a standardized communications and operation terminology for meteorologists and hydrologists in flood forecasting and flood risk management (selected terminology) with a view to communicate to this to users in an effective and understandable manner.
- d) Establish guidance for enabling involvement of all stakeholders in the development and operation of flood forecasting services, especially at the community level.
- e) Expose hydrologists to operational meteorological forecast activities and meteorologists to flood forecasting through attachments and secondments.
- f) Establish joint working groups of hydrologists and meteorologists to work on the development of new methods and technologies of forecasting (e.g. improvement of flash flood forecasting).
- g) Promote and encourage dialogue, cooperation and exchange of expertise between the meteorological and hydrological communities by encouraging establishment of institutions, societies or bodies that bring together meteorologists and hydrologists.
- h) Develop a policy of closer collaboration between the NMHSs and academia to maximize mutual benefits from the exchange of information, data, studies and research.
- i) Ensure that hydrologists and meteorologists participate equally in relevant meetings organized for flood forecasting and warning purposes.
- j) Encourage NMSs and NHSs to issue joint bulletins.
- k) Continue the organization of fora, under the WMO Flood Forecasting Initiative, for strengthening of institutional capacity of countries and allowing continuous dialogue and exchange of experience in the field of flood forecasting and warning. As required, these mechanisms should be transferred to other regions and member countries.

Action Domain V
Strengthening of Cooperation and Coordination between Countries on issues related to Flood Forecasting

- a) Promote dialogue between NMSs and NHSs with a focus of improving tools and methodologies for weather-and flood forecasting including workshops.
- b) Foster twinning agreements between NMSs and NHSs with the objective of sharing know-how and technology in improved cooperation and use of advanced forecasting products.
- c) Set-up focal points between riparian states of an international basin for flood warning systems, for alerts and generation of awareness and provide a platform for their regular interaction.
- d) Encourage and promote close links between hydrological, meteorological and civil defence groups and services within the countries at the basin level.
- e) Establish agreements for the provision of flood forecasting and warning services at regional/catchment levels as required.
- f) Promote access to NWP products, observations and hydrological forecasts between countries sharing the same river basin.
- g) Establish networks using a cascade of information from the global level through regional and catchment based groups in the developing countries, in a similar manner to the project on severe weather forecasting and warning, to enable support to the developing countries in flood forecasting and warning.
- h) WMO and international river basin organization to also consider support to those countries where international rivers represent only a minor share of the total of their water resources so as to also strengthen their national for flood forecasting and warning activities and allow them to benefit from participating in international river institutions' activities. *[RA I]*
- i) Latin American countries, as required, to strengthen their joint networks and national systems of hydrometeorological information by means of an adequate co-ordination at highest level between the NMSs and NHSs. *[RAs III/IV]*
- j) WMO should also consider possibilities of assisting the Sava River countries (Albania, Bosnia and Herzegovina, Croatia, Serbia, Montenegro and Slovenia) in implementing the Sava Initiative for improving their forecasting systems. *[RA-VI]*
- k) Countries concerned, with the assistance of WMO, consider the strengthening of the Drought Monitoring Centre (DMC) of SADC countries to address hydrological forecasting needs. *[RA / SADC]*

Action Domain VI
Promoting Training and Capacity Building in NMHSs

- a) Identify staff training requirements as regards meteorology and hydrology, particularly in flood forecasting, and prepare and implement long-term proposals to address these needs.
- b) WMO to plan and execute capacity building programmes that include training activities for meteorological and hydrological forecasters, so that they acquire a wider and up-to-date knowledge of modern tools for monitoring, forecasting, communicating information and emergency management and disaster preparedness in general.
- c) WMO to review and periodically revise the training programmes (both regional and national) aimed at providing NMSs and NHSs staff at different levels with advanced technology, so as to meet the challenge of emerging technology. Training should be targeted at more than one level of capability and provide appropriate knowledge and advice relevant to the level of development and capability of the agencies involved. .

- d) Provide training on hydrologic data assimilation techniques, methods to communicate and express uncertainty, interface techniques between meteorological inputs and hydrological models, and advantages and weaknesses of radar applications for hydrological purposes.
- e) Plan and undertake capacity building activities and the development/adaptation/improvement of hydrological forecasting models, in cooperation with local universities and research communities and regional agencies.
- f) Plan and provide training for the development of user-oriented products.
- g) WMO to assist in the organization of regional training activities as required, including roving seminars with the services of experts from within the corresponding WMO Region.
- h) Ensure regular budget allocations for staff training and continuing education.
- i) Encourage WMO to continue to assist training of staff of NMHSs in developing countries and developed countries, for example, by promoting and supporting temporary staff secondments.
- j) Ensure that following training, participants are provided with the data, information, software, hardware and other tools necessary to implement the training in their own organisations.
- k) Develop a specific educational//training package targeted at flood forecasting related to the occurrence of tropical cyclones.
- l) Use pilot projects to support capacity building and education opportunities in relation to flood forecasting.

Action Domain VII
Formulation of Technical Documentation and Guidelines related to
Flood Forecasting

- a) Prepare guidelines for the dissemination of flood forecasting products to include probability statistics aimed at enhancing their utility for end-users.
- b) Compile documentation on the effects of flooding to help amongst others demonstrate to decision-makers the benefits of a flood forecasts.
- c) Undertake a compilation of regional experiences in the use of improved techniques for meteorological modelling, including QPE and QPF, for flood forecasting.
- d) Make available documentation on the state of development of ensemble forecasting techniques related to flood forecasting.
- e) Develop guidelines for data quality control and management associated with flood forecasting (including the evaluation of forecast accuracy).
- f) Case studies should be used in guidance material to demonstrate best practice in flood forecasting.

