WORLD METEOROLOGICAL ORGANIZATION

Weather • Climate • Water

REGIONAL WORKSHOP ON IMPROVED METEOROLOGICAL AND HYDROLOGICAL FORECASTING FOR FLOODS IN WEST AND CENTRAL AFRICAN COUNTRIES

(Niamey, Niger, 4 – 6 April 2006)

FINAL REPORT

1. OPENING OF THE WORKSHOP

At the kind invitation of the Government of Niger and of the AGRHYMET Regional Centre, WMO organized the Regional Workshop on Improved Meteorological and Hydrological Forecasting for Floods in West and Central African Countries in Niamey, Niger, from 4 to 6 April 2006. The meeting was attended by 35 experts representing the Hydrological and Meteorological Services of 13 countries and 5 regional institutions. The list of participants is given in Annex I.

The meeting was opened by Mr Etienne Sarr, on behalf of the interim Director General of the AGRHYMET Centre. In his opening address Mr Sarr welcomed the participants and recalled that since 1994 the AGRHYMET Centre is supporting the CILSS member countries and other countries in the region in the hydrological monitoring activities on the major rivers and since 1998 the Centre is issuing a seasonal hydrological forecasting bulletin. Furthermore the Centre is committed to cooperate with and support the Hydrological and Meteorological Services in particular through capacity building activities. In this context he mentioned that four students presently attending courses at AGRHYMET centre have been awarded grants by WMO. At national level the CILSS is supporting through the AGRHYMET Centre the activities of the Multidisciplinary Working Groups (GTP) which are gathering experts from Hydrological, Meteorological, agriculture and other state Services to address common problems and concerns including flood preparedness and forecast. Mr Sarr finally recalled that the continuous degradation of the observing network is one of the key factors hampering effective flood forecasts in the region.

Mr M Tawfik, Chief, Hydrology Division on behalf of Dr M. Jarraud, Secretary-General of the World Meteorological Organization, added his words of welcome to the participants and thanked the AGRHYMET Centre for hosting the workshop. He highlighted the importance of the availability and proper use of accurate and timely meteorological and hydrological forecast products to effectively prepare and respond to the various flood related disasters and to assist the disaster management authorities in taking the appropriate response actions.

He informed the meeting about WMO plan to organize a series of regional workshops to bring national experts from Meteorological and Hydrological Services together to discuss problems and suggest solutions for issues related to strengthening flood forecasting in their countries. He added that the conclusions and recommendation of these regional workshops will provide an input to an international conference to be organized by WMO in 2006 / 2007. He thanked the participants and wished them a successful meeting.

The representative of the Niger Basin Authority recognized the importance of the meeting as an effort to improve the national and regional capacities for flood forecasting and stressed the commitment of NBA to further working in collaboration with its partner countries to address this issue. He stressed the crucial role that data observation and transmission networks play in ensuring that National Hydrological Services can adequately address flood forecasting and water resources assessment. He thanked WMO for organizing the workshop and assured the participants of NBA support to their food forecasting activities in their countries and wished them a successful meeting.

2. ORGANIZATION OF THE WORK

The agenda (see Annex II) and the work programme of the workshop were approved without amendments. The workshop was conducted in English and French with simultaneous interpretation. Mr E. Martin (Ghana) and Mr S. Diallo (Senegal) agreed to co-chair the meeting and Mr F. Azonsi (Benin) acted as rapporteur.

During the meeting country representatives presented thirteen country reports on the status and perspectives of the flood forecasting activities in their countries jointly prepared by the Hydrological and Meteorological Services. Five technical papers were also presented on monitoring, data management, forecasting, risk prevention, and integration of meteorological data. The meeting was conducted in five sessions, each of them comprising country reports, technical presentation and closed by a round table discussion on institutional aspects, training requirements, challenges and opportunities of enhanced cooperation amongst Hydrological and Meteorological

Services and strategies to improve integration of meteorological and hydrological forecasting of floods.

3. SETTING THE SCENE – COUNTRY PAPERS

3.1 Benin (F. Azonsi, F. Dide)

Benin has six synoptic stations and 76 precipitation stations, 19 of which are also used as agrometeorological and/or climatological stations. The national hydrometric network comprises 39 stations, of which 14 are located on bodies of water (lakes, lagoons, tidal zones) in southern Benin and two are equipped with broadcasting systems.

