

WORLD METEOROLOGICAL ORGANIZATION

Comprehensive Review of the World Hydrological Cycle Observing System



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Photos on cover page: The photos on the cover page were taken by Dr Paul Pilon during the Review Team visits to the Niger-HYCOS and the Carib-HYCOS and represent the flow of hydrological information collection, the fundamental focus of WHYCOS.

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LIST OF ACRONYMS

ACMAD	African Centre of Meteorological Applications for Development
ADCP	Acoustic Doppler Current Profiler
AGRHYMET	Agriculture, Hydrology and Meteorology
AMDAR	Aircraft Meteorological Data Relay
ASAP	Automated Shipboard Aerological Programme
BSRN	Baseline Surface Radiation Network
Cg	WM Congress
CHy	WMO Technical Commission for Hydrology
CIC/Carib	Caribbean Islands Component/Caribbean
CILSS	Regional Centre for AGRHYMET
CIMH	Caribbean Institute for Meteorology and Hydrology
CNR/IRD	Compagnie nationale de Rhône/Institut de recherche pour le développement - France
DCPs	Data Collection Platforms
DEAL	Direction de l'Environnement de l'Aménagement, et du Logement
DMAs	Disaster Management Agencies
DPD	Detailed Project Document
FEDER	Fonds européen de développement régional (European Regional Development Fund)
FFGS	Flash Flood Guidance System
GAW	Global Atmospheric Watch
GCOS	Global Climate Observing System
GOS	Global Observing System
HWRP	Hydrology and Water Resources Programme
HYCOS	Hydrological Cycle Observing System
ICIMOD	The International Centre for Integrated Mountain Development
IKMP	Information Knowledge Management Programme, MRC
IRD	Institut de recherche pour le développement
IWRM	Integrated Water Resources Management
LCBC	Lake Chad Basin Commission
MED	Mediterranean
MOU	Memorandum of Understanding
MRC	Mekong River Commission
NBA	Niger Basin Authority
NHMSs	National Hydrological and Meteorological Services
NHSs	National Hydrological Services
NMSs	National Meteorological Services
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Maintenance
OECD	Organisation for Economic Co-operation and Development
PCC	Project Coordinating Committee
PCD	Project Concept Document
PIC	Pacific Island Country
PMU	Project Management Unit
PRC	Project Regional Centre
PSC	Project Steering Committee
RRR	Rolling Requirements Review
SADC	Southern African Development Community

SARFFGS	Southern African Region Flash Flood Guidance System
SEA-HYCOS	South East Asia - HYCOS
SOPAC	Secretariat of the Pacific Community Applied Geoscience and Technology Division
STUDI	Société Tunisienne d'Ingénierie
UN	United Nations
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WCG	WMO Coordinating Group
WDIP	WIGOS Development and Implementation Plan
WHYCOS	World Hydrological Cycle Observing System
WIAG	WHYCOS International Advisory Group
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization
WWW	World Weather Watch
ZAMWIS	Zambezi Water Information System

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1. EXECUTIVE SUMMARY

The World Hydrological Cycle Observing System (WHYCOS) concept was launched by the World Meteorological Organization (WMO) as a major long-term initiative to improve knowledge of water resources and to assist governments in overcoming obstacles that hinder the achievement of sustainable development. The concept has evolved over time and remains a very positive influence in developing and strengthening the capabilities of countries and regional organizations in this regard. Donors, regional organizations and National Hydrological Services working with WMO have made significant contributions to implement the WHYCOS concept through regional initiatives termed Hydrological Cycle Observing System (HYCOS) components.

With time comes the realisation that additional change is warranted to strengthen the programme and its derived outcomes and enhance societal impacts. To do this, it is recommended that the concept of WHYCOS further evolve to make operational, within its HYCOS components, institutional, organizational and human resources capacity development to allow the attainment of sustainable outcomes and societal impacts. Adequate attention needs to be given to achieving outcomes such as the provision of flood forecasts and warnings, and not solely outputs such as the acquisition and distribution of hydrological data. In order to achieve the needed changes, all parties will need to modify in some way how the problem has been approached, some needing to make small adjustments, while others requiring to adjust their policies and to commit to contributing more towards the sustainability of the investments, thereby allowing even more benefits to accrue into the future.

It has been recognised that the capacity building model of WHYCOS and its HYCOS components needs to be broadened to allow a more holistic strengthening of the capabilities of the National Hydrological Services and regional organizations to occur. There is a growing collaborative movement of recipient countries and donors to improve the effectiveness of aid in building capacity and achieving desired results. This has been reflected through the "Paris Declaration on Aid Effectiveness" (OECD, 2005), and the commitments expressed therein are most relevant to the WHYCOS programme. Countries and donors should adopt the "Paris Declaration on Aid Effectiveness" (OECD, 2005) when working with the WMO on implementing the WHYCOS concept through its HYCOS components. This would include, *inter alia*, simplifying donor policies and procedures, increasing flexibility to better reflect the amount of time to implement components, and aligning components within national priorities.

The WHYCOS programme has five principles that are instrumental in shaping it. Recommendations are made to reinforce two of them. One is the commitment of participating countries to the long-term sustainability of the investments, and the second is the commitment of participating countries to the unrestricted and free exchange of hydrological data collected under the WHYCOS programme among all parties participating in the component and the international community at large. The first ensures that countries will be active participants in the project initiation stages, the project implementation stages, and the project maintenance stage, which is the primary tenant allowing sustainability to occur. The second allows the fulfilment of the global aspect of WHYCOS, allowing the international community the ability to monitor water resources more accurately at the global and regional levels and to use these data for a variety of scientific and humanitarian purposes.

A number of recommendations are made in this report to further enhance and focus the efforts of WMO in exercising its leadership role for the WHYCOS programme and

its HYCOS components. It recommends that WMO take a much more proactive role in providing oversight and technical assistance by increasing its ability to provide advice and guidance on the operational implementation of on-the-ground projects such as HYCOS components. The report also recommends that WMO play a more significant role in mid-term and final evaluation reports that should also address the state of technical outcomes. WMO should also be undertaking a review of the post project stage approximately three years after completion of the project implementation stages to evaluate ongoing sustainability and operational issues. The report recommends that WMO pay more attention to understanding the causes of issues and in preventing the recurrence of the common pitfalls.

The report calls upon the WMO Secretariat to create a permanent Office for the WHYCOS programme to help focus Secretariat leadership. It should have the delegated authority to respond to operational requirements in a timely fashion, and to take advantage of opportunities as they arise. The report recognises that WMO will need to invest in acquiring and developing its staff to be subject-content experts so they can more effectively provide advice and undertake analyses associated with operational aspects of HYCOS components and the WHYCOS programme in general.

The report also calls upon the WHYCOS International Advisory Group (WIAG) to meet regularly, limiting meeting attendance to essential participants so that it can once again become an effective coordinating body and be more able to provide recommendations to the Secretary General on policy and programme development. This will allow the programme to more rapidly respond to issues and be adjusted over time. WIAG, among its other duties, should focus on defining the persistently recurring issues associated with the project implementation stages and project maintenance stage and should assist the WMO Secretariat in developing strategies and approaches to resolve them. WIAG, through its coordination function, should monitor the development of issues and should assess the effectiveness of the strategies and approaches employed to overcome them.

The report also calls upon the WMO and its WIGOS, WIS and WHYCOS programmes to carefully analyse and clearly determine what specific efforts will be necessary and what costs and benefits will be incurred for HYCOS components to take advantage of the WIGOS and WIS initiatives and for the WHYCOS programme in general. It recommends that efforts should be undertaken to document these in as clear and concise a fashion as possible, as well as the costs and benefits that would likely accrue through the integration of the WHYCOS programme with WIGOS and WIS.

The report also notes that should it be established that benefits exceed costs, WMO and the WHYCOS programme focus on increasing awareness of the WIGOS and WIS initiatives, and more importantly on the requirements they place upon the WHYCOS programme and its HYCOS components. Efforts at increasing awareness should be made as broadly as possible through the hydrology and water resources communities that may consider undertaking a HYCOS project. As well, the report recommends that WMO and the WHYCOS programme develop a strategy to assist existing HYCOS components in taking advantage of the WIGOS and WIS initiatives.

It is hoped that this report will assist the donors, regional organizations and National Hydrological Services working with WMO to strengthen the WHYCOS programme and its HYCOS components. For it is through this programme that major strides forward can be made in strengthening the capacity of National Hydrological Services and regional organizations to address the needs of today's and future generations.

2. INTRODUCTION

Congress (Cg-XVI, see Annex I, WMO, 2011a) requested the Secretary General of the World Meteorological Organization (WMO) to carry out an independent external evaluation of the World Hydrological Cycle Observing System (WHYCOS) programme as a follow-up to the one conducted in 2005 (WMO, 2005a). In addition, Congress requested a review of the WHYCOS International Advisory Group (WIAG) mechanism to make it better respond to the new challenges facing the WHYCOS programme. Congress requested the review focus on:

- (a) reviewing and assessing the concept, objectives and progress towards them, expected benefits/costs, and future development of WHYCOS and proposing strategies for any necessary remedial action to possible shortcomings;
- (b) ensuring the efficient relationship of WHYCOS with other relevant initiatives and international programmes, especially its integration with the WIGOS and WIS; and
- (c) coordinating with stakeholders, especially national and regional partners and donors, the implementation of the various HYCOS component and WMO inputs.

In September 2011, a meeting of the Review Team was held in Geneva (WMO, 2011b). The objectives of the meeting were: to ensure that the Review Team had agreed on its terms of reference (Annex II); to develop a framework for the review; and to allow the Review Team an early opportunity to request any information it required from the Secretariat to undertake the review. During this meeting, it was mentioned that this report would be a priority area for the next Commission for Hydrology (CHy) Session to be held late 2012, after being considered at the WIAG meeting in early December 2011.

In essence, the Review Team was asked to evaluate in today's climate the concepts and approaches of the WHYCOS programme and to assess its progress, proposing remedial action to any perceived shortcomings. In doing so, the Team was also asked to assess the role and composition of WIAG as it is instrumental to the continued success of the WHYCOS programme.

This report provides an overview of the existing WHYCOS programme, the evolution of the concept from its inception, a review of the implementation principles, and a status of the various HYCOS components (Chapter 3). The report then provides a brief description of the fact finding methodology including problems encountered in data and information gathering (Chapter 4), while Chapter 5 provides a brief review of some HYCOS components by its various stages, describing what was accomplished, what may have gone wrong and what actions had been taken to correct it, or what could have been done. Chapter 6 presents the main findings of the review, including results from a detailed survey and an assessment of the suitability of component objectives, project design, progress, efficiency in use of project resources, effectiveness of management relations and oversight responsibilities, and the evaluation of the commonality and synergy potential among HYCOS components. Chapter 7 delves into the WMO Integrated Global Observing System and WMO Information System initiatives and what might assist in the integration and conformance of the WHYCOS programme with these initiatives. Chapter 8 focuses on conclusions from the findings, lessons learned, and provides recommendations

directed to the WMO Secretariat, to Member Nations, National Hydrological Services, regional basin or other regional organizations, and to donors and partners.

3. THE WHYCOS PROGRAMME

3.1 The Need

Timely and accurate information about water resources forms the foundation of effective water resources management, which, in turn, forms the basis of national development strategies and is key to attaining sustainable development. Unfortunately, the ability of many nations of the world to collect, maintain and use such data is grossly inadequate. This situation results from a general lack of investments in human and financial resources, resulting in the deterioration of many data collection networks and the inability of National Hydrological Services (NHSs) to provide information necessary for social and economical development and environmental protection. In many cases, the inability to appropriately plan for and forecast extreme conditions can seriously place in jeopardy the lives of citizens and their economic prosperity.

The need for monitoring systems, data archives, resource assessment and management, and pollution monitoring, protection and control has been recognised in various country reports of the UNDP and World Bank. The Sub-Saharan Africa Hydrological Assessment Project of the UNDP and World Bank highlighted the decline of monitoring networks, absence of computer archives and lack of qualified staff as a result of funding cuts to hydrological services (WMO, 2005b). The situation is similar in many countries, including a number of developed ones, and unfortunately is occurring in other regions of the world.