Action Domain VIII
Supporting Disaster Management

- a) Link forecasting services to socio-economic factors including the development of a standardized methodology for damage assessment.
- b) Promote the development of standardized methodologies for impact and damage assessment and information linked to hydrologic forecasting services.
- c) NMHSs should be actively involved in the national emergency/disaster response system.
- d) Consider strengthening the role of NHSs in disaster management by including other specific related functions, such as hazard identification, risk assessment, reviewing risk assessments, and communication of hazards through forecasting, in their functions.
- e) Chose and establish a multi-hazard approach in terms of observation systems, telecommunications and the development and communication of forecasting products, ensuring a close cooperation between NMSs and NHSs.
- f) Re-enforce links with national disaster managers, also ensuring close collaboration/interaction with other institutions, and possibly including the participation of the affected community.
- g) Develop common regional warning Internet websites for meteorology/hydrology information for disaster risk management.
- h) Develop risk-qualified hazard maps, including coastal maps in a way that these can be easily visualized for the target group, so as to make flood forecasting and warning more meaningful for communities.
- i) Promote public education and awareness with regard to flood maps and flood management.
- j) Develop decision support systems to assist local authorities, civil protection, etc. in taking the necessary preventive measures.
- k) African countries concerned to study and undertake accordingly a realistic reorganization of the ORSEC (disaster relief organization) plans in place, so as to bridge gaps and rectify weaknesses, through awareness-raising amongst the various stakeholders, capacity-building. *[RA-I]*

Action Domain IX
Addressing Climate Variability and Change in the Light of Extreme Events

- a) Initiate or continue studies on basin, national and regional levels examining the hydrological effect of climate variability and change on flood frequency and magnitude so as to be able to adapt the flood forecasting and warning systems as required.
- b) Review new developments in climate indices/signals (e.g. ENSO) for use in hydrological studies and water management.
- c) Plan and undertake studies to examine the effects of La Niña and ENSO events on the respective affected regions as a whole and its individual countries.
- d) Undertake studies on the use of climate prediction for assessing changes in the availability of fresh-water resources.

Action Domain X
**Demonstrating the Value of Meteorological and Hydrological Data,
Information and Products**

- a) Develop and implement a programme to raise general awareness of the social and economic importance of flood forecasting of NMHS in order to ensure the required financial, technical and staffing support for these services.
- b) Compile documentation on the effects of flooding to help demonstrate to decision-makers the benefits of a flood forecasting system.
- c) Governments should, where required, increase support to the NMHSs to enable them to provide appropriate and timely flood forecasting to their nations and fulfil their national, regional and international obligations.
- d) NMHSs should take advantage of the World Meteorological Day and the World Water Day celebrations to promote and disseminate information on the role and value of NMHSs.

WMO FLOOD FORECASTING INITIATIVE

Consolidated Activity Plan of the Strategy and Action Plan

Activity Plan

Action Domain 1 – Strengthening of Observing and Information Systems (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) - Based on objectives-driven data requirements, develop and implement plans, including, as required, network re-design (rain gauges and river gauges) and appropriate real-time data transmission, to achieve a significant upgrade and strengthening of the <i>meteorological</i> and <i>hydrological</i> networks for flood forecasting. Integration with general purpose networks may be required</p> <p>Activity I: Evaluate the existing network using rational design methods (number and location, type of station, kind of data needed) Activity I: development of training manuals, short term course to aim people to optimize gauging network design</p> <p>Activity II: If needed, implement, redesign or improve the network Activity II: Review the existing hydro-meteorological network including private observations and communication systems</p> <p>Activity III: study the relevance of the different type of networks (e.g. station for water quality is it useful for flood forecasting?)</p> <p>Activity IV: Practical training for observers</p>	I II III	III and VI	I and II	National assessment studies Could be done by WMO Investments to implement the network Each nation Each nation	Financial resources could be limited for investments

<p>Action (b) Plan the establishment of reliable and, if possible, redundant real or near real-time data transmission systems for flood forecasting purposes within a country, among institutions and agencies, and among countries as required, especially taking into account transboundary needs</p> <p>Activity I: Identify stations/locations where real-time data is crucial (e.g. upstream of town)</p> <p>Activity II: Setup pilot projects</p> <p>Activity III: Incorporate and upgrade to real-time data transmission Activity IV: Setup workshop, demonstrate existing network</p> <p>Activity V: Ensure redundancy of real-time data transmission stations</p> <p>Activity VII: Select of voluntary group consisting of experts from countries in level II to level III</p>	<p>I</p> <p>II</p> <p>III</p>	<p>III and VI</p>	<p>I to III</p>	<p>National assessment studies</p> <p>Investments to implement the network</p>	<p>Financial resources could be limited for investments.</p> <p>Transmission problems in non-covered GPS/GSM area or remote areas</p>
<p>Action (c) Ensure that the instruments selected for equipping observing stations and for data communications are in compliance with WMO standards and regulations and are appropriate for and capable of being operated and maintained by the NMHSs and suitable for operation in the environment in which they are required to work. Ensure that adequate training of all staff is provided. Emphasis should be placed on the importance of ongoing station maintenance including the provision of adequate staffing of the operation of these stations</p> <p>Activity I: Review guidelines and recommendations Activity I: Set up promoting programme for WMO standards Activity II: Schedule training programmes and activities (use and maintenance of equipments)</p>	<p>I</p> <p>I</p>	<p>III and VI</p>		<p>Reference to WMO publications and training materials</p>	

<p>Activity III: Coordinate with ISO-standards</p> <p>Activity III: Share and coordinate activities between countries</p> <p>Activity IV: Staff training programme for equipments</p>	<p>II</p>			<p>Training of trainers from instrument providers</p>	
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Action Domain 1 – Strengthening of Observing and Information Systems (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) In the national context, recipient countries of externally funded projects need to ensure compatibility and inter-operability of appropriate technologies used in network operation, while donor countries should coordinate their actions through appropriate mechanisms and programs such as WMO’s Volunteer Cooperation Programme (VCP)</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (e) Periodic reviews, assessments and revisions of hydrological networks need to be included in operational and maintenance procedures to ensure that high quality measurements of the observed variables are available for flood forecasting purposes.</p> <p>Activity I: Recommendation to NMHSs to take this particular action</p>		All	I - III	Each national, regular reporting programme	
<p>Action (f) Prepare and implement plans to evaluate the need for, and benefit of, establishment, and /or modernization or upgrade of meteorological radar networks, allowing for different information systems (radar and rain gauges)</p> <p>Activity I: Review the existing system, identify gaps</p> <p>Activity II: Promote the implementation of advanced technologies (specifically calibrated radar network system)</p>	<p>II</p> <p>III</p>	<p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p>	<p>Each NMHS,</p> <p>Nationally bilateral investments</p>	

Action Domain 1 – Strengthening of Observing and Information Systems (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) Encourage the development of improved techniques for the estimation of observed rainfall from satellites to provide improved observation coverage in remote and poorly instrumented river basins</p> <p>Activity I: Provide training</p> <p>Activity II: Get in contact with providers and possible users and evaluate utility of the products</p>	<p>II</p> <p>I</p>	<p>All</p> <p>All</p>	<p>I – III</p> <p>I - III</p>	<p>Workshop</p> <p>Organizational changes</p>	
<p>Action (h) Take steps to periodically assess, adapt and/or adopt new emerging observing technologies including the required training.</p> <p>Activity I: Set up expert group to implement action (h), review the latest development and implementation of technologies</p>		<p>All</p>	<p>I - III</p>	<p>Task team</p>	
<p>Action (i) In parallel with the upgrade of networks put in place mechanisms to improve quality of measurement and accessibility of data, particularly during extreme events, and to implement or further develop established data quality control procedures.</p> <p>Activity I: Setup quality criteria</p> <p>Activity II: Provide adequate communication and data management system to follow best practices</p>	<p>II</p> <p>II</p>	<p>All</p> <p>All</p>	<p>I – III</p> <p>I - III</p>	<p>Task team in WMO</p> <p>National bilateral and regional</p>	