Whilst meteorological data are recorded in real time, there is a time lag in the reception of hydrological data. Under these circumstances, it is not possible for an operational flood prediction and warning system to be established. There is room for improvement in the way in which the meteorological and Hydrological Services carry out their respective duties relating to observation, monitoring and prediction of disasters such as floods. However, real time data and a reliable communications network are prerequisites for high-quality prediction and although an ORSEC (disaster relief organization) Plan is in place in the majority of our countries, it falls short in terms of functionality. A realistic reorganization of these systems will be needed in order to bridge gaps and rectify weaknesses. This will require awareness-raising amongst the various stakeholders, capacity-building and provision of suitable materials. States should seek to make human and financial resources available in order to encourage development partners to provide whatever assistance they can.

3.2 Burkina Faso (G. Baki, J-P. Mihin)

A clear legal and institutional framework covering water issues is in place in Burkina Faso, based on the principles of environmental protection and integrated water resources management. This framework served as the starting point for the Action Plan for Integrated Water Resources Management (PAGIRE), which was adopted by Burkina Faso in March 2003 and which is currently being implemented. A series of specific actions are currently being undertaken within the context of PAGIRE to design and implement a national water information system (SNIEau), with a view to improving the quantitative and qualitative monitoring network and raising levels of usage and demand. The procedures for interaction between the various producers and users of data will also be simplified, again within the appropriate frameworks for cooperation at a shared basin scale.

Despite the fact that the coverage of the hydrometric network does not always meet WMO standards, this network is relatively satisfactory, although the rating curves for certain stations require updating. There is appropriate monitoring of meteorological variables and national coverage by the network is satisfactory, both in terms of synoptic and precipitation stations.

Deficiencies can however be seen in terms of the human resources dedicated to meteorological and hydrological activities, with visible reductions in capacity to design and manage such activities. The meteorological and hydrological data collection networks are also equipped with classic recording devices that are old and poorly monitored, with the many consequent gaps precluding the availability of reliable real-time data.

3.3 Côte d'Ivoire (K. B. Djé, S. Koné)

Côte d'Ivoire has dense, reliable precipitation and hydrological observing networks. The hydrological observing stations are largely comprised of staff gauges.

Information is collected on rainfall, stage and discharge. The main difficulty facing Côte d'Ivoire concerns the processing of these data, a problem that has technical, financial and human aspects. Specifically, if hydrometeorological data are to be properly exploited, new data collection and handling technology must be applied, necessitating the installation of automatic stations and the application of models.

The Hydrological Service of Côte d'Ivoire does not currently prepare flood predictions on an operational basis. The Service uses the results of seasonal forecasts from the Meteorological Service to estimate flood probability. However, travel times are estimated using hydrographs.

3.4 The Gambia (Ms F. John, L.M. Touray)

The Gambia flanks the River Gambia on its North and South banks, this position places the country within the flood plains of the river. Flooding in The Gambia is caused by riverine floods, high tidal levels, heavy rains and poor drainage. Floods are not generally considered a problem in the country, except localised flooding caused by heavy rainfall events in the Upper River Division or densely urbanized areas.

Both the NMS and NHS in The Gambia are housed within the Department of Water Resources. The Services are mandated to collect, process and disseminate data and information on hydrology and meteorology. Meteorological network has 15 synoptic stations and all are operational (two are 24 hour station). Hydrological network has 12 recording stations, but only 5 are operational, and 4 discharge measurement stations, of which 3 are operational.

Lack of automatic data logging system, deterioration of the observation network, lack of flood forecasting models, inability to monitor small scale flood events and the inadequate financial and human resources, are the main reasons hampering the capability of the NMHS of the Gambia to issue flood forecasting.

3.5 Ghana (L. Mawuli, E. Martin)

The Ghana Meteorological Agency (GMA) currently uses the MSG satellite to monitor meteorological patterns. This method of forecasting is however inadequate for real time flood forecasting. The Agency at the moment is seeking funding to purchase a radar system to enable them forecast with a higher degree of accuracy a rainfall event in real time.

The Hydrological Services Department (HSD) currently has 167 hydrological monitoring stations for water resources management. Accra, the capital city has no single operational hydrological station for storm runoff monitoring, although every year there are incidents of flooding with its concurrent disastrous effects on the people. Furthermore, HSD has no hydrological flood forecasting model in place that can take advantage of the storm forecasting from the GMA to issue real time flood forecasting and warning. There is need to develop an extensive program to install a comprehensive hydrological network with modern equipment and to also seek assistance to either develop or adapt a reliable flood forecasting model.

Even though the level of collaboration between the HSD and GMA at moment is satisfactory, there is a need to strengthen this collaboration to develop flood maps for the country. Furthermore, the two institutions will have to make efforts to link up with the other research institutions in the water sector, especially the universities, to help conduct and implement research. Last but not least, there is the need to speed up the collaboration efforts between Ghana and our neighbours, especially Burkina Faso, particularly in near real time data and information exchange, to avoid lost of lives and properties due to lack of adequate warning on natural or artificial floods.