In order to address these issues, the World Meteorological Organization (WMO) launched the World Hydrological Cycle Observing System (WHYCOS) concept in 1993 (WMO, 2005b) with the World Bank, while other partners joined the initiative later. The concept was endorsed by CHy-IX in 1993 (WMO, 1993), followed by Cg-XII in 1995 (WMO, 1998a and 1995). WHYCOS is an umbrella programme of WMO, and its success depends on the combined efforts of its partners, participating countries, regional basin and other regional institutions, international agencies and financial partners and donors.

3.2 The Original WHYCOS Concept

As reported in the comprehensive evaluation undertaken in 2005 (WMO, 2005a), WHYCOS was initially developed as a global programme with the objective of establishing approximately 1000 stations on the major rivers of the world, measuring up to 15 variables, such as flow, sediment, water chemistry and nearby meteorological variables. The programme was to use the same information and telecommunications technology as the World Weather Watch programme. It was seen as part of a future UN Water Information System allowing the international community the ability to monitor more accurately water resources on a global level and to better understand the global hydrological cycle. At the same time, the WHYCOS programme was expected to enhance the capacity of National Hydrological Services, so that they were more able to meet the demands placed on them for sustainable development.

As provided in the initial WMO brochure on WHYCOS (WMO, 1998a) and as reported in the comprehensive evaluation in 2005 (WMO, 2005a), the original main objectives of the programme were to:

- Strengthen the technical and institutional capacities of hydrological services to capture and process hydrological data, and meet the needs of their end users for information on the status and trend of water resources;
- Establish a global network of national hydrological observatories providing information of consistent quality, transmitted in real time to national and regional databases, via the Global Telecommunication System (GTS) of WMO; and
- Promote and facilitate the dissemination and use of water-related information using modern information technology such as the World Wide Web and CD-ROMs.

It had two main objectives: one of support to strengthen cooperative links among participating countries having common hydrological problems and an operational objective to help achieve on-the-ground implementation at regional and international river basin levels.

The original concept of WHYCOS was a **global** network of reference stations transmitting hydrological and meteorological data in near real-time, via satellites, using the GTS to national hydrological services and regional centres. This global focus gave rise to questions as to whose interests were being served, those of the country or region versus the global demand for data (WMO, 2005b). Some argued that the global focus, although responding to a valid need, should have been obtained through a more bottom-up strategy of supporting regional and country HYCOS components. It is through this collective of a number of regional HYCOS components that the WHYCOS programme should have been attained. Over the years since the original inception of WHYCOS, a growing recognition of the needs of countries and their regions transformed the application of the programme. The concept continues to evolve over time based on country and regional needs, recognition of the need to build upon the collected data by developing value-added products and services, and taking advantage of transformations and advances in technologies.

3.3 Evolving Concept

While the original concept, aims and principles of WHYCOS remain sound, the implementation of WHYCOS has evolved, primarily in response to the experience gained from practical applications of regional HYCOS components.

Although Cg-XII (WMO, 1995) had pointed out that the first priority for WHYCOS was to meet the needs of the countries, at the onset greater emphasis had been placed on the concept of a global database to capture data and information on the hydrological cycle. As previously mentioned, this global focus was viewed by many as being at odds with what should have been the major thrust of the WHYCOS concept - a bottom-up approach of building upon regional and basin HYCOS projects. That is, while the concept is global in nature, the benefits of capturing data for specific purposes at the regional and national level should have been the primary focus. The global need for data could then be met by the flow of data from the successful implementations of the regional HYCOS components.

Recognising the importance of the evolving concepts to the long-term success of the programme, the WIAG members in the first meeting in 1998 (WMO, 1998b) reiterated the overall goal of WHYCOS -- "to work towards a global water observation and information system". At the same time, WIAG reformulated the programme's objectives as follows:

- To strengthen the technical and institutional capabilities of National Hydrological and Hydrometeorological Services (NHMSs) through training and capacity building;
- To develop and enhance information systems for providing reliable water-related data, information and products to meet users' needs (for example, flood forecasting and warning, drought forecasting and water resources management);
- To establish a global network of key national observing stations for providing consistent, high-quality data on water quantity, water quality and weather, transmitted in real-time to national and regional data centres;
- To promote and facilitate the dissemination and use of water-related information through up-to-date technology;
- To stimulate water resources assessment activities;
- To strengthen cooperation at the basin, regional and international levels as a contribution to integrated water resources management;
- To enable the availability and use of water-related information for larger scale applications in other WMO and international scientific programmes; and
- To establish a framework of guidelines and compatible standards for data collection, storage.

The first recommendation of the WIAG at its inaugural meeting was the "adoption by WMO of the [reformulated] objectives for WHYCOS... subject to their regular review to cater for changing circumstances." Discussions at this first meeting, which are reflected in the reformulated objectives, led to the broadening of the WHYCOS/HYCOS concept to include strengthening the use of data for the provision of water resources information for decision making, for example, water resources assessment, flood forecasting and warnings, drought prediction and water resources management.

During the subsequent WIAG meeting in June 1999 (WMO, 1999a), while discussing the outcome of Cg-XIII (WMO, 1999b) on the WHYCOS programme, it noted that the global concept of the programme remained a leading objective. The WIAG appreciated that the global concept was driven by scientific needs and by the need of governments and intergovernmental bodies for rendering advice on the state of the world's water resource. However, it recognised that the regional developments were driven by the priorities of the countries for socio-economic development. WIAG noted the need for the adoption of a bottom-up approach to ensure the involvement of the countries concerned and respond to their needs.

At this meeting, it was also noted that Cg-XIII (WMO, 1999b) had adopted Resolution 25 on the free and unrestricted exchange of hydrological data. The WIAG

recommended that "all intending participants in HYCOS should be requested to agree to and implement the conditions relating to the exchange of hydrological data that are established in Resolution 25 (Cg-XIII)." This represented a significant new policy and an advancement in the sharing of hydrological data through HYCOS or by other means, allowing the benefit of data collected by regional HYCOS initiatives at both the national/regional and global scales.

As a result of the decisions and recommendations by WIAG, the WHYCOS changed its focus from 1998 through 2000 to more of a basin approach (WMO, 2005a and 2000) and is being implemented through regional components referred to as HYCOS. This now ensures that the components will meet the objectives and priorities expressed by the National Hydrological Services (NHSs) and end-users of the participating countries. This is accorded by having each HYCOS component independently designed and implemented to meet specifically tailored national and regional needs. The approach also recognises that a HYCOS component should only be launched when the countries concerned have expressed their collective desire for such a development, and their commitment to making it a success. This shift in approach represented a significant evolution allowing the fulfillment of the WHYCOS concept.

Implementation on a basin or regional scale enables each HYCOS component to address the particular needs of the participating countries and their NHSs and the end users and establish institutional and financial arrangements. It allows each HYCOS project to select activities and procedures, design the necessary network of sites and variables to be measured, develop national and regional data bases, design value-added products and develop services, all being specific to the hydrological characteristics and needs of the basin/region.

3.4 The Primary Objectives of a HYCOS Component

The primary objectives of a HYCOS component comprise two thrusts. The first is the strengthening of the capacity to collect data on the hydrological cycle so as to improve the accuracy and availability of water resources data and information through the development and implementation of national and regional hydrological information systems. The second primary objective is the use of data and information for a variety of needs, such as for issuance of early warnings and mitigation of impacts from water-related natural disasters. The WHYCOS Guidelines (WMO, 2005b) provides a list of possible primary objectives, from supporting integrated water resources management (IWRM), water quality and ground water monitoring, to strengthening institutional capacities, to strengthening existing hydrological observation programmes, to the adoption of international standards to improve the quality of hydrological data and related information, to the development of information management systems. The Guidelines indicate that the component can focus on one or a combination of these objectives.

The WHYCOS Guidelines (WMO, 2005b, p. 8) also mention a number of secondary objectives. These relate to a number of international efforts to understand global water issues and to strengthen cooperation between NHSs and National Meteorological Services (NMSs). This latter objective is seen as being important for the early warning and forecasting of water and related hazards and furthering understanding of the hydrological cycle necessary for sustainable water resources management.

3.5 Component Stages

A number of activities are undertaken to develop the intentions and plans regarding a particular HYCOS component and its implementation, including activities to ensure long-term sustainability of the overall investment. To facilitate and regularise this process, WIAG through the WHYCOS Guidelines developed six stages covering the establishment of the feasibility of a project, termed Project Initiation Stage, followed by preparation of detailed plans, alignment of funding and project implementation, termed the Project Implementation Stage. The final stage is the Post-Project focusing on maintenance to ensure sustainability of the investments. The Guidelines list the following 6 stages:

Project Initiation Stages

Stage A: Request stage
Stage B: Concept stage
Stage C: Project proposal stage

Project Implementation Stages

Stage D: Preparatory implementation stage
Stage E: Field implementation stage

Post-project Stage

Stage F: Project maintenance stage

The **request stage** (A) is when a regional body or the NHSs, sharing a basin or common concerns, approaches WMO individually making a request for the development of a HYCOS component under the umbrella of WHYCOS. WMO investigates the feasibility of the project as a basin or regionally based HYCOS.

The **concept stage** (B) and the **project proposal stage** (C) are concerned with the development of a short project concept document (PCD) that contains an expression of intent of the countries to work together and develop a HYCOS component. It is based on consultations and preliminary discussions between WMO and the requesting institutions. The PCD should describe the current status of hydrological networks, the issues that need to be addressed, and should clearly identify the objectives of the project. Preparation of the PCD is funded by the WMO as an activity under the Hydrology and Water Resources Programme (HWRP) of WMO. The project proposal should also contain the preliminary agreement among the participating countries committing themselves to the project. It should also specify the proposed activities, expected results, and input from the countries themselves as well those expected from external sources. The document is to serve as a basis for soliciting financial support from donors. WMO provides the necessary technical and financial support to ensure an acceptable project proposal. Finalisation of the project document is the completion of the Project initiation stages.

The **project implementation stages** are undertaken based on the support of one or more donors. One donor may choose to fund the preparatory implementation stage that involves the development of a detailed project document (DPD), while another may choose to fund the field implementation stage (E). The format of the DPD should closely relate to the requirements of the donor, and it should be developed reflecting robust, appropriate and affordable technology and should be designed and implemented to promote national ownership and long-term sustainability. The DPD should cover all the technical and administrative details and field activities, such as the description and number of sites to be strengthened in the network, a detailed

budget and work plan, and identification of the Project Steering Committee (PSC), the Project Management Unit (PMU), the Project Regional Centre (PRC), and all administrative and financial arrangements.

The **field implementation stage** (E) is devoted to fulfilling all concrete activities identified in the DPD, including, for example, field and office work including procurement of hardware and software, installation of new equipment, establishing a regional and various national data bases, development of water-related information products, and training activities. The PMU is responsible for facilitating and coordinating all activities. The donor funds all activities during this stage including the costs of running the PMU and the costs of both the executing agency and the supervising agency. WMO supervises the implementation of the project through regular monitoring and provides a mid-term evaluation report to the PSC. WMO is also responsible for the training activities. WMO with the support of the PSC and PMU prepares a final completion report at the closure of the project to document the lessons learned and how to improve and adopt best practices in subsequent HYCOS projects.

The **post project stage** (F) follows the field implementation stage and is subsequent to the donors fulfilling their financial commitments. It is at this stage that the participating countries agree to maintain the network and continue the activities under the project to ensure its sustainability. At this time, participating countries should also agree and decide on the continuance of the PRC and specific activities, such as maintaining the regional data base. As well, the countries should continue their cooperation in the exchange of data and information. The WHYCOS Guidelines (WMO, 2005b, p. 12) indicate that "WMO should support the countries in this effort." A post-project evaluation approximately three years after completion of the field implementation should be conducted, with this being part of the donor's commitment during the preparatory implementation stage and the development of the DPD. Additional post project evaluation should be periodically undertaken.