Action Domain 1 – Strengthening of Observing and Information Systems (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) Promote and provide support to WHYCOS components and other regional and national projects geared to the strengthening of the national observing systems with flood forecasting as one of the application objectives.</p> <p>Activity I: Expand this programme to cover other regions and basins</p> <p>Activity II: Incorporate flood forecasting systems in HYCOS project</p>	<p>II</p> <p>II</p>	<p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p>	<p>Investments</p> <p>Pilot projects</p>	
<p>Action (k) Take appropriate steps to ensure the continuous maintenance and sustainability of observing networks</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (l) Where necessary, there should be a close collaboration in the design of hydrometeorological networks</p> <p>Activity I: covered in Action (a), (c), (d)</p>					

Action Domain 1 – Strengthening of Observing and Information Systems (p. 5)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (m) With the assistance of WMO Regional Associations where required, assess the possibility of donor support to establish a fund for network maintenance for those countries in need of such support. The benefits of support from appropriate technology providers (e.g. mobile telephone network operators) should be investigated.</p> <p>Activity I: Compile countries' information on network upgrade requirements</p>	I and II	All	I – II	National level, regional associations	
<p>Action (n) Countries should, as required, strengthen joint networks and national systems of hydrometeorological information by means of an adequate co-ordination at highest level between the NMSs and NHSs in their corresponding WMO Regions</p> <p>Activity I: WMO should develop a template of MoU that can be used by countries to coordinate NMSs and NHSs</p>	II	All	I – III	National RBOs and WMO, task team	

Action Domain 2 – Improvement of Meteorological Forecasting Practices and Products (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) NMSs should take into account the hydrologists' needs in terms of meteorological forecasts for a closer integration of meteorological inputs in flood forecasting. This may require meteorological training courses to include some elements of hydrological training</p> <p>Activity I: Develop an easy guide on advantages/disadvantages of available forecasting models (technical document on inter-comparison of forecasting models) and setting criteria for the selection Activity II: More participation of the operational hydrologists in the development of meteorological forecast (THORPEX/HEPEX are two examples). Activity III: Include THORPEX in South America</p>					
<p>Action (b) Develop or continue the development/improvement of meteorological techniques particularly for hydrological forecasting purposes, in particular those of QPE and QPF</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (c) Promote bilateral and regional arrangements to deliver derived NWP products for further use at local level.</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 2 – Improvement of Meteorological Forecasting Practices and Products (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Promote the use of MRWF on an operational or semi-operational basis for hydrological forecasting purposes</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (e) Continue improvement of the meteorological models and now-casting products, both deterministic and probabilistic, particularly in relation to high intensity rainfall</p> <p>Activity I: workshop on now casting for hydrologists to take advantage of the new developments in this area Activity II: to promote the national meteorological services providing advice to hydrological institutes in the field of forecasting particularly in the satellite image interpretation, use of forecasting models and rain fall forecasts</p>					
<p>Action (f) Provide advice to NHSs, through specialized meteorologists in the field of forecasting, particularly in the following areas: radar and satellite image interpretation, use of forecast models in the field of now-casting, rainfall forecasts, both deterministic and probabilistic uncertainties and most frequent errors of meteorological models</p> <p>Activity I: Encourage dissemination of forecasts through reports considering uncertainty of the forecasts</p>					

Action Domain 2 – Improvement of Meteorological Forecasting Practices and Products (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) Provide advice to NMSs and NHSs on aspects of downscaling, bias correction and calibration of NWP forecasts to specific locations and river catchments to assist hydrologists to obtain the best possible information from the limited skill of NWP models in QPF.</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (h) Study and undertake downscaling of global models for areas of complex topography, aiming at improvement of the spatial and temporal location of the convective phenomena that produce large quantities of precipitation in very short time intervals</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (i) Continue further development of calibration techniques for radar and satellite derived rainfall data.</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 2 – Improvement of Meteorological Forecasting Practices and Products (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) Consider as required the application of tools of an international nature such as the software application of the Satellite Application Software (SAF) of now-casting from EUMETSAT, the TRMM satellites and others NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (k) WMO should promote and organize efforts including case studies to study the role of NMHSs in addressing the problems associated with forecasting of floods that result from snowmelt, ice jams, glacier lake outbursts and landslides. The International Polar Year (IPY) may provide one opportunity for such initiatives. NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (l) Develop and make available state-of-the-art NWP products and techniques from meteorological services, RSMCs and other centres of excellence for application by NHSs NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 2 – Improvement of Meteorological Forecasting Practices and Products (p. 5)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (m) Continue the development of hydrological ensembles coupled with hydrological models for improving long-range hydrological forecasting and decision-making under uncertainty</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (n) Develop decision-support systems to assist local authorities, civil protection agencies, etc. in taking the necessary preventive measures.</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (o) WMO include in its future plans actions to improve the capacities of NMSs for developing meteorological products for flood forecasting, particularly QPF and probabilistic Quantitative Precipitation Forecasting. [RAs I-VI]</p> <p>Activity I: Creation of working groups including hydrologists and meteorologists oriented to adaptation of meteorological products for direct use in flood forecasting models</p>					

Action Domain 2 – Improvement of Meteorological Forecasting Practices and Products (p. 6)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p style="text-align: center;">NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p> <p>(It was considered to be highly depending on very local conditions and need to be tailor-made)</p>					

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Prepare detailed national consolidated requirements assessment as a basis to jointly develop NMS and NHS tailor-made forecasting products</p> <p>Activity I: Look for example documents as demonstrate</p>					
<p>Action (b) Plan and implement improvements in flood forecasting systems through the use of new technologies with high quality estimation and forecast products</p> <p>Activity I: Promote twinning arrangements</p>					
<p>Action (c) Take steps to strengthen or upgrade, as required, the application of data management and data assimilation procedures and improved methodologies and models for flood forecasting</p> <p>Activity I: For data management, to promote twinning arrangements Activity II: For data assimilation to setup research projects Activity III: Make a library of models</p>					