3.6 Guinea (F.P. Camara, Ms P. Fofana)

The Minister of Water, through the National Water Directorate and its national prediction centre, is responsible for the prediction of floods and dry-weather flow, in close collaboration with the National Meteorology Directorate

Execution of the mission to protect life and material goods is hampered by the absence of an efficient early warning system, the lack of technical, computing and real time communications equipment and a shortage of qualified staff with the capacity to carry out proper flood prediction. Of the seven automatic stations installed within the framework of the HYDRONIGER project, only three remain operational. However, Guinea is unable to receive data from them because of a lack of receiving stations.

The most urgent priorities for action to improve flood prediction are as follows : training to upgrade capacity amongst managers at the hydrometeorological prediction centres, installation of a flood and high flow early warning system and the establishment of and support for a framework of collaborative hydrometeorological partnership to bring about improvements in the quality of flood prediction products.

3.8 Mali (A. Fofana, M. Koite)

The Malian National Meteorological and Hydrological Services are tasked with producing meteorological and hydrological information destined to help protect lives and goods during extreme meteorological and hydrological events and to contribute to increases in the productivity and efficiency of economic and social activities.

A suitable meteorological data collection and processing network has been set up in order to provide systematic and regular observation of meteorological variables. The measured (or observed) values for these variables (data) are verified, recorded, stored and archived. Data are processed scientifically depending on the type of information or derivative product required by users.

A hydrometric stage-measuring network of 100 stations equipped with staff gauges is used to collection and process hydrological data. Twenty-nine of these stations are fitted with real time hydrological data collection platforms. The Hydrological Service is equipped with hydrometric apparatus for measuring discharge. Data are validated, processed and archived electronically.

Products and information prepared by the Service are regularly disseminated to all state and private media organizations and are used by a number of different business sectors.

As part of their respective missions, the NMS and NHS work in cooperation with a number of bodies, including Multidisciplinary Working Groups (MWCs), Local Meteorological Assistance Groups, integrated water resources management (IWRM) projects and the Selingué Dam Water Management Commission.

However, in order to provide better-quality and more reliable predictions and enhance flood prevention measures, rainfall and discharge models need to be improved.

3.9 Mauritania (Dj. Sarr, S. Ould Dah)

The purpose of the Hydrological Service is to collect and manage data on water resources. The contribution of the institutions responsible for meteorology is limited to supplying data.

The hydrological and meteorological observing networks comprise nine water level recorders within the Senegal river basin, 13 synoptic stations, 70 precipitation stations, all referenced to the national network, and eight agrometeorological stations (out of order). MSG satellite data are also available. Although the Hydrological Service makes use of products from the Meteorological Service in the course of its activities (research, preparation of reports and directories), there is currently no organization responsible for prediction and technical management of floods, nor are there any prediction models in place.

3.10 Niger (A. Daouda, M. Daouda)

The main legal texts with a direct bearing on water resources management are Edict No. 93-014, which defines the water regime and establishes the conditions for the use and protection of this resource, and Decree No. 97-368/PRN/MH/E, which sets out the modalities of application for the aforementioned edict. The texts pertaining to this piece of legislation are very rarely applied and significant work is required in order to publicize it amongst the various stakeholders involved in this field. However, there is no specific legal framework for flood management in the true sense. Nevertheless, the Ministry of Water Resources, Environment and Desertification Control, working through the Water Resources Directorate (DRE), is responsible, inter alia, for the collection, processing and dissemination of information on water resources. As a result, hydrological prediction falls within the remit of DRE.

To this end, DRE has at its disposal, in addition to the National Hydrological Service, a National Hydrological Prediction Centre (CNPH), the national branch of the HYDRONIGER project. At the same time, the National Meteorological Directorate (DMN) of the Ministry of Transport is responsible for collecting and disseminating meteorological information. However, meteorological products are not currently taken into account during flood prediction.

At the stream level, stage and discharge readings are taken. In addition to this information, the small number of stations equipped with DCPs produce real time rainfall data. The basic national hydrometric network in Niger comprises 66 stations on streams, distributed among six (6) hydrological units.

Meteorological and climatological data and information (precipitation, temperature, humidity, pressure, evaporation, insolation, etc.) are collected using a network comprising 15 synoptic stations, ten climatological stations and around 300 precipitation stations.

The NHS does not specifically carry out flood prediction and does not have models available for this purpose. The results of PRESAO, in which the NHS is participating, provide information on flood events from a largely qualitative point of view. Information notes on the hydrological situation are prepared only in the event of exceptional flooding of the Niger river and the methods employed are based on the relationship between discharge readings at a station or between different stations within the basin. The main channels used for alerting the authorities and the public are bulletins, radio and television.