3.6 Status of HYCOS Components

Annex III outlines in tabular format the status of HYCOS components as of September 2011. It also provides a Gant chart showing the different HYCOS components and their status with respect to the project stages as defined in WMO (2005b). Completed components, including phases, include: MED-HYCOS, implemented 1997-2001; SADC-HYCOS, phase I implemented 1998-2001, phase II implemented 2005-2008; AOC-HYCOS, implemented 1999-2002; Niger-HYCOS, phase I implemented 2005-2009; Volta-HYCOS, implemented 2006-2009; and Pacific-HYCOS, implemented 2006-2010. Projects currently being implemented include: Carib-HYCOS, 2009-2012; HKH-HYCOS, 2010-2013; IGAD-HYCOS, 2011-2015; Senegal-HYCOS, 2011-2012; and Mekong-HYCOS, 2006-2012. Components that have a DPD and are awaiting donor funding for implementation include: Lake Chad-HYCOS and Congo-HYCOS. Components that have successfully completed the project initiation stage, but have not yet attracted a donor to support the Project implementation stages include: Aral-HYCOS, Arctic-HYCOS and La Plata-HYCOS. WMO has received some statements of interest and some activities have been undertaken, with the Project initiation stages partially completed, include: Amazon-HYCOS, Nile-HYCOS, and SEA-HYCOS. There are three additional HYCOS components that are at various stages of development and have not advanced for some time as donor funding has not yet been attracted. These include: Baltic-HYCOS, Black Sea-HYCOS and Danube-HYCOS.

4. REVIEW METHODOLOGY

4.1 Sources of Information

4.1.1 Reports

A number of reports were provided the Review Team by the WMO Secretariat. Many of these were project proposal documents, namely: 1) SADC-HYCOS -- Phase II, Draft Implementation Document March 2002 (WMO et al., 2002); 2) IGAD-HYCOS Project Document, WHYCOS No. 1, 2004 (WMO, 2004a); 3) Mekong-HYCOS Project Document, April 2005 (WMO and MRC, 2005); 4) Lake Chad - HYCOS, A Draft Project Proposal, December 2005 (WMO and LCBC, 2005); 5) Niger-HYCOS Project Document, July 2006 (WM, 2006); 6) Senegal-HYCOS Preliminary Project Document, September 2007 (WMO and OMVS, 2007); 7) SADC-HYCOS Approved Implementation Document, October 2008 (WMO et al., 2008); 8) The Hindu Kush-Himalaya (HKH)-HYCOS Full Project Document, June 2009 (WMO and ICIMOD, 2009); 9) Caribbean Island Component CIC/CARIB-HYCOS Draft Project Document, August 2004 (WMO, 2004b); and 10) CIC/Carib-HYCOS Project Document 2009 (WMO, 2009a).

Two other documents were provided regarding steering committee proceedings: 1) CIC/Carib-HYCOS Report of the 3rd Steering Committee Meeting, June 2011 (CIC/Carib-HYCOS, 2011); and 2) Niger-HYCOS Report of the 5th Meeting of the Regional Steering Committee, December 2009 (NBA, 2009). A technical document "Strategic and Optimum Network Design for the SADC-HYCOS Phase II Project" (Murwira and Mazvimavi, undated) was also provided.

In addition, the Review Team were provided a number of evaluation reports on the WHYCOS programme or on individual HYCOS components. These included: 1) a SADC-HYCOS Evaluation Mission Report, May 2002 (Rutoshoby and Wellens-Mensah, 2002); 2) the Final Report on the Implementation of the SADC-HYCOS Project, September 2004 (WMO, 2004c); 3) the Comprehensive Review on WHYCOS and on Status of HYCOS Projects Underway, April 2005 (WMO, 2005a); 4) Volta-HYCOS Final Project Report "January 2006 - June 2009", March 2009 (WMO, 2009b); 5) Niger-HYCOS Project Evaluation Draft Report, December 2009 (STUDI, 2010); Evaluation of the SADC-HYCOS II Project, July 2010 (Rhebergen, 2010); 6) Review of the WHYCOS Programme, August 2010 (WMO, 2010); and 7) Pacific-HYCOS 7th Progress Report, Period covering January to June 2010, 2011 (SOPAC, 2011).

4.1.2 Surveys

A survey was developed and distributed by the WMO Secretariat to active HYCOS projects. Additional questions were added to this questionnaire (Annex IV) during the Meeting of the Review Team (WMO, 2011b) and was distributed during site visits of the Review Team to participants of Niger-HYCOS, Mekong-HYCOS and CIC/Carib-HYCOS. The following completed questionnaires were received from CIC/Carib-HYCOS (3), IGAD-HYCOS (1), Mekong-HYCOS (2), Pacific-HYCOS (1), SADC-HYCOS (4) and Volta-HYCOS (1).

4.1.3 Meetings

In September, 2011, the Review Team met with members of the WMO Secretariat (WMO, 2011b) Hydrology and Water Resources Department. While in Geneva, the Review Team were provided presentations and had discussions with officers on WIS and WIGOS from the WMO Secretariat, Information and Telecommunication System Division. In November, 2011, the review team met again with members of the WMO Secretariat and associate reviewers of the WHYCOS programme. During this meeting, the Review Team had the opportunity to hold discussions with the WMO Internal Oversight Office and had a teleconference with one donor, namely the African Development Bank's African Water Facility.

The two lead members of the Review Team had the opportunity to visit Niger, Republic of Mali, and Burkina Faso concerning the Niger-HYCOS component. Meetings were held with representatives of the Niger Basin Authority (NBA) in Niamey, Niger and with representatives of the NHSs in Niamey, Niger; Bamako, Republic of Mali; and Ouagadougou, Burkina Faso. Meetings were also held with representatives from the African Centre of Meteorological Applications for Development (ACMAD) and the CILSS/Centre Regional AGRHYMET in Niamey. The Reviewers also met with a representative of the Ministry of Energy and Water and a representative from the Direction nationale de l'agriculture in Bamako. These latter meetings were with users of hydrological data collected by the NHS and the Niger Basin Authority (NBA). The Review Team also met with representatives of the NMS of the Republic of Mali in Bamako.

Following the meetings in the Niger basin, one reviewer continued to the Caribbean to meet with various parties associated with CIC/Carib-HYCOS, while the other reviewer travelled to Asia to visit with the parties associated with the Mekong-HYCOS project.

While in Martinique, the Reviewer met with representatives of the Institut de recherche pour le développement (IRD), Météo France (Prévision), Conseil général (Réseau Hydro), and Direction de l'Environnement de l'Aménagement, et du Logement (DEAL). The reviewer also met in Barbados with representatives of the Caribbean Institute for Meteorology and Hydrology and the Barbados Water Authority.

Annex V provides a list of all people met by either or both Lead Reviewers.

4.2 Limitations of Fact Finding

The Lead Reviewers were able to visit three regional HYCOS components, while one associate reviewer had visited one prior to this review process. These visits represent a limited sample of possible projects that have been completed or are being implemented. Complementing the information obtained first hand from these visits are the various review and evaluation reports that were provided by the WMO Secretariat (see for example, WMO, 2005a) and the responses to the questionnaire. Given the number of HYCOS projects that have been implemented or are in the process of implementation where mid-term review reports should be available, the Reviewers assume they have only been able to obtain a fraction of such review or evaluation reports that may have been prepared, but are not available to them.

Overall, only a small number of meetings were held with users of hydrological data and information that have been made available through specific HYCOS projects. Lead Reviewers met representatives from the hydro-electricity and agriculture sectors, as well as those having responsibility for the production of flood forecasts and warnings.

The findings, conclusions and recommendations made within this report emanate from an analysis of the various sources of information as outlined in this chapter.

5. REVIEW OF WIAG, WHYCOS AND HYCOS

5.1 WIAG

The WIAG held its first session in Geneva in June 15-17, 1998. In the report of the session (WMO, 1998b), it was noted that the formation of WIAG was approved by the Secretary General of the WMO Secretariat to be a "WHYCOS external coordination mechanism... both internally within the WMO Secretariat and externally, between WMO and other partners, so as to ensure the effective implementation and management of the programme." At the 2nd Session, the WIAG learned that it reported to the Secretary General through its Chairperson. As well, during this 1st Session, WIAG learned that there was a WHYCOS Coordinating Group (WCG) established by the Secretary General to channel inputs from all the various departments concerned with WHYCOS .

The second recommendation to be made at the inaugural meeting of WIAG was for the adoption of its Terms of Reference and Composition (Annex VI). These have not since been modified. The Report of the 1st Session indicated that "the membership of this group should be restricted to a small number if it is to be effective in fulfilling its mandate as an advisory body." Also tabled at its 1st Session was the recommendation to adopt "the objectives for WHYCOS... subject to their regular review to cater for changing circumstances." It was noted at the 2nd Session of WIAG (WMO, 1999a) that the Secretary General approved these two recommendations.

When reviewing the minutes, it was evident that the first meetings tended to have a dual focus, spending considerable attention on policy and procedures, followed by an update on the status of the HYCOS components. The meeting's format then transitioned into mostly being a review of the status of the implementation of various HYCOS components, with little time spent on policy and procedures. The latter few meetings have further transitioned in that the main attention has been the association of the meeting with a technical conference or meeting, predominating the allocated time for the meeting. This latter format has allowed individuals associated with HYCOS components an opportunity to interface with the science initiatives associated with the technical meeting and to interface with a variety of individuals including donor representatives. From the Reports of the Meetings, it is not evident if the WHYCOS programme has benefited from the continual shifting of formats for its sessions, particularly when many of the topics of the technical meetings do not have strong linkages with the technical design of the HYCOS components being implemented.

During the various sessions, WIAG requested WMO to consider, or that it undertake certain matters. For example, during its 1st Session in 1998, WIAG recommended the establishment of a WHYCOS Office within the Hydrology and Water Resources Department. In addition, it requested "as a high priority the WMO Secretariat to

review what is currently available in the area of information infrastructure and develop a clear concept for WHYCOS in this area." At the 3rd Session, it was reported that the *"meeting welcomed the offer of the representative of the World Bank to channel appropriately for consideration by the Bank any WHYCOS proposal submitted for the development of water information systems."* [original text was italicised]

During the 4th Session of WIAG in 2001, it was informed that the proposal for the creation of a WHYCOS Office was still under consideration of the Secretary General. As well, the WIAG was informed that the requirements of information systems for WHYCOS was being incorporated within the WHYCOS standards and guidelines, which were being prepared by the WMO Secretariat. In essence, the Secretariat did not proceed with the development of the terms of reference for the development of a water information system, and the WHYCOS programme was not able to take advantage of the offer of potential funding to develop such a system. The lack of a water information system whereby users can attain useful products based on water resources data and information remains a challenge to the WHYCOS programme. The inability to take advantage of opportunities that broaden the utility of the WHYCOS programme into the domain of value-added products is perplexing.

At this same meeting, the 4th Session of WIAG in 2001, the WMO Secretariat was requested *"to finalize the draft of the WHYCOS guidelines and standards and to circulate them to the WIAG."* [original text was italicised] In the 5th Session of WIAG in January 2003, the "WIAG requested the Secretariat to pursue the development of such guidelines, in the way it deemed most appropriate, and to submit to WIAG members a first draft by July 2003." For an operational programme such as WHYCOS, response to the development of guidelines and standards for the implementation of components should have been undertaken in a more timely fashion. The inability of the Secretariat to respond to the needs of an "on-the-ground" operational programme in a timely fashion is a serious management shortcoming. On this point, no mention was made in the Report of the 5th Session or later Sessions regarding a decision of the Secretary General on the recommendation to create a WHYCOS Office. Given such an office has not been created, it is assumed the recommendation was either not accepted or possibly a decision has not yet been made.

Regarding the Terms of Reference of WHYCOS (Annex V), there are three of fundamental importance to operational aspects of the programme. These are:

1. Consider and advise on the concept objectives, expected benefits/costs, and future development of WHYCOS;
2. Review and assess the status of WHYCOS, and progress towards its objectives, and propose strategies for any remedial action; and
4. Identify and evaluate constraints on and potential risks to the future implementation and sustainability of WHYCOS, and propose strategies to minimise those risks. Risks include, *inter alia*, those of a financial, technical, operational, and institutional/political nature.

During the WIAG meetings, representatives from the various WHYCOS components have attended and have provided concrete examples of where problems were being encountered in the implementation of the component. Some examples include: training; purchase of inappropriate hardware; approaches to selection of data base software; inability to attain objectives not associated with primary data collection; and overall lack of sustainability during the post-project stage. For example, training

provided on the national and regional data base software was stated as being insufficient. Training on installation and maintenance of DCPs was also insufficient. Trainers were not always experts in the subject content in which they were instructing, leading to the recommendation that trainers be from the equipment suppliers. People receiving training were often the same individuals and did not work in the area for which training was offered. The technical ability of many trainees was inadequate to absorb training materials. Too few people are trained in the NHSs, and the training-the-trainer approach was not working.