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Define and assess the NHSs' needs in terms of meteorological forecasts, with a view to integrate meteorological inputs in flood forecasting</p> <p>Activity I: regular coordination between NMS and NHS</p>					
<p>Action (e) Develop and adapt hydrological models that suit the user needs as well as the characteristics of the river basin and level of risk, as no single solution applies to all circumstances</p> <p>Activity I: Covered in Action c, model libraries</p>					
<p>Action (f) Exchange software and data/information for hydrological forecasting and prediction</p> <p>Activity I: Setup MoU about exchanging software</p> <p>Activity II: Promote joint development of the models</p>	<p>II</p> <p>II</p>	<p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p>	<p>Regional, transboundary basins, joint projects</p>	

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) Provide professional guidance to other NHSs that are developing their flood forecasting abilities and skills in the selection, adaptation, calibration and use of hydrological models to suit operational requirements.</p> <p>Activity I: Promote twinning arrangements</p>					
<p>Action (h) WMO to promote the application, as required, of remote sensing information for flood forecasting</p> <p>Activity I: create awareness of emerging technology</p>		All	I –III	Call for poster presentations or flyers, videos	
<p>Action (i) Undertake, as required, storm surge modelling activities, possibly in collaboration with other countries of regions that are similarly affected</p> <p>Activity I: Each Regional Association should develop a plan for storm surge modelling, taking into account the local conditions, needs, and abilities of the individual NMHSs</p>		All	I –III	National and regional level,	

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) Efforts should continue to be made to use the probabilistic forecasts from the ensemble prediction systems that will produce different scenarios such as: most likely scenario and extreme scenarios</p> <p>Activity I: Organize a task committee to evaluate the existing technology and capabilities and write a white paper to advise individual NHMSs</p>	II - III	All	II - III	WMO task force	
<p>Action (k) Continue the development of meteorological ensembles coupled with hydrological models for improving long-range hydrological forecasting and decision-making under uncertainty. These should feed directly into decision support tools</p> <p>Activity I: Highlight efforts to advance the science of ensemble forecasts in venues accessible to practicing engineers/scientists</p>	II	All	II - III	Website, poster presentation, workshop	
<p>Action (l) Expand the forecast products' provision to include long-range hydrological forecasting through regional climate centres, noting the limitations of such products</p> <p>Activity I: Each Regional Association should identify the modelling techniques that are most-appropriate for long-range hydrologic simulation within their region</p>	III	All	I - III	Regional workshop	

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 5)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (m) Develop/improve hydrological modelling for extension and interpolation of hydrological data needs in areas where the networks are inadequate, recognizing that there will be limitations to our capabilities</p> <p>Activity I: Organize a task committee to evaluate the current abilities in ungauged hydrology, and make general recommendations for NHSs</p> <p>Activity II: Coordinate with international institutions (e.g. IAHS) to learn the latest development</p>	I – II	All	I – III	Workshop, task force	
	I - II	All	I - III	Workshop	
<p>Action (n) Develop decision support systems to assist local authorities, civil protection agencies, etc. in taking the necessary preventive measures</p> <p>Activity I: Encourage NHSs investigate the various decision support systems that are now available</p> <p>Activity II: Promote twinning arrangements</p>	I – II	All	I – III	National, regional level	
	II	All	I – III		
<p>Action (o) Consider and ensure the participation and involvement of local communities in activities related to hydrological forecasting and warning.</p> <p>Activity I: Encourage NHSs to consider local needs and concerns</p> <p>Activity II: Provide community training in flood preparedness</p>	II – III	All	I – III	National, basin level	
	II - III	All	I – III	National, basin level	

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 6)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (p) Promote steps in filling gaps in historical time series of hydrological and meteorological data and ensure rescue of historical data</p> <p>Activity I: Appropriate statistical techniques exist to fill data gaps using surrounding observation stations. Encourage NMHSs to work on extending data during the non-flood season</p> <p>Activity II: Provide technical training of trainers</p>	<p>I – III</p> <p>II – III</p>	<p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p>	<p>WMO task force</p> <p>WMO organize a training of trainers workshop</p>	
<p>Action (q) Promote steps in using data assimilation in hydrologic models, including, amongst others, soil moisture and stage data</p> <p>Activity I: Highlight projects that use data assimilation to improve forecasts</p> <p>Activity II: WMO in coordination with CHy to promote research projects that advance the science</p>	<p>II – III</p> <p>II - III</p>	<p>All</p> <p>All</p>	<p>II – III</p> <p>II – III</p>	<p>Research project</p> <p>CHy, research project</p>	<p>Technical limitations</p>
<p>Action (r) Promote the collection of real time data for flood forecasting purposes.</p> <p>Activity I: Highlight demonstration or pilot projects that have shown value to the NMHSs operating the system</p>	<p>II</p>	<p>All</p>	<p>I - II</p>	<p>WMO</p>	

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 7)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (s) Provide guidance for the development of performance monitoring of flood forecasting systems and floodplain mapping and for addressing specific issues such as flash floods and extreme events</p> <p>Activity I: collect and assess applicability of existing guidelines at national, regional and international level</p> <p>Activity II: set up experts working-group to draft guideline</p> <p>Activity III: Encourage the use of NWP products for flash floods and extreme events</p>	<p>II</p> <p>II – III</p> <p>II - III</p>	<p>All</p> <p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p> <p>I - III</p>	<p>task force in WMO</p> <p>in WMO</p> <p>WMO</p>	
<p>Action (t) Countries are encouraged, with WMO's support, to participate actively in the EUMETSAT SAF-Hydrology project to strengthen capabilities in the use of satellite technology. [RAs I/VI]</p> <p>Activity I: Explore and apply the concept of the Satellite Application Facilities (SAFs) globally</p>	<p>I – II</p>	<p>All</p>	<p>I – III</p>	<p>WMO</p>	
<p>Action (u) WMO to include in its future plans actions to support development and outreach activities between NHSs on effective methods to incorporate probabilistic products into their hydrological forecasting, when possible</p> <p>Activity I: disseminate successful examples (e.g. France) to NHSs</p> <p>Activity II: set up training program on how to do it</p>		<p>all regions</p>		<p>task force</p> <p>national, regional level, and WMO, Training courses</p>	

Action Domain 3 – Improvement of Hydrological Forecasting Practices and Products (p. 8)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (v) In the case of design and implementation of technical assistance projects with external funding for new or upgraded national flood forecasting systems, it should be ensured that the relevant characteristics of the basins are addressed, the actual capabilities of the receiving country are taken into account, that the training of staff and the maintenance costs of the system are adequately considered and, above all, that the project will be sustainable once the external funding has ended</p> <p>Activity I: provide standard guideline or template on criteria for project design including exit phase</p>	I – II	All	I – II	WMO with project partners	