The principal barriers to effective flood prediction are as follows:

- Deterioration of the hydrological and meteorological observing networks;
- Inadequate systems for rapidly collating hydrological and meteorological data and information;
- Inadequate data on groundwater;
- Inadequate rainfall data and lack of flood prediction models for small catchments.

3.11 Nigeria (J.N. Okpara, F.O. Osse)

Meteorological and hydrological data collection network in Nigeria dates back to before 20th century. Due to multiplicity of factors contributing to the generation of floods, both natural and man-made, an integrated approach is adopted to address these problems. Hence for proper networking and exchange of data and information, it has been established a number of collaboration schemes between NIMET (Nigerian Meteorological Agency) and the Federal Ministry of Water Resources (FMWR), the National Emergency Management Agency (NEMA), and the Federal Ministry of Environment (FME).

Organizational responsibilities involve the promotion of a culture of prevention and pre-disaster strategies through monitoring, forecasting for early warnings, and timely dissemination of vital information on the impending disasters. NIMET through an in-house developed rainfall-forecasting model provides early warning and advisory services with good lead-time of one or two months on severe meteorological phenomena especially extreme weather and climate events that could lead to disasters. The FMWR carries out real-time hydro meteorological data collection and forecasting through a network of Argos satellite based stations installed in the framework of the NBA/Hydro-Niger project. These stations are being phased out and replaced by the METEOSAT system in the framework of the Niger-HYCOS Project implemented by Niger Basin Authority (NBA).

The forecast generated is often disseminated through electronic and print media including Internet. In the light of the above, the National Meteorological and Hydrological Services in Nigeria still face a lot of challenges that ranges from inadequate hydrometeorological network density to diminishing financial support and insufficient state-of-the-art equipment.

The following recommendations are however proffered among others:

- Hydrometeorological data-collection activities should be accorded priority and integrated into the economic decisions and policy-making in the country;
- Provision of more telemetric stations, autographic raingauges, automatic weather stations to cover the whole country;
- Capacity Building in Software Modeling and Training is advocated for effective National Forecasting Centres;
- Bi-annual routine monitoring of the performance of the various in Africa hydro meteorological networks of stations and the National Forecasting Centres in Africa by the World Meteorological Organization (WMO) officials is strongly recommended – this will lend credence to the importance of data gathering and forecasting and ensures decision-makers recognition.

3.12 Senegal (S. Ba, S. Diallo)

The legal and regulatory framework includes texts such as the Water Code and Water Policy. Reforms are being undertaken in urban and rural Water-management and Meteorological Services, with a view to increasing the effectiveness of the services provided. Greater involvement by the public in the management of water points is also being sought. In addition, a flooding and disaster management committee has been set up under the coordination of the Ministry of the Interior. The Ministry of the Interior is also responsible for the disaster relief organization (ORSEC) plan. Furthermore, a special flood management plan, also known as the JAXAAY plan, has been established. Within the Organization for the Development of the Senegal River, the Permanent Water Commission (CPE) provides flood management and monitoring for the Senegal River basin.

The institutional framework is frequently ambiguous, complex and unstable and despite the coherence of this framework, a number of different stakeholders from the water resources sector are involved. There is a need for the framework to be strengthened and for better and urgent application of texts intended to protect the resource whilst maintaining water availability, as well as to prevent human activities from taking over the catchment and water courses in a chaotic fashion.

Water resource monitoring activities tend to suffer from serious under-funding. Alternative sources of funding should be sought, with users participating to a greater extent in the funding of climatological and hydrological monitoring activities and basin agencies contributing more funds to equipment procurement and capacity-building in countries responsible for water resources management.

3.13 Sierra Leone (A. Bockari)

The parliament has adopted an act establishing the country's Disaster Management Committee (DMC), hosted by the Office of National Security. It comprises all stakeholders potentially affected by likely natural disasters or involved in prevention, protection, and rescue actions. The DMC has developed a contingency plan for the country to respond to any natural disaster. The hydrometerological sub-committee is responsible for flood management when and where it occurs.

There is no definite flood forecasting system in place and the use of hydrological models is hampered by the limited availability of hydrological data, in particular real time data. There is no storm detecting radar in the Meteorological Service to assist in weather forecasting, though this particular instrument would be very helpful in predicting the extent of precipitation that likely affects the rivers to overflow.

There is a need to strengthen the capacities of the country in flood forecasting activities by improving the observing network and enforcing a training programme for the meteorological and hydrological personnel, particularly on the modern trend in hydrological forecasting techniques with special emphasis on flood forecasting. There is also need to strengthen the cooperation with regional institutions and international river basin organizations as the country so far has not benefited from the cooperation with them since only few and minor rivers are internationally shared basin.