Given the primary intent of the WHYCOS programme and HYCOS initiatives are to strengthen and build the capacity of NHSs, such reported weaknesses in training should be taken seriously and corrective action should be taken. Such deficiencies have been reported at various sessions and in various reports, for example Rutashobya and Wellens-Mensah (2002). The most recent WIAG meetings (WMO, 2009c, p. 22) also heard many of the above concerns and recommended "Training is a major component in Capacity Building, therefore it is necessary to ensure that training activities are given priority in any HYCOS project and WMO has to ensure that training modules and relevant materials which have been prepared for current projects under implementation, are available for utilization by other projects and NHSs. .. WMO should collaborate with technical partners to ensure that training sessions and related materials are bilingual when more than one language is spoken in the region or to organize separate sessions for different languages... Trainers should be selected with right qualifications related to the topic... and training on instruments and equipment should be undertaken by the supplier."

It is evident that the WIAG meetings offer an ability to succinctly review the progress on HYCOS initiatives and to receive first-hand information on a number of different problems encountered. This allows discussion on solutions, often resulting in prompt advice on how to improve the WHYCOS programme. There is evidently an inability to adjust the implementation of the programme, as many of the same problems seem to persist from HYCOS component to component and over time.

One approach to helping prevent the reoccurrence of problems is through an analysis and sharing of lessons learned to all parties involved in the process. The WHYCOS Guidelines (WMO, 2005b, p. 12) states that "WMO, with support of the PRC [Project Regional Centre] and the PMU [Project Management Unit], should prepare a final completion report at the closure of the project to document the lessons learned and how to improve and adopt best practices in subsequent HYCOS projects." Undertaking such an activity, compiling all of the lessons learned into one compendium in a logical fashion, and sharing this broadly with the entire community, including NHSs, regional centers, project implementing agencies, and donors may help avoid having the same pitfalls develop over time. Sharing this document on the WHYCOS website would seem a suitable approach to making the material available for all. As "owner" of the WHYCOS programme and as supervising agency on HYCOS component implementation, WMO should carefully monitor and ensure that common pitfalls are avoided and mechanism are put in place to prevent them.

The concept of WHYCOS was created by the WMO Secretariat. Ownership, and more importantly the success of the programme, is attained by showing leadership. Leadership is, in part, building the tools and capacities to move from data acquisition to data use, developing the necessary policies, guidance material and standards so that data are collected using documented procedures and have a known quality, and providing the necessary tools to the NHSs to ensure sustainability. Leadership is also, in part, ensuring that such outputs are used to establish outcomes that influence societal impacts. To retain ownership of the concept, the organization needs to listen

to its advice from WIAG and take appropriate action, which, at times, may be remedial in nature.

5.1.1 Data Exchange

Cg-XII (WMO, 1999b) adopted Resolution 25 on the free and unrestricted exchange of hydrological data, the first reference to this new resolution appears in the Report of the WIAG during its 2nd Session in 1999. WIAG recommended that the "coordinators of the MED-HYCOS and SADC-HYCOS projects consider the application of Resolution 25 (Cg-XIII) to their respective projects and to advise what data might be exchanged without conditions and what might be made available under certain conditions." WIAG also recommended that "[a]ll intending participants in HYCOS should be requested to agree to and implement the conditions relating to the exchange of hydrological data that are established in Resolution 25 (Cg-XIII)."

This recommendation on the surface is consistent with the WHYCOS Guidelines (WMO, 2005b, p. 29) wherein it states "In order to develop a regional cooperative framework, the data from the HYCOS components should be shared among the participating countries to meet regional and international requirements in accordance with international guidelines and recommendations." However, Resolution 25 (Cg-XIII) does not require countries to actually exchange data in a free and unrestricted fashion, but rather promotes the concept, but it is left to the countries to decide whether they will or will not share data. WIAG could have recommended that data collected under the auspices of a HYCOS component *shall* be exchanged freely and without restriction. This aspect would have to be reflected within all relevant legal agreements with each country and the regional body, should one exist, regarding the implementation of the component and would need to indicate the availability of data during the post-project stage. This would help attain and be consistent with the WHYCOS principle (WMO, 2005b, p.6) "(c) There should be a free exchange of data among all the participating countries and the international community at large." To do so would also help ensure that the bottom-up approach through implementation of HYCOS components would meet the global requirements for data and would lead to the fulfillment of the global concept of the WHYCOS programme.

5.1.2 Frequency of Meetings

Thus far there have been 8 sessions of WIAG, these being held in 1998, 1999, 2000, 2001, twice in 2003 (January and November), 2006, and 2009. Only two meetings have been held since 2003, a period of 8 years. For WIAG to be an effective coordinating body and to provide recommendations to the Secretary General on policy and programme development, regular meetings should be held so that the programme can be more rapidly adjusted over time.

As mentioned during the 1st Session of WIAG, it was felt that the number of participants should remain small so as to be effective in fulfilling its mandate as an advisory body. A portion of this advice is based on what is transpiring in the implementation and post-project stages of HYCOS initiatives, as well as on the views of financial partners and users of the HYCOS products. The question is how many representatives from each possible group need participate in the meeting and if there are not other avenues for obtaining their input to the forum. The last two Sessions of WIAG, namely the 7th and 8th Sessions, were convened with a technical conference

or meeting, thereby allowing a much larger participation at the meeting. Table 1 below lists the number of participants for each Session of WIAG.

Table 1: Sessions of the WHYCOS International Advisory Group (WIAG) and the Number of Participants

WIAG Session (year)	No. of Participants	No. of WMO Staff Present ¹
1 (1998)	6	4
2 (1999)	10	6
3 (2000)	11	8
4 (2001)	11	12
5 (2003)	18	6
6 (2003)	13	6
7 (2006)	32	15
8 (2009)	31	unknown

1: Many WMO staff attend in a part-time capacity

5.1.3 Sustainability

The issue of sustainability has persisted since the implementation of the first HYCOS component. The 1st session of WIAG (WMO, 1998b, p. 8) noted there "was concern about the sustainability of these projects when the external funding ends. Although it is foreseen that the maintenance of the systems will be the responsibility of the NHSs, the group recognized that in the long term the sustainability of the HYCOS projects would depend on convincing those with the necessary authority and/or resources that their data and other outputs were of sufficient value to justify expending the necessary resources." The WIAG thought at the time that a greater involvement of the user community in the planning and design of the HYCOS project would help "users feel a sense of ownership and be prepared to share the costs involved."

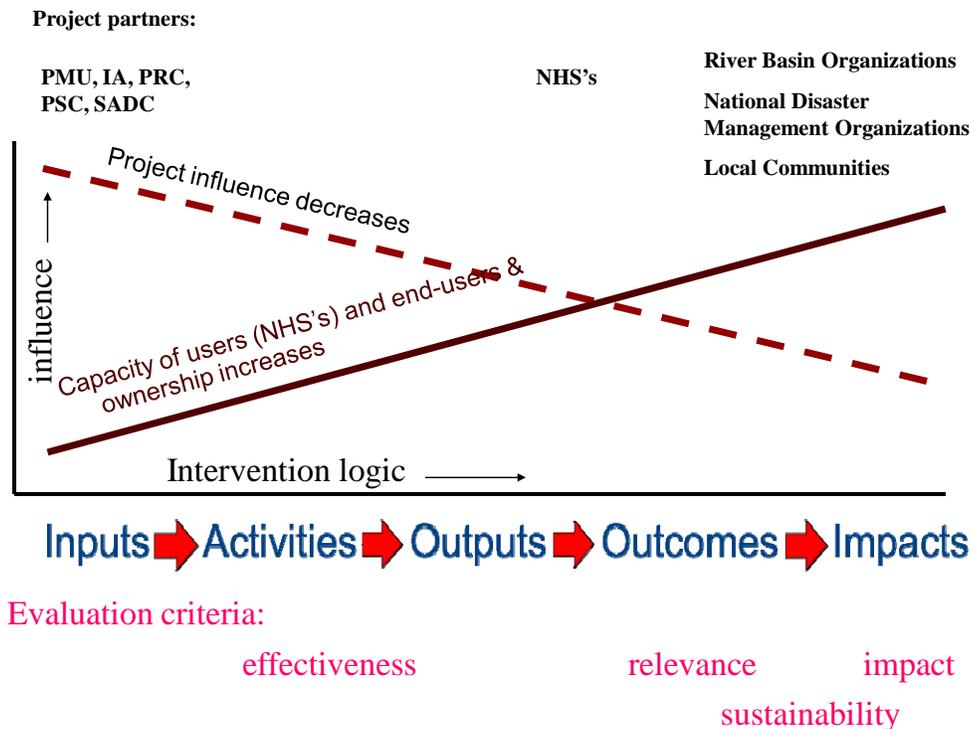
The report of the last Session of WIAG (WMO, 2009c, p. 23) stated " there is no single solution for the sustainability of HYCOS projects. Each Project will need to look closely at its own objectives, with members and partners to ensure sustainability. WMO was requested to develop strategies and provide guidance to ensure sustainability."

In order to improve the sustainability the HYCOS projects, there is a need to adopt a more comprehensive approach to the design of the implementation plan, which should also be reflected in the objectives of the HYCOS components. To allow a common understanding of the concepts of capacity development, the relation between evaluation criteria and intervention logic will be described and illustrated (Figure 1) as will the concepts captured in the capacity pyramid (Figure 2). Within the continuum of the intervention logic, the objectives are met by provision of inputs and transforming these to impacts, in various steps, as shown in Figure 1. The "inputs" (e.g., human resources and finances) are required to undertake "activities" (e.g., purchase equipment, software, and training) that result in "outputs" (e.g., measurement of river stage, flows, and rate of rainfall). Once outputs are attained, additional efforts are required to produce "outcomes" (e.g., functioning NHSs that produce flood forecasts and warnings). The successful development of outcomes provides the organization with the ability to influence societal impacts (e.g., reduction of loss of life from floods, increased food production, increase in prosperity). Outcomes contribute to the purposes of the projects, and the impacts allow attainment of the overall goals. HYCOS projects have mostly concentrated on the

achievement of the outputs, such as procurement of equipment, data base development and the provision of training. Activities have typically not been implemented or at times not even included in the overall plan to secure outcomes such as organizational and institutional strengthening of NHS's to allow the development of outcomes having positive societal impacts.

In the context of these concepts, the terms effectiveness, relevance, impact and sustainability, as shown in Figure 1, are now described. Effectiveness refers to the timely achievement of the planned outputs and fall under the responsibility of the PMU's and Executing/Implementing Agencies. Outputs only become relevant if they result in sustainable outcomes. Outcomes refer to the enhanced capacity of the NHSs that have taken place as a result of the more holistic design of the projects and its derived outputs, such as organizational improvements or the production of hydrological products, such as flood forecasts. Societal impacts are the desired positive changes that take place with end-users or local communities, and attaining these impacts is likely through the influence of many factors often outside the direct control and influence of the project. This high degree of outside influence or contributions that are independent of the project, which allow the attainment of the impacts, is why the project cannot be held accountable for them as it has little influence over them. However, the project should be held accountable for attaining the desired outputs, with some responsibilities for attaining outcomes, as these may require substantial influence exerted from other groups. The relation described above between the evaluation criteria and the intervention logic is illustrated in Figure 1.

Figure 1: The relation between evaluation criteria and intervention logic (adapted from Earl et al., 2001, p. 9, <http://www.outcomemapping.ca/>)

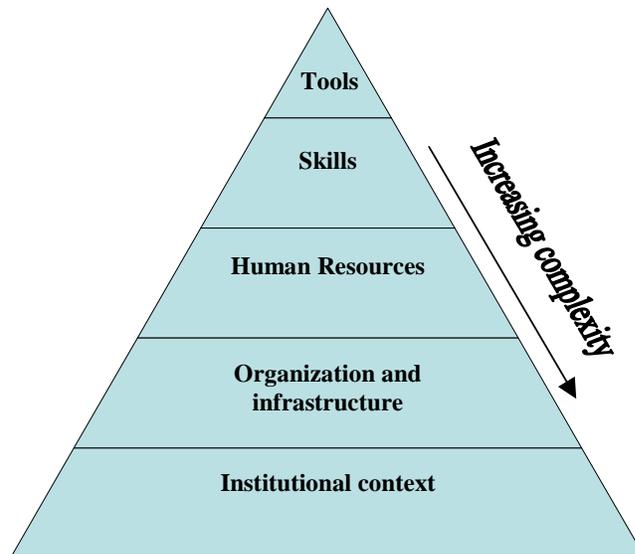


HYCOS components need to adopt a more systematic and holistic capacity development approach. Capacity can be described as a five-tier hierarchy of capacity

building (Potter and Brough, 2004) reflecting needs as shown in Figure 2. Five layers or aspects of capacity are recognized: (1) institutional context; (2) organization and infrastructure; (3) human resources; (4) skills; and (5) tools and equipment. The institutional context, shown as layer 1, refers to legislation, relations between organizations, and etcetra. Layer 2 is about organizational structures, financial management systems, and roles and responsibilities, as well as physical infrastructure. Layer 3 refers to the human resources elements such as career development and human resources management; while layer 4 is about the development of skills (training) and competences (attitudes). In layer 5, the needs for equipment and software are assessed. It should be realized that the complexity of capacity building interventions increases from layer 5 to 1, but that sustainable outcomes can only be expected if capacity development is successful in all layers.