Action Domain 4 – Strengthening of Institutional Coordination, Cooperation and Integration between NMSs and NHSs (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Review the issue of administrative and legal reforms required for improved institutional arrangements for flood forecasting and warning operations in a national context, in relation to: lines of responsibility, sharing of specific data, and provision of warnings and information and propose/develop guidance material on this topic for the use of NHSs and NMSs</p> <p>Activity I: Encourage countries to Initiate river basin (in-countries and transboundary) coordination/working groups, involving joint cooperation between hydrologists and meteorologists on flood forecasting issues</p> <ul style="list-style-type: none"> o Invite all administrative districts/organizations within the river basin o Share experiences, knowledge and ideas about how collaboration and coordination can be improved o Discuss, agree, and set up responsibilities and working routines <p>Activity II: Implement pilot projects and case studies on the above</p> <p>Activity III: Establish international links at the technical level between National Services to solve common technical problems</p>					
<p>Action (b) Develop a checklist of common areas of cooperation between the NMSs and NHSs and establish areas of responsibility in terms for flood forecasting, as well as with corresponding civil protection agencies and others involved in disaster mitigation</p> <p style="text-align: center;">NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (c) Develop a standardized communications and operation terminology for meteorologists and hydrologists in flood forecasting and flood risk management (selected terminology) with a view to communicate this to users in an effective and understandable manner.</p>					

<p>Activity I: Develop an integrated glossary of hydro-meteorological terminology, based on the existing ones on hydrology or meteorology (e.g. CEMAGREF, P. Hubert, etc.) specifically oriented for operational staff</p> <p>Activity II: Establish a common forum to share benchmarks on the use of operational tools</p> <p>Activity III: Finalize the UNESCO-WMO Glossary of Hydrology</p>					
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Action Domain 4 – Strengthening of Institutional Coordination, Cooperation and Integration between NMSs and NHSs (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Establish guidance for enabling involvement of all stakeholders in the development and operation of flood forecasting services, especially at the community level</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (e) Expose hydrologists to operational meteorological forecast activities and meteorologists to flood forecasting through attachments and secondments.</p> <p>Activity I: Organize joint trainings for meteorologists and hydrologists on flood forecasting Activity II: Establish joint working groups for meteorologists and hydrologists on flood forecasting</p>					
<p>Action (f) Establish joint working groups of hydrologists and meteorologists to work on the development of new methods and technologies of forecasting (e.g. improvement of flash flood forecasting).</p> <p>Activity I: To use the experience gained in EXCIFF and EXIMAP (set up by European Water Directors) and encourage initiation of similar activities in the topic of flood forecasting within the Regions through WMO Activity II: Start a pilot project activity on uncertainty related to flood forecasting leading to a tool/methodology that can be used by operational centres Activity III: Start a pilot project on rationalization of data requirements (principle of parsimony)</p>					

Action Domain 4 – Strengthening of Institutional Coordination, Cooperation and Integration between NMSs and NHSs (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) Promote and encourage dialogue, cooperation and exchange of expertise between the meteorological and hydrological communities by encouraging establishment of institutions, societies or bodies that bring together meteorologists and hydrologists.</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (h) Develop a policy of closer collaboration between the NMHSs and academia to maximize mutual benefits from the exchange of information, data, studies and research</p> <p>Activity I: Enhance cooperation between UNESCO and WMO to increase involvement of academic world in the operational field of flood forecasting and to benefit from the latest research in the topic Activity II: Propose funding to support the development of applied research involving research laboratories/universities and operational centres Activity III:</p>					
<p>Action (i) Ensure that hydrologists and meteorologists participate equally in relevant meetings organized for flood forecasting and warning purposes.</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 4 – Strengthening of Institutional Coordination, Cooperation and Integration between NMSs and NHSs (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) Encourage NMSs and NHSs to issue joint bulletins</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (k) Continue the organization of fora, under the WMO Flood Forecasting Initiative, for strengthening of institutional capacity of countries and allowing continuous dialogue and exchange of experience in the field of flood forecasting and warning. As required, these mechanisms should be transferred to other regions and member countries</p> <p>Activity I: Promote coordination of initiatives between different WMO programmes Activity II: Improve the visibility of the FFI and hydrological matters in WMO webpage, including specific activities oriented to the dissemination of results Activity III: Provide a subscription service to get latest news via e-mail on specific programmes</p>					