3.14 Togo (K. Agouda, G. Kpabeba)

In Togo, the status of legislation concerning flood prediction and/or disaster prevention is far from secure. However, should a disaster occur, national leaders, in collaboration with the Ministries of Infrastructure, Mines, Energy and Water, the Environment, the Interior and Social Affairs, can take the necessary measures and organize relief operations.

The Meteorology Directorate supplies meteorological data to the Hydrological Service, which uses them to determine water levels and updates the basin-level hundred-year hydrographs. These products are also used to determine rainfall-discharge relationships.

There is no information structure built into the national hydrometric network to enable flood prediction to be carried out. However, whenever water from the Naugbéto dam on the Mono river is released, dam managers send out bulletins to the state-run media (radio, television, press), for the attention of the riparian population, fishers and sand harvesters.

For the purposes of flood prediction, bankfull stage data are collected, enabling annual, five-yearly, decadal and hundred-year flood events to be determined.

4. TECHNICAL PRESENTATION

4.1 Problems of hydometeorological data and hydrological forecasts in West Africa (A. Amani - AGRHYMET Regional Centre)

Hydrometeorological data and information are essential to both the planning and design of water resource mobilization and development projects and to the effective management of future infrastructure and installations.

Unfortunately, despite the encouraging conclusions of the Sub-Saharan hydrological appraisal conducted between 1990 and 1992, current findings indicate that the gauging networks in the majority of countries have been suffered continual deterioration since the late 1980s, in the absence of the large-scale funding needed by the meteorological and Hydrological Services to properly monitor these gauging networks. Such a situation directly affects the quality of data collected, with significant gaps to be found in the majority of hydrometeorological datasets. Resolving this problem is a matter of the utmost urgency, since failure to do so could jeopardize the investment channelled into development projects linked to water resources.

The quality of a hydrological prediction is connected at a fundamental level to the quality of the hydrometeorological data used both in developing the prediction method (modelling) and during its operational use. Bearing in mind the climate regime and the size of the hydrographic basins of West Africa, the usable prediction tools can be divided into two general categories:

(a) Rainfall/discharge modelling at a daily or sub-daily time step, used in small and medium-sized basins, i.e. those in which collection time is less than a month;

(b) For basins classified as large, with collection times of over a month, hydrographs are generally regularly available. Station-to-station, upstream-downstream and flood propagation techniques for flood forecasting can all easily be used.

With regard to prediction using rainfall/discharge models, particular attention should be paid to collecting information on the spatial and temporal distribution of rainfall within the basin, given the high degree of sensitivity of the hydrological response, as demonstrated in the case of the Sirba basin using the FEWS Net GeoSFM hydrological model.

Finally, it is also possible to carry out seasonal hydrological predictions (hydraulicity during months of high flow) for the major basins of the region from the beginning of the rainy season onwards, creating a statistical link between sea surface temperature of particular oceanic zones during the months of April, May and June and hydraulicity during the months of high flow (August, September, October) at stations on the major streams of the region. This exercise has been conducted since 1999 by a consortium comprising the AGRHYMET Centre, ACMAD and NBA.

4.2 ACMAD contribution to the improvement of the operational flood forecast in the countries of central and Western Africa

(Z. Mumba – ACMAD)

Flooding and drought are perennial problems that affect West and central Africa, as well as other parts of the African continent, causing damage and considerable loss of life, as evidenced by a number of cases presented for the year 2005 alone.

Meteorological Services over the world, and in Africa in particular, are coming under increasing pressure, not only in meeting the present obligations concerning the provision of weather and climate information and services, but also in adapting to new roles to confront the challenges posed by extreme weather events such as floods which seem to be occurring with increasing frequency and severity.

The presentation addressed the following issues:

- The role of Flood Forecasting and Warning in Flood Management;
- Inadequacies in Current Flood Management Approaches in West and Central Africa;
- Need for Flood Forecasting and Warning Systems;
- Opportunities that exist for establishing Flood Forecasting and Warning Systems.

It also presented the current actions undertaken by ACMAD in support of flood forecasting and warning services, including development efforts for strengthening flood forecasting and warning services.

4.3 Flood Risk Management and Prevention in the River Niger Basin (C. Brachet – IRD Adviser to NBA, ACMAD, AGRHYMET)

The hydrological regime of the Niger river at Niamey is characterized on the one hand by flow yield from the right bank tributaries during the rainy season and on the other, by flow from the Upper Niger basin, the most significant portion of which reaches Niamey during the rainy season between December and January. The flood associated with water yield from tributaries in Burkina Faso is referred to as the local flood, owing to its localized nature both temporally and spatially, whilst the other flood is known as the Malian (or Sudanese, or Guinean) and is generated by distant water yield originating in the Upper Niger basin in Guinea, Côte d'Ivoire and Mali.