The first step in capacity development is to undertake and assess the capacity needs of the NHS, which is then followed by a critical gaps analysis. This allows a more comprehensive understanding of the capacity development needs and an increase in the ability to plan on how to fulfil them. This should result in the creation of an improved capacity development plan. This leads to more effective use of resources and to more sustainable outcomes.

Figure 2: Capacity development pyramid (adapted from Potter and Brough, 2004).



It is recognised that the highest political levels need to be engaged, as the inability to sustain benefits from investments is tied to inadequate financial and human resources being brought to bear on the issue of data collection through delivery of outputs and to produce outcomes. As stated in the Report of the 8th Session of WIAG, there is no one problem, and as every situation may be somewhat different, there is no one solution, and the solutions may not be simple. It has been recognised that there is a need for NHS to have ownership for the HYCOS sites, with this being assisted by having NHSs implicated in project design and its implementation as much as practicably possible. There is a need, as expressed to reviewers, that the project design reflects the priorities of the individual countries, which has not always been the case. In addition, there is the need for the country to firmly commit financially to its involvement in both the project implementation stages and the post-project stage and

to meet those commitments. The intent is not to foster a long-term dependency on donor funding to undertake national monitoring programmes.

Various problems related to sustainability have been encountered, and these will be further discussed in the Section 5.3 on the HYCOS Components.

5.2 WHYCOS

As previously mentioned, WHYCOS is an umbrella programme of the WMO, and its success depends on the combined efforts of participating countries, regional and basin institutions, international agencies, and financial partners. WMO plays an integral role in maintaining the programme, its momentum, and in bringing the various players together to attain agreed upon goals and objectives.

Overall, the success of the WHYCOS programme is a result of the efforts of WMO and the organizations, groups and individuals that have contributed to it. As with all successful programmes, there is an opportunity for those who have contributed to realise their successes, and it is also an opportunity to study what has worked well, and to review what could have worked better so that future implementations can proceed with less difficulty and with greater likelihood of success.

The main achievement of the objectives of the WHYCOS programme is through the successful implementation and maintenance of the accomplishments of the various individual HYCOS components. Most of the main focus of HYCOS components has been in strengthening the NHSs' ability to collect hydrological data and to maintain these data in a data base. Again, most components have had an element of developing applications that use the data, some being the ability to issue flood forecasts and warnings and to assist in water resources management.

In most cases, the secondary aspect has been the use of the collected data, and this has been sacrificed to attain the first objective, the successful deployment of equipment and software combined with training. It is commonly recognised that having basic data being collected allows the development and application of tools to assess and attain the sustainable management of water resources at the national, regional and global levels. As noted by Rhebergen (2010, p. 37) in evaluating the SADC-HYCOS Phase II project, it was "focused on outputs and was not designed to be outcome oriented, [which] has negatively influenced the sustainability of the results." Project plans and detailed project documents should increase their focus on achieving outcomes and increasing efforts to attain societal impacts, while still achieving outputs, as necessary, to allow attainment of the outcomes and impacts.

There are a number of aspects that require attention to further the development of the WHYCOS programme, many of which are at the "WHYCOS" level, rather than at the "HYCOS" level. For example, thought should be given to developing and adopting for use a "qualified products list". Such a list would be based on specifications and functionality of equipment and software that manufacturers and suppliers would have to meet. Proof would be required that all equipment and software meet the specifications and desired functionality to be on the approved list. This could greatly facilitate the acquisition of equipment and software for the individual HYCOS components. Currently each HYCOS component goes through the inefficient process of equipment and software acquisition as a "new" and independent process each time, as though it were the initial HYCOS component.

As well, the WHYCOS programme may be able to develop the equivalent of an "international standing offer" procurement process for qualified products, where preferred pricing for items on the list may be acquired through a tender process or negotiations with the supplier. Purchasing a large number of units of the same equipment can usually be arranged at a lower unit cost as compared with buying a few directly from the manufacturer.

There is a need to ensure that the recommendations of WIAG are clearly documented and when these recommendations are approved or disapproved, it should be so noted. This documentation should be maintained as a separate compendium and should be accessible for all. As well, all WHYCOS policies and procedures that have been recommended and approved should be compiled in a separate and related compendium. As mentioned earlier, a "lessons learned" compendium should also be maintained and be made available on the WHYCOS website available for all to use, as should the compendium on WIAG recommendations and WHYCOS policies and procedures.

Reports of the WIAG Sessions and meetings of the WCG should be posted on the WHYCOS website so as to be accessible for all. Reports of such sessions should be available on the site no more than two months after closure of the session or meeting.

5.2.1 WHYCOS Guidelines

The WHYCOS Guidelines (WMO, 2005b) are widely used as they provide detailed information on the WHYCOS programme and steps necessary to initiate and successfully undertake a HYCOS component. These guidelines were issued in 2005, and it would be opportune to review and revise them, issuing new guidelines. The reviewers observed and received some input on aspects of the guidelines that should be taken into account when undertaking the revisions. Some pertain to policy, while others are dealing with how the approach is implemented.

The Guidelines state (WMO, 2005b, p. 6) that the WHYCOS mission is "To strengthen the technical and institutional capacities of National Hydrological Services to collect and transmit, in real or near real time, hydrometeorological data and information of a consistent quality..." It then states "WHYCOS is being developed in the form of regional components referred to as HYCOS, each of which meets the priorities expressed by the NHSs and end-users of the participating countries." The Guidelines also state (WMO, 2005b, p. 11) that "it is being developed primarily as a vehicle for promoting appropriate, robust and affordable technology and should be able to create national ownership." Overall, the data model being put forward is the need for real or near real time data using modern equipment and, if possible, making use of the GTS. In many situations, human observers are being paid to provide observations either once or twice daily, while the DCPs, if working, are transmitting data on a more frequent basis from the same site. Once the project funding has ceased, on many occasions, technologists do not visit sites to repair the modern equipment that is either broken or vandalised, while human observations continue.

It should not be overlooked that the application of a HYCOS component usually affects a small proportion of the overall network of each NHS. As the HYCOS component is implemented, the NHSs continue to operate their networks. In most cases, the component introduces a hydrological information system or data base management system that the country could adopt for national implementation. To do so, may require additional expenditure of resources by the NHS and additional

training of personnel in the use of the new software system. In many cases, the component introduces countries to new monitoring equipment and data transmission systems that allow more frequent measurements to be taken, for example, of water stage, water quality parameters and rate-of-rainfall. These increased abilities to monitor the situation can then, in turn, be used to develop and produce outcomes through value-added products and services, such as early warnings of pending floods. However, the circumstances must dictate that the increased frequency of observations is warranted.

It is clear in some cases that new technology is being acquired for the sake of acquiring new technology. On large, slow response rivers, there is little need to acquire data more frequently than as currently undertaken by the NHSs, which continue to employ paid observers. The cost to acquire data via paid observers, who can transmit data on a regular basis, is far more economical and reliable than by using the more expensive modern technology, which may breakdown and suffers from vandalism. Many countries are also maintaining the programme of paid observers even after the new technology has been deployed. There is a need to revisit the Guidelines and mission statement so that data are provided as required by the user communities and is not pre-specified as needing to be in real or near real time. Secondly, the solution to acquiring the data may not lie in new technologies such as DCPs as these may not be affordable, sustainable, or desirable solutions, at least not until the economic model states otherwise.

The above statements do not infer that "new" technologies should not be embraced, the argument is how best to make use of the newer technologies for the local situation. For example, if gauge readers had a GSM phone system, and the central data base had appropriate software, the data could be transmitted by the reader and archived automatically into the system. As well, the NHSs may be able to make good use of Acoustic Doppler Current Profiler (ADCP) technologies if and where warranted. As well, should the river characteristics be responsive such that once or twice daily human observations are insufficient to describe accurately the hydrograph, then newer technologies may be required.

The point being raised is that in many circumstances, the HYCOS approach to data collection has taken a "cookie cutter" approach, whereby there have been highly technologically driven solutions with very little acknowledgement that there may be more optimal approaches to obtaining data and information needs. The strength of the WHYCOS programme should be in developing HYCOS components that truly meet the requirements of the local communities without attaining unaffordable solutions. The solutions put forward by the HYCOS component should allow the flexibility to make use of more conventional approaches that solve the need.

Within the WHYCOS Guidelines, terminology is used that many find confusing and misleading, and the overall management structure appears overly complex and confusing, possibly due to the terminology that is used. There are National Implementing Agencies, possibly NHSs, Project Executing Agencies, Project Implementing Agencies, and Project Supervising Agency, not to mention the Project Steering Committee, Project Management Unit, the Project Regional Centre, the Regional Centre, and the External Support Agencies. To make matters more confusing, the Guidelines use the term ESA on page 10 yet only define it on page 21. The reader learns on page 21 that ESA means "External Support Agencies", and "donor" is provided in parenthesis to describe it. To make things more comprehensible and effective, streamlining of the organizational structure and terminology would be helpful.

Another confusing item is the misuse of the word "centre", as in the Project Regional Centre. Centre is "a place in which an interest, activity, or purpose is centered", which usually is a "building" and does not imply "people". Various groups or individuals may go to the centre, visit the centre or work within the centre. Its use in various WHYCOS and HYCOS documents seems to be oriented to being the "building" to house the activities, while at other times is used to differentiate between indeterminate staff versus term or contract staff, and at times, it is used to differentiate between one unit doing the regional software implementation versus those doing equipment acquisition and field implementation. Simplification and normal use of words would greatly assist in the comprehensibility of the HYCOS management model being described.

5.2.2 Role of WMO

WMO plays various roles within the WHYCOS programme and its HYCOS components. It provides overall leadership to the WHYCOS programme, sets the policy and procedures through the assistance of WIAG, establishes the guidelines to be followed when initiating and undertaking a HYCOS component, provides overall coordination of HYCOS components, assists in the dissemination of information pertaining to the programme through, in part, maintaining a programme website, and assists and funds the project initiation stages including development of the project proposal stage. WMO plays the role of supervising agency, and on occasion has taken on the role of executing and implementing agency.

When acting as a supervising agency as per project documents (WMO, 2010, p. 12), WMO responsibilities include:

- securing project funding through Agreements with donors;
- advising the Implementing Agency on technical standards;
- advising on the preparation of tenders for equipment and services;
- offering linkages with the meteorological community for use of satellite-based data exchange;
- undertaking regular missions and participate in Project Steering Committee meetings; and
- assisting in training activities.

The Guidelines (WMO, 2005b, p. 20) indicate that the role of WMO as supervising agency is "to supervise the project implementation stages to ensure that the project is implemented in accordance with the objectives and in line with these Guidelines and will contribute towards the preparation of the DPDs [Detailed Project Documents], and the regular evaluation and assessment of project implementation." Furthermore, the WHYCOS Guidelines (WMO, 2005b, p. 12) also states that "the implementation of the project will be supervised by WMO through regular monitoring, mid-term evaluation (to be submitted to the PSC [Project Steering Committee]) and training activities... WMO... should prepare a final completion report at the closure of the project to document the lessons learned and how to improve and adopt best practices in subsequent HYCOS projects.