Action Domain 5 – Strengthening of Cooperation and Coordination between Countries on issues related to Flood Forecasting (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Promote dialogue between NMSs and NHSs with a focus of improving tools and methodologies for weather-and flood forecasting including workshops</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (b) Foster twinning agreements between NMSs and NHSs with the objective of sharing know-how and technology in improved cooperation and use of advanced forecasting products</p> <p>Activity I: Establish a regional flash flood prediction system through regional cooperation</p> <p>Activity II: develop a common approach to satisfy telecommunication requirements in the regions</p>					
<p>Action (c) Set-up focal points between riparian states of an international basin for flood warning systems, for alerts and generation of awareness and provide a platform for their regular interaction</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 5 – Strengthening of Cooperation and Coordination between Countries on issues related to Flood Forecasting (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Encourage and promote close links between hydrological, meteorological and civil defence groups and services within the countries at the basin level</p> <p>Activity I: Promote establishment of cooperation agreements regarding data exchange and forecasting products and warnings</p> <p>Activity II: To promote participation in virtual laboratories in order to analyze the meteorological and hydrological situation</p> <p>Activity III: Establish river coordination groups</p>	I I I	III and VI			
<p>Action (e) Establish agreements for the provision of flood forecasting and warning services at regional/catchment levels as required</p> <p>Same as above</p>					
<p>Action (f) Promote access to NWP products, observations and hydrological forecasts between countries sharing the same river basin</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 5 – Strengthening of Cooperation and Coordination between Countries on issues related to Flood Forecasting (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) Establish networks using a cascade of information from the global level through regional and catchment based groups in the developing countries, in a similar manner to the project on severe weather forecasting and warning, to enable support to the developing countries in flood forecasting and warning</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (h) WMO and international river basin organization to also consider support to those countries where international rivers represent only a minor share of the total of their water resources so as to also strengthen their national for flood forecasting and warning activities and allow them to benefit from participating in international river institutions' activities. [RA I]</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (i) Latin American countries, as required, to strengthen their joint networks and national systems of hydrometeorological information by means of an adequate co-ordination at highest level between the NMSs and NHSs. [RAs III/IV]</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 5 – Strengthening of Cooperation and Coordination between Countries on issues related to Flood Forecasting (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) WMO should also consider possibilities of assisting the Sava River countries (Albania, Bosnia and Herzegovina, Croatia, Serbia, Montenegro and Slovenia) in implementing the Sava Initiative for improving their forecasting systems. [RA-VI]</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (k) Countries concerned, with the assistance of WMO, consider the strengthening of the Drought Monitoring Centre (DMC) of SADC countries to address hydrological forecasting needs. [RA I SADC]</p> <p>Activity I: Move this important issue to a more appropriate place</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 6 – Promoting Training and Capacity Building in NMHSs (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Identify staff training requirements as regards meteorology and hydrology, particularly in flood forecasting, and prepare and implement long-term proposals to address these needs</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (b) WMO to plan and execute capacity building programmes that include training activities for meteorological and hydrological forecasters, so that they acquire a wider and up-to-date knowledge of modern tools for monitoring, forecasting, communicating information and emergency management and disaster preparedness in general</p> <p>Activity I: Develop training and professional capacity building through the Regional Training Centres</p> <p>Activity II: WMO encourages dissemination of information provided to PRs and HAs to the whole country, opening training sessions to all stakeholders in the country</p>					
<p>Action (c) WMO to review and periodically revise the training programmes (both regional and national) aimed at providing NMSs and NHSs staff at different levels with advanced technology, so as to meet the challenge of emerging technology. Training should be targeted at more than one level of capability and provide appropriate knowledge and advice relevant to the level of development and capability of the agencies involved</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 6 – Promoting Training and Capacity Building in NMHSs (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Provide training on hydrologic data assimilation techniques, methods to communicate and express uncertainty, interface techniques between meteorological inputs and hydrological models, and advantages and weaknesses of radar applications for hydrological purposes</p> <p>Activity I: find solutions to share information about current research and techniques appropriate for operational use</p>					
<p>Action (e) Plan and undertake capacity building activities and the development/adaptation/ improvement of hydrological forecasting models, in cooperation with local universities and research communities and regional agencies</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (f) Plan and provide training for the development of user-oriented products</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 6 – Promoting Training and Capacity Building in NMHSs (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) WMO to assist in the organization of regional training activities as required, including roving seminars with the services of experts from within the corresponding WMO Region NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (h) Ensure regular budget allocations for staff training and continuing education NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (i) Encourage WMO to continue to assist training of staff of NMHSs in developing countries and developed countries, for example, by promoting and supporting temporary staff secondments NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 6 – Promoting Training and Capacity Building in NMHSs (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) Ensure that following training, participants are provided with the data, information, software, hardware and other tools necessary to implement the training in their own organisations</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (k) Develop a specific educational/training package targeted at flood forecasting related to the occurrence of tropical cyclones</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (l) Use pilot projects to support capacity building and education opportunities in relation to flood forecasting</p> <p>Activity I: Include in the pilot project specific training programmes Activity II: complementary action for the dissemination of results</p>					

Action Domain 6 – Promoting Training and Capacity Building in NMHSs (p. 5)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
NO SPECIFIC ACTIONS OR ACTIVITIES WERE RECOMMENDED BY THE GROUP					

Action Domain 7 – Formulation of Technical Documentation and Guidelines related to Flood Forecasting (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Prepare guidelines for the dissemination of flood forecasting products to include probability statistics aimed at enhancing their utility for end-users</p> <p>Activity I: Form a task team of OPACHES and identified experts to prepare the Guidelines</p> <p>Activity II: Post the draft Guidelines on the CHy E-board for comments and discussions</p> <p>Activity III: Finalize Guidelines and distribute</p>	<p>I – II</p> <p>I – II</p> <p>II – III</p>	<p>All</p> <p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p> <p>I – III</p>	<p>WMO, CHy</p> <p>WMO, CHy</p> <p>WMO, CHy</p>	
<p>Action (b) Compile documentation on the effects of flooding to help amongst others demonstrate to decision-makers the benefits of a flood forecasts</p> <p>Activity I: NMHSs are to capture flood event on video and photography and collect flood damage information</p> <p>Activity II: Prepare a post-event report to include flood damage and possibly the cost of damages</p> <p>Activity III: Share experiences with other services by distribution of reports and video. WMO could assist in reproduction and distribution of the documentation</p>	<p>II – III</p> <p>II – III</p> <p>II – III</p>	<p>All</p> <p>All</p> <p>All</p>	<p>I – III</p> <p>I – III</p> <p>I - III</p>	<p>National and basin level</p> <p>National and basin level</p> <p>National and basin level</p>	
<p>Action (c) Undertake a compilation of regional experiences in the use of improved techniques for meteorological modelling, including QPE and QPF, for flood forecasting</p> <p>Activity I: RAs are to encourage NMHSs who use improved techniques and QPE and QPF to write scientific papers and reports on their experiences for publication by WMO</p>	<p>I – II</p>	<p>All</p>	<p>I – III</p>	<p>National and basin level</p>	

Action Domain 7 – Formulation of Technical Documentation and Guidelines related to Flood Forecasting (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Make available documentation on the state of development of ensemble forecasting techniques related to flood forecasting</p> <p>Activity I: WMO should coordinate compilation of documentation on the state of development of ensemble forecasting and distribute</p>	I - II	All	I - III	workshop	
<p>Action (e) Develop guidelines for data quality control and management associated with flood forecasting (including the evaluation of forecast accuracy)</p> <p>Activity I: Form a Task team of OPACHES and identified experts to develop the guidelines for data quality control and management. Involve GRDC and GPCC</p> <p>Activity II: Post draft guidelines on CHy E-board for comments and discussion</p> <p>Activity III: Finalize guidelines and distribution (by WMO)</p>	I –II II II – III	All All All	I – III I – III I – III	Task force, CHy Task force, CHy Task force, CHy	
<p>Action (f) Case studies should be used in guidance material to demonstrate best practice in flood forecasting</p> <p>Activity I: Encourage NMHSs and Flood Forecasting Centres to prepare case studies on their flood forecasting activities</p> <p>Activity II: Form a task team of OPACHES and identified experts to review the case studies and select "Best Practice" Case Studies for publications (by WMO)</p>	II II	All All	I – III I – III	Task force, CHy Task force, CHy	

Action Domain 7 – Formulation of Technical Documentation and Guidelines related to Flood Forecasting (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>NO SPECIFIC ACTIONS OR ACTIVITES WERE RECOMMENDED BY THE GROUP</p>					