Part of the city of Niamey is located in a flood-prone area, at least for hundred-year flood events. This is the case particularly for the alluvial zone on the right bank, where protection from embankments exists only up to a certain threshold. The University of Niamey, the AGRHYMET Regional Centre and the Niger Basin Authority are all located in this zone.

The latter two institutions have taken the initiative of conducting a research study in order to anticipate a disaster of this kind and enable the necessary steps to be taken, including regulatory measures (new buildings, public information, insurance).

It should be noted that Niamey is also at risk from flooding by minor tributaries (*koris*) However, the stormy nature of this type of event (flash flooding) makes establishing the flood footprint a hazardous undertaking. They are therefore not covered by the study.

The general objective of the study undertaken by CRA and NBA is to guard against the risk of flooding in Niamey as a result of overtopping of the Niger river. The specific objectives are as follows:

- To characterise reference hydrological events connected with flood risk;
- To construct reference water surfaces associated with these events;
- To map corresponding flood hazards (footprint, water height and possibly, duration of submersion);
- To map risks, comparing the hazard with the degree of vulnerability (land use).

The expected outcomes and products are as follows:

- Discharge figures for 10- and 100-year return periods;
- Two perpendicular water surface profiles for the city of Niamey;
- Two hazard maps for the city of Niamey on an appropriate scale (1:5 000 to 1:15 000);
- Two risk maps on the same scale, with adapted legend. A study report.

Services destined for the city of Niamey are provided internally by the AGRHYMET Centre and NBA. This methodology could be extended, for example, to Bamako or other urban centres flanking streams within the basin, or indeed to other basins.

En plus des études de prévention, des modèles de prévision doivent être élaborés, testés et utilisés, y compris avec la participation des riverains (centres urbains, agriculteurs...). Enfin les mesures de protection locale et éloignées adéquates doivent être prises. Par exemple pour la ville de Niamey :

In addition to prevention studies, there is a need for prediction models to be designed, tested and used. These should include participation from riparian populations (urban centres, farmers, etc.). Finally, adequate local and remote protection measures must be taken. In the city of Niamey, for example :

- Levees along the right bank must be inspected and reinforced, including their foundations ;
- Potential exceptional use of the Kandadji dam as a retarding basin (possibly with preventive releases of water to maintain a given level) could be examined.

4.4 The NBA experience in regards hydrological data collection, processing and dissemination the in the Niger river basin

(S. Mahmoud and A. Abdulaye – Niger Basin Authority)

Data collection at the Niger river basin scale depends on information supplied from the network of automatic stations. The first network was installed between 1984 and 1987 within the framework of the HYDRONIGER project and comprised 65 Argos-type data collection platforms distributed throughout the countries sharing the basin.

Various problems and complications were encountered in the operation of the network. These grew in magnitude over the years and included the following in particular : vandalism of equipment, faults in certain modules, the cost of Argos fees, ageing equipment and a shortage of spare parts, since these were no longer in production. As a result, the NBA and countries were persuaded to switch to the METEOSAT system. This change was undertaken in stages, with the acquisition of 16 DCPs by the GHENIS (Hydroecological Management of the Upper Niger) project in 2001, 32 DCPs by NBA and six by Cameroon between 2003 and 2005 and finally, three DCPs ordered by Nigeria in 2006.

It is anticipated that for the purposes of the Niger-HYCOS project, older METEOSAT DCPs will be rehabilitated, with no new automatic satellite transmission DCPs being purchased. Financial and material assistance is being provided to each member country to ensure that the network is maintained.

The following table lists the DCPs making up the observing network for the two projects:

Country	HYDRONIGER (ARGOS)	Niger-HYCOS (METEOSAT)
Benin	2	5
Burkina-Faso	1	10
Cameroon	5	8
Chad	0	5
Côte d'Ivoire	2	5
Guinea	7	12
Mali	21	20
Niger	9	11
Nigeria	18	19

In addition to the data collected by the network of automatic stations, data gathered by national networks are also retrieved by the Interstate Centre for Prediction (ICP) during maintenance missions or by correspondence (paper copies of documents or electronic versions on diskette). These data are generally supplied by observers or staff gauge-reading personnel.

The data gathered via the network of automatic stations and by the NHS are stored in the HYDRONIGER databank. For each station in the databank, the following variables are listed : station characteristics, water level, rating and the mean daily discharge values on which the various studies are based. Data input is carried out manually and the databank is managed using the Hydrom 2 and 3 software.