In essence, the role of WMO and how effectively it conducts its role is central to the success or failure of the WHYCOS programme and each HYCOS component. From discussions held among the Reviewers and representatives of various regional entities and NHSs, it was clear that all felt that the WMO should be actively involved with each HYCOS project stage and that the WMO plays an important role as a supervising agency. It was felt, however, that WMO should be more proactively involved "supervising" the work of the executing agency in this capacity to ensure that

the project is actually following the WHYCOS Guidelines and that the WMO's standards were being integrated within the implementation of the project. It was also felt that it would be of additional benefit if the WMO representatives participating in meetings and undertaking the supervisory role would have operational experience and would be subject-content experts that could provide advice on an ongoing basis to the implementing agency, the Project Steering Committee, and the Project Management Unit in a "supervisory" capacity. As well, it was felt that WMO, as described in the WHYCOS Guidelines (WMO, 2005b), should lead the mid-term and final evaluation of the implemented project. The WMO should also remain engaged in the post-project stage, undertaking, among other activities, an evaluation approximately three years following the completion of the field implementation stage.

In order for WMO to effectively undertake the role of supervising agency, the responsibilities and authority to do so within the specific project should be documented in agreements with the donor, executing agency and implementing agency. Such documentation would allow WMO to provide direction to the implementing agency or other entities such that corrective actions could be taken in a timely manner, as WMO sees fit, thereby helping to ensure success of the project.

At times, WMO also assumes the role of executing agency and implementing agency. This may occur when a regional organization may not yet exist in the transboundary basin or is unable to undertake the roles. It has been made clear through the interviews and feedback received that the ability of WMO to undertake these roles in an effective manner is challenging. It was felt that it would be appropriate and possibly very beneficial to have WMO continue to undertake these roles when other organizations are not able to do so, but that it would be most beneficial for WMO to modify its current practices to facilitate implementing large operational projects. Specific examples were the amount of time necessary to have signed agreements in place to initiate implementation, the inability to procure equipment, other items and services in a timely fashion, and the general lack of empowerment of staff to initiate meetings and other activities in a timely fashion. For the benefit of the hydrological community, it is hoped that administrative procedures can be modified to allow more timely implementation to occur should WMO be the executing and/or implementing agency.

5.3 The HYCOS Components

Two main areas of concern with HYCOS components comprise the Project implementation stages and the Post-project stages. The concerns regarding the latter are primarily lack of sustainability for the capacity that has been gained through the implementation of the project. The former comprises a number of issues typical of project implementation. Unfortunately, the lack of sustainability relates back, in part, to the Project initiation stages and the Project implementation stages.

As noted in various documents (for example WMO (2009c, p. 21)), an agreement or Memorandum of Understanding (MOU) should be signed during the Project initiation stages (or possibly at the Preparatory implementation stage once a detailed project document has been created) at the highest political level. This would be at the Ministerial or Permanent Secretary level and would clearly define the obligation of the country towards the project implementation and post-project stages, thereby making the highest levels not only cognisant of commitments but agreeing to them. Such an agreement should be made prior to the Field implementation stage, and it should specify the expectations in terms of human and financial resources required to

be made by the country and over what time lines, as well as depict the expected benefits and products to be derived from the investments.

Clearly the country needs to commit to providing its NHS with a maintenance and recapitalisation budget for the new stations and/or existing stations that have been refurbished with new equipment as defined in the detailed project document. A maintenance budget would cover visits to the site to affect repairs, while recapitalisation funds would be used to purchase replacement equipment, should it be non-repairable, stolen or lost due to natural hazards. It is at this point an economic analysis should be undertaken to ensure affordability of technology for the country. There is little benefit resulting from investing in technologies if they are soon to be in disrepair due to insufficient funds to recapitalise and maintain the benefits from the original investment. This relates to the selection of the most appropriate technologies that meet the requirements for data and the ability of the country to maintain them (e.g., selection of equipment that is less prone to vandalism, ability to visit sites and pay for recapitalisation and repairs).

An approach that may assist the long-term sustainability of the HYCOS component may be through an expansion of the Detailed Project Document (DPD) to explicitly include the post project stage or Project maintenance stage. This broadening is not directed to increasing donor support for maintenance, although this might be advised for a few transition years, but rather is directed to articulating the obligations of the countries, particularly in the maintenance aspects. The DPD would clearly outline the responsibilities of the different parties and how these responsibilities would be undertaken over time.

It has been stated in a variety of documents that NHSs need to take ownership of the HYCOS components, yet in many cases the NHSs are not fully engaged in the implementation of the activities. Full engagement of the NHSs' personnel in all activities assists in the capacity building process. The development of the DPD should reflect the principle to maximise the engagement of NHSs' personnel in the implementation of the component.

Some issues that surface during project implementation include:

- training:
 - insufficient number of individuals being trained within the NHS;
 - insufficient amount of training to be competent with the new equipment in terms of how to operate them, repair them (trouble shooting), appropriate site selection and installation procedures;
 - insufficient training on the use of the new software for the hydrological information system or hydrological data base;
 - insufficient training in hydrometry or other related hydrological topics associated with the type of observations being taken;
 - training by individuals who are not specialists in the area of instruction;
 - repeated training of individuals in various courses who do not work in hydrology and may not be from the NHS;
 - training and training materials not being provided in an appropriate language;
- selection of equipment;
 - purchase of equipment without sufficient spare parts being provided and no contract in place to assure availability of parts to be supplied for a reasonable time into the future;
 - selection of equipment that is inappropriate for site conditions (e.g., DCPs that cannot withstand high temperatures and high humidity, gas

- o bubblers for ephemeral streams, "power hungry" designs that require large solar panel arrays and batteries);
 - o use of less or inappropriate communication technologies for a specific location (e.g., installation of a GSM-GPRS without network coverage);
 - o purchasing of specific equipment when less expensive alternative technologies are available;
 - placement of equipment;
 - o selecting the site such that high water destroys the installation and equipment;
 - o selecting the site in areas prone to vandalism
 - selection of software;
 - o use of software for the national and/or regional data base that is not supported or does not have the desired functionality;
 - o use of software and documentation that is not in the language of the NHSs;
 - data exchange;
 - o countries persisting in not sharing data with others;
 - quality management system;
 - o lack of attention placed on procedures to ensure quality control and assurance of the quality of data; and
 - o lack of rigorous measurement programmes to ensure accuracy and sufficiency of rating curves;
 - o insufficient maintenance programme allowing for infrequent visits to ensure, for example, that rain gauges are clear of debris;
 - lack of engagement of NHSs in installing and maintaining the network;
 - lack of emphasis on developing value-added products and services such as the provision of flood forecasting and warnings.

Various efforts have been undertaken by implementing agencies to overcome some of the above listed deficiencies, but some have escaped solution. However, the above rather long list of issues basically is an indication that a quality management system should be developed and adhered to within the implementation of HYCOS components and in the Project maintenance stage. This represents a cultural shift from purchasing and installing equipment and software with some targeted training courses, to being more proactive in assisting the regional basin authority and the NHSs in implementing a quality management approach to its monitoring functions and value-added products and service delivery. Creating a Project Management Unit that undertakes the majority of activities including equipment purchases, site installation and possibly maintenance may be efficient from a project management perspective, but it does little to build the capacity of the NHSs nor does it engender ownership by these same services to maintain and repair the equipment once the field implementation stage has been completed. Approaching this more broadly in terms of capacity building may require marginally more resources and time to allow development of the capacity, but it would also assist in creating a more sustainable future for the implemented project.

A brief review of some HYCOS projects wherein the Lead Reviewers have received evaluation reports, project related documentation or response to questionnaires will now be undertaken. The following sections are presented at a relatively high level, drawing out salient issues.

5.3.1 SADC-HYCOS

An evaluation report has been prepared on the Phase II SADC-HYCOS project (Rhebergen, 2010) and responses were received from four of the countries participating in the project. The Phase II project was implemented between July 2005 and May 2010. Due to administrative delays signing agreements and misunderstandings, establishing the Project Management Unit (PMU) was delayed until late 2006, allowing only three years for project implementation.

According to Rhebergen (2010, p. 5) "the project achieved a large part of the planned output: all equipment was purchased, a network design study was published, new data base software with 60 licences purchased, HYSTRA hydrological data base training to 7 countries was provided, 30% of the planned DCP's installed, all local civil works have been completed by the member countries." During the course of Phase II, the PMU realised that most of the Phase I equipment had to be replaced with new equipment, with the Phase I equipment upgrades being delivered in 2007 (Rhebergen, 2010). As well, the data base software acquired in Phase I was no longer appropriate and was replaced by HYDSTRA software, which was purchased in Phase II.

Rhebergen (2010, p. 29) reported that the response of trainees was very positive and satisfactory test results were reported. The HYDSTRA software was "enthusiastically" accepted by the Member Countries. It was noted that data quality assurance was customised within HYDSTRA and standardised for each country.

Responses to questionnaires indicated that work on refurbishing Phase I stations and installing Phase II stations had only commenced, with most DCPs not being installed by end of Phase II. One country reported that equipment remains uninstalled due to lack of internal or external funding. It was generally felt that capacity building in the countries was insufficient, and training provided was such that the countries' technologists could not trouble shoot equipment problems. The ability to use hydrological data and information for value-added products was handicapped by the lack of availability of such data. One country indicated that it had not yet received the new data base software, which placed it at a great disadvantage as it remained using the outdated package from Phase I. Concern was also expressed with the high degree of vandalism and the lack of ability to acquire spare parts locally.

Rhebergen (2010, p. 31) made a number of observations in his evaluation. For example, he noted that "awareness building has not been given much systematic attention in the project, nor have strategies been identified to promote the activities of NHSs." He also noted that it was not clear from the documents he reviewed "how the Regional SADC-HYCOS data base will be sustained in the future after external funding comes to an end." Furthermore, "the project document did not provide the vision on capacity development of the NHS's to contribute to a sustainable situation... but also lacked the vision and probably the means to secure a sustainable future for SADC-HYCOS activities." Rhebergen (2010, p. 38) also mentions that "in the project document no vision was presented on how the future SADC-HYCOS unit should be organized, how it should be funded, and how this situation [institutional positioning of SADC-HYCOS] was to be achieved." He recommends (Rhebergen, 2010, p. 8) "that a SADC-HYCOS Phase III Project is formulated with the main outcome a sustainable and independent SADC-HYCOS organization, owned by the member countries."

In summary, the SADC-HYCOS has achieved moderate success. It has assisted many of the participating countries in acquiring new technologies at a limited number of sites, has provided some training on these technologies, and has acquired and trained many county representatives on the HYDSTRA data base. The appetite for the new technologies has been acquired and responses to the questionnaires indicate the desire to expand further into this area. To do so requires additional internal and external funding and further attention to capacity building of the NHSs as opposed to sole reliance on training initiatives.

At this juncture it is not possible to evaluate the effectiveness of transmission technologies, instrumentation, and the use of HYCOS data in routine forecasting services and water resources management. However, responses from questionnaires indicate that the low deployment rate of equipment and the state of disrepair of those deployed would make it difficult to allow the use of data for specific outcomes.

5.3.2 Pacific-HYCOS

The Review Team were provided the 7th Progress Report on Pacific-HYCOS (SOPAC, 2011) and received one response to the questionnaire. Pacific-HYCOS, which spanned 2005-2010, has been completed, but the final report on the project was not yet available for use by the Reviewers.

The 7th Progress Report indicates that the implementation plan was 90% complete. All countries had received the equipment, installation was completed, data base software, and training had been given allowing the countries the ability to commence work on attaining the major project components. There are 6 major components including; flood forecasting; water resources assessment in major rivers; water resources data bases; drought forecasting; groundwater monitoring and assessment; and water quality monitoring and assessment.

The report indicates (SOPAC, 2011, p. 6) that "ongoing technical assistance especially on the ground is still highly essential as well as capital and finance resource support for the NHS's." The report indicates that "the NHS's generally remain seriously under resourced, many still do not have transport, water resources are only assessed in part, and floods are not being measured... Recurrent resources severely limit the NHS mobilisations to the field to measure this essential information, even for small floods."

With respect to the ability to produce flood forecasts and warnings, SOPAC (2011, p. 7) reports that "ongoing institutional, resourcing, capacity and communication issues... have precluded any effective flood monitoring or warnings to be generated to date.... For many NHS's, it is taking some effort to maintain a basic two or three station pilot system for water resources management." It also reports (SOPAC, 2011, p. 22) that "a concerning issue is that not one PIC NHS [Pacific Island Country National Hydrological Service] has a professional hydrologist on staff... During missions the commitment shown by many of the NHS staff is very good, where they work to get the job done, however all too frequently when HYCOS staff departs the country, impetus is lost and the recommended program of tasks, ongoing field work and skill consolidation falters or stalls completely."