Action Domain 8 – Supporting Disaster Management (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Link forecasting services to socio-economic factors including the development of a standardized methodology for damage assessment</p> <p>Activity I: To promote multidisciplinary studies of vulnerability, danger and risk and to show the results using different ways Activity II: To promote the establishment of national and regional multidisciplinary work groups, through periodical workshops, Activity III: To strengthen the public communication and education, including the vulnerability, danger and risk topics in the educational system, and media</p>					
<p>Action (b) Promote the development of standardized methodologies for impact and damage assessment and information linked to hydrologic forecasting services</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (c) NMHSs should be actively involved in the national emergency/disaster response system</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 8 – Supporting Disaster Management (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Consider strengthening the role of NHSs in disaster management by including other specific related functions, such as hazard identification, risk assessment, reviewing risk assessments, and communication of hazards through forecasting, in their functions</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (e) Chose and establish a multi-hazard approach in terms of observation systems, telecommunications and the development and communication of forecasting products, ensuring a close cooperation between NMSs and NHSs</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (f) Re-enforce links with national disaster managers, also ensuring close collaboration/interaction with other institutions, and possibly including the participation of the affected community</p> <p>Activity I: Promote working groups between end-users and service providers to assess the end-users needs in term of information and language used in providing flood forecasts and warnings Activity II: Reinforce the Public Relations Departments capacities in communicating to the public hydrological aspects of flood forecasts and warnings Activity III:</p>					

Action Domain 8 – Supporting Disaster Management (p. 3)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (g) Develop common regional warning Internet websites for meteorology/hydrology information for disaster risk management</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (h) Develop risk-qualified hazard maps, including coastal maps in a way that these can be easily visualized for the target group, so as to make flood forecasting and warning more meaningful for communities</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (i) Promote public education and awareness with regard to flood maps and flood management</p> <p>NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 8 – Supporting Disaster Management (p. 4)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (j) Develop decision support systems to assist local authorities, civil protection, etc. in taking the necessary preventive measures NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					
<p>Action (k) African countries concerned to study and undertake accordingly a realistic reorganization of the ORSEC (disaster relief organization) plans in place, so as to bridge gaps and rectify weaknesses, through awareness-raising amongst the various stakeholders, capacity-building. [RA-I] NO SPECIFIC ACTIVITIES WERE RECOMMENDED</p>					

Action Domain 9 – Addressing Climate Variability and Change in the Light of Extreme Events (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Initiate or continue studies on basin, national and regional levels examining the hydrological effect of climate variability and change on flood frequency and magnitude so as to be able to adapt the flood forecasting and warning systems as required</p> <p>Activity I: to learn about the state-of-the-art of research works, and to share existing research results Activity II: ... to analyze the large variations in the synoptic systems that produce changes in the hydrological situation of the basin producing extreme events in both directions in a short time period (Maximum Floods and Low Flow in a short time).</p>				workshop, website distribution of publications and research report	
<p>Action (b) Review new developments in climate indices/signals (e.g. ENSO) for use in hydrological studies and water management</p> <p>Activity I: call for professionals and representatives from countries and regions as well as IPCC experts to share the new technical development of the research</p>				workshop	
<p>Action (c) Plan and undertake studies to examine the effects of La Niña and ENSO events on the respective affected regions as a whole and its individual countries</p> <p>Activity I: coordinate NMSs to share knowledge</p>					

Action Domain 9 – Addressing Climate Variability and Change in the Light of Extreme Events (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) Undertake studies on the use of climate prediction for assessing changes in the availability of fresh-water resources</p> <p>Activity I: Coordinate with other ongoing research projects in UNESCO IHP and IPCC and disseminate the latest developments through joint projects or workshops.</p>		All regions		workshop	

Action Domain 10 – Demonstrating the Value of Meteorological and Hydrological Data, Information and Products (p. 1)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (a) Develop and implement a programme to raise general awareness of the social and economic importance of flood forecasting of NMHS in order to ensure the required financial, technical and staffing support for these services</p> <p>Activity I: organize national stakeholder meetings to create awareness of importance of flood forecasting services Activity II: Stakeholders to identify their requirements for flood forecasting services in communication with NMHSs, private enterprises and insurance companies Activity III: Develop cost benefit assessments of the value of flood forecasting services versus potential damage</p>					
<p>Action (b) Compile documentation on the effects of flooding to help demonstrate to decision-makers the benefits of a flood forecasting system</p> <p>Activity I: Collect case studies demonstrating benefits of flood forecasting services. Case studies need to be quantitative wherever possible Activity II: demonstrate with case studies and scenarios benefits of FF-services for flood and water resources management including waters in dams and reservoirs (hydropower, irrigation.) management</p>					
<p>Action (c) Governments should, where required, increase support to the NMHSs to enable them to provide appropriate and timely flood forecasting to their nations and fulfil their national, regional and international obligations</p> <p>Activity I: see activities described under a) above Activity II: strengthen public private partnerships (enterprises, farmer communities, municipalities, insurance companies, banks) to participate in investments in FF-services from which they ultimately benefit.</p>					

Action Domain 10 – Demonstrating the Value of Meteorological and Hydrological Data, Information and Products (p. 2)

	Priority I - III	WMO RA I - VI	Capacity Level I - III	Implementation means	Constraints
<p>Action (d) NMHSs should take advantage of the World Meteorological Day and the World Water Day celebrations to promote and disseminate information on the role and value of NMHSs</p> <p>Activity I: Organize public awareness and promotion workshops, engage the media in public awareness campaigns Activity II: Organize open door days of NMHSs to the public to demonstrate their activities Activity III: Seek closer cooperation with schools, universities and other research institutions in promoting and developing improved services</p>					

Final remarks:

- WMO website is difficult to consult. Try to make it more effective by making it easier to find reports on various topics.
- Links between WMO and other UN programmes? Mention something about UN-Water and the need for a mapping exercise of water related activities, and the need to finalize it ASAP
- Non-WMO programmes mentioned in the text above should be strongly linked to WMO
- Stress in Action 9 the variability of hydrological trends

The participants of the workshop by acclamation endorsed this activity plan

IMPROVING THE EFFICIENCY OF FLOOD FORECASTING SERVICES

A framework for the assessment of service delivery capabilities of hydrological services

- OUTLINE -

1. Introduction

The Strategy and Action Plan (SAP) of the WMO Flood Forecasting Initiative (FFI) states that flood forecasting services in many parts of the world do not meet requirements with regard to timeliness, accuracy and user demands.

The Activity Plan that is being developed to supplement the SAP provides for a comprehensive overview of activities to improve flood forecasting services in a number of domains that are critical for flood forecasting, including an improved cooperation between national meteorological and hydrological services.