Hydrological predictions are prepared using a set of mathematical models, including the following :

- The SIP (*Système Informatique de Prévision*) [computerized forecasting system] model, which incorporates four methods:
  - Musik (Muskigum),
  - CLS (Constrained Linear System),
  - SPHARI (*Saisonnière d'Autocorrélation Multiple pour la Prévision d'Hydrogrammes avec Actualisation des Résidus*) [seasonal multiple autocorrelation for hydrograph forecasting with residual update]
  - ARIMA (Auto Regressive Integrated Mobile Average)
- HYDRONIGER model (designed at the IPC in 1987).

The main prediction products issued by NBA are the monthly hydrological situation bulletin, technical notes and the seasonal prediction bulletin. They are disseminated via the NBA and Niger-HYCOS websites, email and DHL courier, as well as during country missions or NBA ministerial sessions.

In anticipation of the implementation of the Niger-HYCOS project and in order to learn from the difficulties encountered with hydrological data collection using the HYDRONIGER networks and during the AOC-HYCOS pilot, NBA carefully analysed the various data collection and transmission methods, establishing the advantages and disadvantages of each one. This enabled the most appropriate hydrological data collection procedures to be selected, giving a variety of methods ranging from an observer with a radio through PSTN or GSM telephones to automatic satellite transmission DCPs.

4.5 OMVS data networks and monitoring tools - mechanisms for flood forecasting and environmental survey

(L. Ndiaye – Senegal River Basin Authority)

The work of the Senegal River Development Organization (OMVS), comprising Mali, Mauritania, Senegal and Guinea, its newest member, has involved the construction of two dams (the Manantali hydroelectric dam and the Diama anti-salt dam). The management of these installations and of their effects has prompted the use of prediction and monitoring tools (SIMULSEN and COREDIAM) and the establishment of an environmental data monitoring network.

SIMULSEN is intended as a means of simulating the operational management of a multipurpose dam (Manantali) over a long period, on the basis of a daily calculation. This tool can be used to assess how variation in water yields and projected management scenarios affects the achievement of objectives. COREDIAM is a propagation model for the exceptional high water event between Bakel and the Diama dam. Since 2004, OMVS has also had in a warning plan in place in order to anticipate likely flood events of an exceptional or catastrophic nature.

For the purposes of environmental monitoring, the OMVS Environmental Observatory has established a data network to monitor 13 indicators (surface and groundwater, climate, water-borne diseases, fertilizers and pesticides, invasive plants, etc.). The data received are stored in a database linked to a geographical information system. Tools available to assist with decision-making include “SOE Notes”, maps and other data disseminated via the website (www.omvs-soe.org). With a view to improving its monitoring capability, OMVS has recently signed an agreement with Météo-France for the supply of prediction data. OMVS is currently putting in place an operating report for the resource and a Master Plan for Water Development (SDAGE).

5. CONCLUSIONS

1. Least developed countries, i.e. most of the countries in the region, are the most vulnerable to natural disasters such as floods, which cause damage representing a significant amount of national GDP; flood forecasting, prevention and protection activities are therefore important tools contributing to their sustainable development.
2. Uncontrolled settlements and urban sprawl have brought a significant increase of the number of inhabitants of flood-prone areas.
3. Risks but also advantages of settlements/developments in flood plains are not fully taken into account in planning policies.
4. In some countries, NHSs have been originally established for the purpose of data collection for water resources assessment. Therefore flood forecasting systems do not exist in these countries and there is a need to expand the mandate of NHSs to include flood forecasting activities.
5. It has been noted that a satisfactory legal framework for flood forecasting exists in most of the countries, but the means for enforcing implementation in the field are lacking.
6. In the majority of countries in the region flood-forecasting activities are very limited, because of shortage of real-time data (due to inadequate observing and communication

networks), outdated models, poor integration of meteorological inputs in hydrological models, inadequate manpower and skills among the NHMS staff at all organizational levels.

7. It was noted that cooperation exists between NHSs and NMSs in the region but only to a limited extent in certain countries. There is definite need for closer cooperation at national level between NHSs and NMSs, in particular when, as it is often the case, they belong to different ministries.
8. The limited geographical coverage and the deterioration of observing networks have left several catchments ungauged which can however contribute significantly to flood events.
9. Historical time series of hydrological and meteorological data are essential for calibrating models, but often they present a significant number of gaps.
10. Among the main obstacles to obtaining reliable data is inadequate incentives and payment to observers.
11. Cooperation among riparian countries exists on transboundary basins and the issue of data exchange and cooperation among NHSs with regional institutions needs to be examined in greater depth.
12. The participants generally agreed that the region needed more support form WMO to strengthen the capacity for flood forecasting, including training.
13. The participants recognized the importance of this workshop and requested WMO to assist the countries in organizing national workshops to increase awareness among the decision makers and national authorities of the importance of the economic value of hydrometeorological information.
14. The participants noted with appreciation the WMO plan to organize an international conference on the socio-economic benefits of hydrometeorological services to be held in March 2007 and requested WMO to support the participation of different stakeholders from Africa in this event.
15. It was recognized that WHYCOS and other regional and national projects are very useful in strengthening the capacities of National Hydrological Services.
16. The importance was stressed of demonstrating the economic value of hydrological and meteorological data and products to decision makers in order to increase the national budget allocations for flood forecasting activities.
17. There is a need to improve knowledge of the impact of climate change and human activities on flood frequency and magnitude.