The report indicates that it is finding it difficult to make even modest progress as the project draws to a conclusion on post-project sustainability as this was not identified in the project design. The report (SOPAC, 2011, p. 25) holds little hope to the

success of mitigation measures to overcome the perceived deficiencies, as "any mitigation measures embarked onto to date have not borne fruit." Efforts to convince NHS management of the need to have a much higher level of sustained support, project ownership and resourcing have been unsuccessful. The report suggests (SOPAC, 2011, p. 29) that "other avenues of support... need to be investigated to support HYCOS initiatives until the NHS's are in a stronger institutional position."

One country responded to the questionnaire indicating the project was helpful in reequipping gauging sites with new equipment, in particular deploying data loggers for water level and rainfall rates, accompanied by training in data management. The respondent indicated positive experience with the hydrological data base software, TIDEDA, with the software having a built-in quality management system to manage data from the field to the office. The respondent also noted that the NHS had no experience with telemetry to obtain real or near real time data, and that data exchange could not occur as the country's project manager would not allow staff to visit the loggers to download the data, although transportation and personnel were available. Additional training in the use and programming of data loggers would have been helpful, given the turnover of experienced staff. Suggestions for mitigation include setting up regional seminars and workshops to allow dialogue on data exchange and sharing information. It was also thought to be helpful if the WHYCOS programme could become more involved in the provision of technical advice on improving the hydrological network and in data collection practices.

Based on the 7th Progress Report, the outlook for long-term sustainability of the investment is rather bleak. It is evident that countries are not providing sufficient resources to allow attraction, retention and development of technical staff. Maintenance of sites, measurements to calibrate rating curves, and the need to physically download data necessitate site visitation, yet it is doubtful sufficient visitations will be possible unless additional financial resources are provided to the NHSs. Project implementation without a clear plan for sustainability for the post-project or project maintenance stage is short-sighted.

5.3.3 Niger-HYCOS

A draft project evaluation report (STUDI, 2010) has been prepared for Niger-HYCOS and indicates that the Niger-HYCOS project has allowed the Niger Basin Authority (NBA) to put in place, for the long term, a water resources information system for the hydrological network of the Niger River basin. Funding has allowed upgrades in internet provision to all NHSs and the NBA, the purchase and installation of new monitoring equipment and data base software, HYROMET, which has also been applied at the national level and as a regional hydrological information system. Efforts have also been made to undertake stream flow measurements, useful for calibration of rating equations.

The project also has allowed the NBA to distribute to all NHSs on a regular basis publications that assist decision making. Funding has also allowed the development of a preliminary forecast information system. The report indicates that there has been a rather uneven adoption of the software system by each country. One country, for example, has not adopted it for use, although it is running on a server in an office of the NHS, with the most recent data being several months old, as compared with the NHS' operational software system running on a separate computer, wherein the data were much more up-to-date. As well, the report indicates that not all countries are

fulfilling the requirements of the agreement to make near real time data available to the NBA, nor are measurements being taken that conform to agreed upon standards.

The evaluation report also noted that the human resources engaged to implement the project were insufficient, particularly from an accounting and project evaluation perspective. As well throughout the period of the project, there was a large turnover of personnel at various levels within the NHSs, the NBA and the donor. This large degree of turnover caused delays in the approval of the annual work plan and the overall management of the project suffered as well.

The report also made some observations regarding issues with training. It was apparent that people nominated by their country did not always possess the requisite knowledge for the training program. As well, the same participants partook in a number of classes. It was also observed that a number of participants from NHSs were around 50 years old, where many countries have a retirement age of 55. The report suggested that the PRC approve all candidates nominated for training by the NHSs to avoid a repetition of the previously mentioned problems.

It was concluded that the long-term sustainability of the institutional advances made from Niger-HYCOS would be greatly assisted by additional human and financial resources being made available to the NBA and the NHSs, and by increasing national and regional planning. The report also makes recommendations for the next phase of the project.

Two responses to the questionnaire were received, one from a NHS representative and one from the NBA. As well, both Lead Reviewers visited the NBA and met with three NHSs in the Niger basin. The responses indicate that the objectives of the project were approximately 90% met, with the HYCOS project being very supportive to the NHSs and assisting them in strengthening their observational network. Of the planned 105 gauging stations, 103 were created or brought back on-line, with 39 of these being equipped with DCPs having real or near real time communication ability. Some difficulties were encountered in mobilising donor funding within the countries.

One responding NHS reports a "very high" number of requests for hydrological information from researchers, students and for projects. The NBA indicated that data are available and accessible for all users who make a request to the Executive Secretary of the NBA. As well, a website has been developed to allow users the ability to graphically view the data and hydrological products, with these being accessible at <http://nigerhycos.abn.ne/portal>.

The NBA is receiving data from approximately twenty real-time sites, while data from additional stations are received on a monthly basis (human observations). The NHSs have encountered problems maintaining the new technology due to vandalism, problems of maintenance, and lack of availability of spare parts. Data can be acquired from operating DCPs and are transferred to the data base, with data being made available through the website for the project. One NHS indicated that the HYDROMET software did lack some functionality, such as the ability to publish annual summaries of data for a site for the yearbook. The NBA noted that the HYROMET software has been modified several times at the request of various users. Since 2007, the number of requests has diminished considerably.

Suggestions for improving the use of data collected by stakeholders include adding functionality to the project's website and funding more field trips. As well, some felt that use of GSM would be better than the current approaches used for data transmission. However, the NBA has tested GSM and has had problems with its use

depending on the local service provider. Problems also exist regarding the calibration of rating curves, as the curves for many sites are impacted by the river's mobile bed. Additional effort will be required to better understand the phenomena and how to make adjustments to the rating curves to reflect the mobile bed, thereby increasing the quality of the estimated discharge.

During Phase I, the NHSs received ADCPs, and these are being routinely used in the discharge measurement programme. When interviewing one member of a NHS, it was mentioned that no formal training on the use of the ADCP had been given, yet the instrument was routinely used. Certification of individuals on use of ADCPs should be required before allowing their use to obtain field measurements.

The NIGER-HYCOS Phase II commenced December 2010, with the objectives of the collection and treatment of data from a number of sites, regular updating of the regional data base, and the publication of monthly bulletins. It is envisaged that the forecast information system will be improved and will provide forecasts having different horizons that will be useful to a variety of users from hydro-electrical producers to irrigation for agriculture.

In closing, the respondents to the questionnaire felt that WMO plays an extremely important role as supervising agency. It was mentioned that WMO should take a more active supervisory role in the HYCOS project and should undertake missions to supervise activities and to directly evaluate progress, not basing its views on project activity reports.

When the Lead Reviewers visited the NBA and the three NHSs, they were told that human observers continue to be used at almost all sites, except one, where the new technologies have been deployed. As well, it was evident that at least one NHS was not using the near real time data available within the office, but rather was using the readings as supplied by human observers. Given the degree to which the sites with new technology fail to report and the associated costs to maintain the technology, the desire to continue with human observers is understandable. This duplication of effort calls into question the motivation for investing in modern technology. Why invest in modern technology if human observers are available and provide reliable data in a fashion sufficient to describe the hydrological conditions of importance. Based on discussions and for the time being (until wages surpass the cost of adopting and maintaining the new technology), the cost of human observers is currently less expensive than the cost of the maintenance and recapitalisation requirements of the modern equipment, which challenges the technological model that has been forward by the WHYCOS programme in such a river system.

5.3.4 Carib-HYCOS

The Project Document (WMO, 2009a) provides detail on the project's objectives and describes its 3 components as: 1) Disaster mitigation, comprising a) Flood forecasting and warning and b) Drought forecasting; 2) Water-related knowledge base, comprising c) Water resources assessment, d) Groundwater assessment and monitoring, e) Water quality assessment and monitoring, and f) Water resources data base; and 3) Regional cooperation. The funding requirement for the project was estimated to be 3,560,000 Euros (WMO, 2009a, p. 26), while available funding was established as being 2,091,000 Euros (Conseil Régional 250k€, Conseil Général 540k€, FEDER 50k€, IRD 800k€ (in-kind), and Member Countries 451k).

Delays in project initiation were reported due to the amount of time required to finalise agreements and administrative complications. It is not anticipated that all objectives will be achieved due to the decreased budget obtained for the project. The main focus will be on acquiring the hydrological monitoring equipment, its installation, implementation of the HYDROMET data base, and all associated training. A workshop on rainfall-runoff modelling is anticipated to be held in April 2012, with an emphasis on small basin models.

Thus far, the HYDROMET data base has been installed in the 11 participating countries and associated training has been provided, with additional training planned. The Project Management Unit is ready to proceed with equipment purchase, once the tendering process has been completed. Installation is anticipated to take place in early 2012, while project completion is for later that year. This represents an extremely tight timeline to achieve the desired outputs.

One Lead Reviewer visited the Project Regional Centre and met with the Project Management Unit in IRD, Martinique. Meetings were also held with representatives of Météo France, Conseil Général, DEAL and IRD. The Lead Reviewer also met with representatives of CIMH and the Barbados Water Authority in Bridgetown, Barbados. As well, three responses to the questionnaire were received related to this project.

In general, the participants indicated that the project document accurately reflected the pressing needs of the countries. There seemed to be agreement, due to decreased availability of funds, with focusing efforts on acquisition and installation of hydrological monitoring equipment and installation of the HYDROMET data base, as well as the provision of all associated training. There also was the view that efforts need to be made, as much as funding permits, on advancing the flood forecasting and warning capabilities.

Concern was expressed on a few fronts. One is the desire to have more regular communications between the Project Management Unit with the project's participating countries, so that the countries would be kept more informed on the status of various initiatives, such as the results of the tendering process, when installations may be occurring, and when and what training was being planned. To date, countries seemed appreciative of the data base software and the training received, and they felt that more training would be required to become proficient in the use of the software and its integration into the operations of the NHSs. There was also concern that the HYDROMET software may require additional functionality to be able to respond to the NHSs need for ground water and water quality monitoring, which is a significant portion of the project plan.

Respondents to the questionnaire were not able to address many questions as the countries have not yet received hydrological equipment and could not address the adequacy of the equipment, data transmission and other such related features. It was pointed out in the responses that sustainability seemed to have been overlooked, particularly with regards to maintaining equipment and ongoing training. An approach suggested to confront this issue was aligning an additional project with funding coming on-line to dovetail with the completion of the existing project. Suggestions were made that future projects be focused on the production of value-added products and services. These would include, but not be limited to, hydrological forecasting (floods, droughts, water availability) climate change assessments and adaptation, agricultural climate products and drought indices/products, products to assist in the recreational use of water resources, and tools and products to assist in water resources management. Some revenue generation to offset the cost of maintenance may be possible through the sale of value-added products and services. As well,

clearly demonstrating the value of the data and products might help convince some governments to commit additional resources to the sustainability of the network and new products.

This HYCOS component has two features of interest. First is that it represents the desires of small island countries to work together to further common interests, noting that most islands are separate countries and as such do not have transboundary watershed management issues. Second is the complication of having at least three main languages among the islands, namely English, French and Spanish. This second aspect creates special challenges, as there has been little traditional technological exchange among the three cultures within the region, although inroads have been made in meteorology for the sharing of radar data and forecasts.

5.3.5 Mekong-HYCOS

A detailed current status report was provided by the Mekong River Commission (MRC) to the Lead Reviewers in response to the questionnaire (Annex IV). The Mekong-HYCOS implementation has four phases, which are described in detail in the Project Document (WMO and MRC, 2005). These are: mobilisation, inception phase, construction and installation phase, and finally follow up and maintenance phase. The main objective of the Mekong-HYCOS project is to establish an efficient, reliable and accurate timely hydrometeorological data collection and transmission system at the basin level, while also strengthening relevant national and regional capacities.

The **mobilisation phase** started in 2006 with input of Technical Assistance from CNR/IRD. The **inception phase**, including mobilisation, lasted sixteen months. This phase included:

- The implementation of the national and regional project's organization and structure including project teams review of activity schedule, establishment of the Mekong-HYCOS Project Coordinating Committee;
- Field visits and final selection of hydrometeorological sites;
- Design of civil works and finishing of the equipment for each station;
- Tendering and contracting; and
- Signature of Memorandums of Understanding (MOUs) on the ownership and Operation & Maintenance (O&M) of the HYCOS stations by the National Agencies.