A procedure is outlined below that has the potential to improve flood forecasting services, taking the approach of institutional strengthening.

2. Methodology

Taking into account different levels of service capabilities including professional skills of staff and available infrastructure, an assessment is undertaken by a team of evaluators over a period of 3-4 days to evaluate flood forecasting efficiency of a hydrological service based on a request from a hydrological service.

The core of the assessment is an evaluation exercise of the flood forecasting team of a hydrological service to provide flood forecasting based on an actual, historic event using historic data. Based on the outcome and in close cooperation with the staff of the evaluated service, a SWOT analysis is prepared and options for improvements of flood forecasting services discussed. The recommended actions are then integrated into the institutional development and capacity building process of the service.

In this undertaking, the Strategy and Action Plan together with the Activity Plan has a central role in the identification of specific action domains for the evaluation process and specific activities recommended that reflect the present and projected capabilities and service levels of institutions issuing flood forecasting information in different regions of the world.

3. Development steps of the methodology

Conceptually, an objective analysis framework needs to be elaborated that provides details of different capabilities of hydrological services providing flood forecasting. An outline of flood forecasting capabilities is provided in annex xxx Categorization of National Meteorological and Hydrological Services (NMHSs).

A benchmark procedure has to be established for all Action Domains (documented in the SAP) relevant for the forecasting service. Likewise a grading scheme for the evaluation, using a catalogue of evaluation criteria and weighing factors for Action Domains needs to be established.

Templates need to be created that allow matching of benchmark criteria with evaluation results and provide a forward looking perspective towards the projected institutional and technical capabilities of a given flood forecasting service.

The entire evaluation procedure and description of methodology and evaluation process needs to be documented, and training manual for evaluators compiled that allows teams of evaluators to perform assessments of flood forecasting efficiency.

4. Implementation issues

To prepare teams of evaluators for their mission, identified teams (preferably drawn from hydrological services with recognized standards in flood forecasting) need to be trained using materials as described above. To be effective, a number of these teams in each WMO Region would need to be identified and trained. Once a service has requested for an evaluation, the following steps could be envisaged:

4.1 Preparatory Phase

Identification of development objectives and assessment of the present status of flood forecasting services and capabilities including identification of reporting lines and procedures;

Compilation of a comprehensive set of historic, event-based data (including meteorological and hydrological data and information, flood risk maps..) to be used in the evaluation;

Agreement on the overall procedure for the evaluation in terms of time, infrastructure used, and staff to take part in the evaluation.

4.2 Evaluation Phase

The evaluators will have compiled a complete scenario for a flood situation and need to have distributed responsibilities in the evaluation process. There might be an option to insert complications in the flood forecasting process such as a flood release from dams, overtopping of a levee, failure of critical gauging stations or means of communication, to test the ability of the participating personnel to react and adapt to the situation. The actual evaluation would last over a period of 3-4 days, from the building-up of a flooding situation to an actual high-alert flood situation and back to a pre-flood situation.

4.3 Post-Evaluation assessment

As mentioned in item 2 above, a SWOT analysis will be prepared based on the observations of the evaluation team and the feed-back from officials of the hydrological service. This analysis can then be used by the hydrological service with advice from the evaluation team to generate a forward-looking quality management perspective with a focus to improve on flood forecasting services in critical action domains that have been documented in the Strategy and Action Plan of the WMO Flood Forecasting Initiative. It can be envisaged that the planning and implementation of necessary measures would be undertaken in form of a (Technical Assistance) project.



Workshop on the Strategy and Action Plan of the WMO Flood Forecasting Initiative

WMO Headquarters (Geneva, 8 – 10 December 2009)

Agenda

Day 1, 08 December 2009

09:00 - 09:15 Registration of participants

09:15 - 09:30 Welcome remarks by representative of WMO

09:30 - 09:40 Adoption of the agenda

09:40 - 09:50 Organizational matters

09:50 - 10:20 The WMO Flood Forecasting Initiative: Overview of the Strategy and Action Plan

10:20 - 10:45 Tea Break

10:45 - 11:00 Implementation Status of the Flood Forecasting Initiative

11:00 - 11:30 Discussion of key features of the SAP

11:30 - 14:30 Region-specific issues of the SAP (WMO Regional Associations)

RA I (Africa)

RA II (Asia)

RA III (South America)

12:30 – 13:30 Lunch

RA IV (North America, Central America and the Caribbean)

RA V (South-West Pacific)

RA VI (Europe)

14:30 Tea Break

14:45 - 15:15 Discussion: Strengthening of Observing and Information Systems

15:15 - 15:45 Discussion: Improvement of Meteorological Forecasting Practices and Products

15:45 - 16:15 Discussion: Improvement of Hydrological Forecasting Practices and Products

16:15 - 16:45 Discussion: Strengthening Institutional Coordination, Cooperation and Integration
between NMSs and NHSS

16:45 - 17:00 Summary of Day 1

17:00 Meeting adjourns

Day 2, 09 December 2009

09:00 - 09:30 Discussion: Strengthening of Cooperation and Coordination between Countries in issues related to Flood Forecasting

09:30 - 10:00 Discussion: Promoting Training and Capacity building in NMHSs

10:00 - 10:30 Discussion: Formulating Technical Documentation and Guidelines related to Flood Forecasting

10:30 - 10:45 Tea Break

10:45 - 11:15 Discussion: Supporting Disaster Management

11:15 - 11:45 Discussion: Addressing Climate Variability and Change in the Light of Extreme Events (Focus on floods)

11:45 - 12:15 Discussion: Demonstrating the value of meteorological and hydrological data, information and products for disaster management

12:15 - 13:15 Discussion: Development of demand-driven integrated weather, climate and hydrological forecasting information and products

13:15 - 14:15 Lunch

14:15 - 14:25 Arrangements for writing session

14:25 - 17:30 Writing Session: Development of a detailed Activity Plan - based on the Strategy and Action Plan - that will assist Members in establishing improved Flood Forecasting Systems

17:30 Meeting adjourns

Day 3, 10 December 2009

09:00 - 11:00 Writing session for the Activity Plan

11:00 - 11:15 Tea Break

11:15 - 12:30 Plenary discussion and adoption of the Activity Plan

12:30 - 14:00 Lunch

14:00 - 15:00 Working arrangements for the promotion and implementation of the Activity Plan as part of the SAP of the WMO Flood Forecasting Initiative

15:00 - 15:30 Tea Break

15:30 - 16:00 General conclusions and closing session

16:00 Closure of the meeting

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