6. RECOMMENDATIONS

1. There is need to promote cooperation at national level between NHSs and NMSs especially in network design and maintenance, to improve synergies and minimize overlaps.
2. It is necessary to better define the hydrologists' needs in terms of meteorological forecasts. With a view to closer integration of meteorological inputs in flood forecasting, NMSs are called to enhance their offer of QPF.
3. It was noted that duplication of activities between NHSs and NMSs exist in some countries. There is need to identify clearly the responsibilities of each Service and ensure synergies among them.
4. There is a need to establish a network among experts in flood forecasting in NHMS and NMS of the region to exchange information and experience on issues related to flood forecasting.
5. Cooperation between NHSs and NMSs should be expanded to include universities and other research institutions involved in flood issues
6. It was noted that in some countries international rivers represented a minor share of the total of their water resources and therefore these countries could not benefit from participating in international river institutions activities. WMO and international river basin organization were requested to consider assistance to these countries to support their national activities for flood forecasting.

7. The national rain gauging network need to be strengthened (including the use of radar) in view of their contribution to hydrological flood forecasting modelling.
8. The instruments selected for equipping observing stations and for data communications should be adapted to the requirement and capacities of the National Services in charge for their operation and maintenance.
9. There is a need to improve real- or near-real-time data transmission networks to ensure data for flood forecasting products.
10. There is need to develop specific tools tailored to region for estimating the discharge of ungauged rivers.
11. There is a need for appropriate models and tools for completing these gaps in available data series. There is also need for training in developing and applying models for data filling.
12. There is a need to develop models taking into consideration the national and regional conditions, requirements and needs. Such hydrological models should be developed in cooperation with local universities and research communities.
13. To effectively perform new tasks such as flood forecasting, there is need to develop an approach by NHMSs, aiming at increasing value-added products and strengthening links with end-users.
14. WMO should assist its Members to develop policies and strategies for promoting the value of NHMSs and their contribution to sustainable development.
15. Training in development of user-oriented products is required.
16. There is need to collect documentation on the effects of flooding to help demonstrate to decision makers the extent of damage that can be avoided or minimized with proper flood forecasting.
17. Human resources represent a crucial factor in forecasting: it is necessary to ensure the strengthening of their capabilities through recruitment, training in basic meteorology and hydrology, and ensuring the replacement of retired staff.
18. Governments are encouraged to involve the local communities with reasonable incentives to encourage their participation in the data-collection activities and to ensure quality data.
19. Flood forecasting within the concept of IWRM should be treated with a multidisciplinary approach taking into consideration environmental, economic, legal and social aspects.
20. The importance was recognized of data exchange, in particular meteorological data as input to flood forecasting models. NHSs and NMSs are invited 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”.

7. ADOPTION OF THE REPORT

The meeting adopted the report of the session and requested the WMO Secretariat to finalize the text and distribute copies to all participants.

8. CLOSURE OF THE WORKSHOP

In closing the workshop, Mr E Sarr, thanked the WMO for organizing the event that had provided the opportunity of bringing together experts from different countries and institutions to exchange experience in flood forecasting. He also thanked all participants for their active participation in the workshop and their valuable contributions. He further emphasised the importance of improving flood-forecasting techniques in the region and urged the participants to promote cooperation between the NHSs in their countries and at regional level. He also encouraged the participants to make use of the facilities of regional centres, including AGRHYMET, to strengthen their national capabilities. He concluded by wishing all participants a safe journey back home.

Mr M. Tawfik added his words of thanks to the participants for their presentations and fruitful discussions that had contributed to the success of the workshop. He extended his thanks to the Government of Niger for their support and to the AGRHYMET Regional Centre for supporting the organization of the event. He also thanked the co-chairs, Messrs Martin and Diallo, and the rapporteur, Mr Azonsi, for the way they had conducted and supported the workshop. He assured the participants of WMO's support for any activity aimed at strengthening their flood forecasting systems and developing international cooperation in the region and encouraged them to communicate with WMO regarding any assistance required.

The workshop was closed on Thursday, 6 April 2006 at 1.15 p.m.