The **construction and installation phase** started in May 2008, and it included:

- Having the supplier build the hydrometeorological station at each selected site;
- Constructing the civil works at each station;
- Conducting regional trainings and national level training in the four countries;
- Installing and testing of equipment and providing on-the-job training; and
- Commissioning of each installed station by the Project Management Unit and the Technical Assistant from CNR/IRD.

The current status of implementation is listed as follows:

- 49 stations have been installed and upgraded to the same standard for both hardware and software;

- 42 stations are currently working well regarding logging of sensor values, transmission of data, and timeliness; and
- 7 stations are not functioning due to a variety of reasons, such as being damaged by flooding, lack of GSM coverage, malfunctioning wires, and etcetera.

The **follow up and maintenance phase** was planned to occur from January 2010 until December 2011. The objective of this phase is to assure proper running of the stations and to train local staff to make the project more sustainable. This phase has now been extended to March 2012.

Currently 42 of the 49 installed stations are operational. For instance, during the month of August and September 2011, the rate of valid hydrological data being received from the stations exceeded 96%. This high rate is indicative of an effective system that has been properly installed, and this compares very favourably with the other HYCOS components. The adequacy of the instrumentation is good. However, additional water quality sensors to monitor more parameters would increase benefits from the system.

In addition to the HYCOS project and its associated activities, there is a complementary project underway termed the IKMP project that is undertaking an intensive programme of discharge measurements and sediment samples at various gauging station locations of the MRC. These measurements are going to be used to establish updated stage discharge rating curves. ADCP and conventional mechanical current meters are being used to measure the discharge rates.

With regards to sharing of hydrological data and information at the regional level, staff of the MRC and the participating NHSs has free and unrestricted access via their portal accounts.

Some of the challenges faced became evident after the stations were commissioned. According to the MRC's Project Management Unit, some of the technical operational difficulties encountered included problems with the GSM coverage at some stations, where signal is weak, requiring replacement of the installed antenna with a larger one. As well, it was found that battery connections corrode, both near the sea and inland. This significantly shortens the life span of the battery, therefore requiring more maintenance visits to the gauging stations. As well, some civil works on the gauging house and its stairs were damaged by high water events. Mitigation measures in future would be more accurate checking of signal strength while conducting site selection visits, thereby allowing a more appropriate design of the data transmission system. The PMU is investigating if measures can be taken to reduce the corrosion of the battery terminals. As well, MRC is looking at redesigning the construction standard and site selection criteria due to the damages sustained at some sites from flooding.

6. THE FINDINGS

6.1 Analytical Framework

The Terms of Reference (Annex II) provides specific direction to the Lead Reviewers to assess the performance of completed phases of and sufficiently advanced HYCOS components (Terms of Reference, item 3). Section 6.2 provides the assessment of performance of the HYCOS components.

6.2 Assessment of Performance

The assessment of performance is based on available reports (see list of references), responses to questionnaires, interviews conducted by the Lead Reviewers, and discussions that were held with a variety of individuals from regional centres, NHMSs, project managers and coordinators, and other individuals associated with the WHYCOS and HYCOS initiatives. Lead reviewers also had valuable assistance from the associate reviewers in the evaluation of performance. Specifically the Lead Reviewers were instructed to assess:

- (a) the effectiveness of hydrological data transmission and hydrological information systems;
- (b) the adequacy of instrumentation, telecommunication and data management systems;
- (c) the integration of HYCOS data in routine forecasting services and water resources management, as appropriate;
- (d) access to HYCOS data and data sharing at regional and global levels;
- (e) the types of data collected and the quality of these data; and
- (f) the effectiveness of the Project Regional Centres (PRCs).

Effectiveness as used above has been taken to imply whether the data: are transmitted in a timely manner; are readily available from the data base; are of good quality. Adequacy as used above has been defined as whether the instrumentation is fit for purpose and the operating environment, and whether the systems are operational and being well maintained.

The following two rating guides were developed to assist in the assessment. The first is the view of the Reviewers (RV) as a measure of their confidence in being able to assess the criteria. The rating is from 1 to 5 using the following scale:

- 1) very poor confidence
- 2) poor confidence
- 3) average confidence
- 4) good confidence
- 5) very good confidence

The second scale is the Reviewers assessment of the criteria (RA), using the following rating guide:

- 0) unknown
- 1) very poor
- 2) poor
- 3) average
- 4) good
- 5) very good

An overview is now provided of the assessment. Only two HYCOS components are evaluated, as Lead reviewers had little to no information on the evaluation of other completed HYCOS projects. One other project, namely the Pacific-HYCOS should have recently been completed. However, the Lead Reviewers only had one progress report (SOPAC, 2011), which was insufficient to perform the assessment. There are other HYCOS components that are in the process of being implemented. As such,

their state of implementation does not allow an effective assessment of performance as described in the Terms of Reference.

Table 2: Assessment of Performance of HYCOS Components

Assessment Criteria	HYCOS Component	
	SADC Phase II (RA, RV)	Niger Phase I (RA,RV)
1. Timely transmission	2, 4	5, 5
2. Data in National Data Base	3, 3	4, 4
3. Data in Regional Data Base	4, 5	5, 5
4. Quality of data	1, 4	2, 4
5. Instrument fit for purpose	2, 4	2, 4
6. Operational state / maintenance	1, 4	2,4
7. Data usage	1, 4	4, 4
8. Data exchange - regional	1, 4	3, 4
9. Data exchange - global	1, 4	3, 4
10. Stage quality	2, 4	2, 4
11. Rate of rainfall quality	0	2, 4
12. PRC effectiveness	4, 4	4, 4

Regarding timely transmission of data, in almost all cases, timely transmission, if stipulated in the project design, has been accomplished, with very few exceptions. The concern with transmission is that the a large number of sites are actually failing to report, due to possible equipment disrepair (lack of maintenance) or vandalism. The rating does not reflect on the appropriateness of the transmission technology employed in the project. This is an entirely separate issue, and the Reviewers have not been provided the technical documents to allow an assessment of possible communication approaches for each site. Note the implication is that the same technology need not be used for each site and should be site specific, based on a variety of factors that should be considered, including power consumption of instrumentation, ease-of-use, and procurement and maintenance costs.

Reviewers had information upon which to base their assessment of the Niger and SADC initiatives, as Lead Reviewers performed site visits of the Niger and associate reviewers had in-depth knowledge pertaining to SADC-HYCOS. This reflects the similar confidence the Reviewers had for the assessment criteria.

The reviewers had little information upon which to base the transference of data into the national and regional data bases, particularly for SADC-HYCOS. However, based on responses to the questionnaires for SADC-HYCOS, it was evident that at least one country had not received the new data base software system, as well the new equipment associated with the project had not been installed. Rhebergen (2010, p. 25) noted only 6 of 13 installed DCPs were either not sent or not installed. A low assessment of timely transmission was accorded due to the low number of the planned DCPs that are actually reporting in a timely transmission. Reviewers were also aware that at least one country in the Niger-HYCOS component was not actively using the HYDROMET database, as it was not being used as the "national" data base. Data from the new equipment were not being regularly updated and were well out-of-date, as compared to the national data base that relied on manual gauge readings, which was up-to-date. Reviewers were shown the regional data base when

visiting the Niger Basin Authority, while one associate reviewer had viewed the regional data base for SADC-HYCOS. In 2010, the system was functioning, but few countries were contributing data to it at that time.

In both SADC- and Niger-HYCOS, Reviewers expect that the quality of the derived stream flow data is of poor quality. It appears that little attention has been given to taking measurements of discharge to establish and validate the rating curve. Reviewers were also made aware of the problems associated with rating curves on the Niger River due to its mobile bed, which can negatively impact on the quality of data, even when an intensive stream flow measurement programme is implemented.

Reviewers have no specific information as to the type of equipment that was purchased and installed in the SADC-HYCOS Phase II. Mention was made in one evaluation report that indicated that the equipment purchased under SADC-HYCOS Phase I had to be replaced under Phase II. The reasons for the need to replace the relatively new equipment were not specified.

It is evident from the small proportion of sites reporting data that maintenance is an issue. Vandalism is also an all too common occurrence. Interviews and associate reviewers confirmed this to be the case, and it is documented in reports.

HYCOS components usually have a number of objectives that comply with those listed in the WHYCOS Guidelines (WMO, 2005b). These usually are focusing on the provision of real or near real time hydrological data and in strengthening the ability to provide early warnings of potential flooding, while others are also listed. Typically it would appear that there are administrative issues that delay the commencement of the project and shorten the amount of time and possibly funds that can be brought to bear on the objectives as deemed important by the NHSs participating in the project. As a consequence, those implementing the project must make modifications so that the items of highest priority to the countries can be accomplished.

The trend is that equipment is purchased, hydrological software (the base data) is acquired, and training on instrumentation, installation, maintenance, the data base software and other related topics is provided. Typically a number of items suffer as a consequence. These include, but are not limited to, a reduction in the amount of training provided, a reduction in the amount of equipment that can be purchased and installed, and a reduction in the objectives that can be attained. Normally it is the value added products that were to have been developed that do not get attention in the re-profiled project. Unfortunately, this has a usually unforeseen consequence that affects the overall long-term sustainability, as the development of value-added products and services has been jeopardised.

In SADC-HYCOS the value-added product develop such as flood forecasting and warnings were not developed. In Niger-HYCOS, efforts have been undertaken to develop a hydrological prediction system, and improvements must be made to the methodologies used therein, prior to its being operational. The Niger-HYCOS component is also making strides forward publishing monthly water bulletins, and other hydrological products are being made available on the Niger Basin Authority website.

Data exchange remains an issue at the policy level. The WHCOS policy is to follow Resolution 25 (Cg-XIII), which is a flexible policy that allows each country to decide whether it will exchange data or not. Hence, countries are not obligated even when participating in a HYCOS component to actually share data within its borders or beyond. In the Niger basin, it is the Reviewers understanding that countries have

agreed to share data with the Niger Basin Authority, but countries may maintain restrictions on transference of data to other countries even within the basin. The Niger Basin Authority and many countries do not make the data readily available on the web, but rather will respond when a written request is received. This restriction on sharing data is not just for the Niger basin, but is a rather broad practice in various regions of the world. The reviewers have some information on the restrictions placed on the exchange of data in SADC, which is not positive. Reviewers have received suggestions that this is an area where WMO should be playing a much more active role, particularly when there are HYCOS projects being considered in a group of countries. It is the opportunity to ensure the free and unrestricted access to data from at least the HYCOS sites. WMO should be taking a much more proactive role in advancing the exchange of data through the WHYCOS programme and its HYCOS components and in tracking the state of the exchange of data within the WHYCOS programme and globally in general.

The reviewers rated the quality of stage data as being poor for Niger-HYCOS, with SADC-HYCOS assessed based on input from an associate reviewer. The poor score was ascribed due to the low maintenance and infrequent site visits. Corrections to stage readings cannot be accurately made if water level checks are not made during site visits to a known datum. It should be noted that although the rating was poor for the region, some countries scored high and are making conscious efforts in this regard. Rate-of-rainfall data are even more questionable when site visits are infrequent, as debris can easily accumulate in the funnel and make recording of rate-of-rainfall inaccurate. Given most stations also have human observers taking manual readings, it may be possible for the NHSs to have these individuals keep the tipping bucket rain gauges free of debris, so that readings are more reliable. As well, it seems to be common practice that precipitation measurement instruments are not installed to standards and have obstructions/shadows.

In both cases analysed, the Project Management Units were effective. Other functions accomplished within the Project Management Centre (the building) by other groups were also effectively accomplished. The managers and staff should be complemented on the efforts undertaken, given the arduous tasks at hand. Projects involving administrative delays, reduced funding levels, the complications of working with international and many national organizations can pose many challenges. It has been noted in various sources that greater effectiveness could have been attained by having increased human resources dedicated to the units. It should be noted that increased effectiveness could have been attained by simplifying the management/organizational structure implementing the project (i.e., reporting requirements were duplicative and heavy, having separate units at the PRC and the PMU). Concern also remains on how to maintain a level of support from the expertise pool once the project has been completed.

7. WHYCOS Relationship with the WMO INTEGRATED GLOBAL OBSERVATION SYSTEMS (WIGOS) and WMO INFORMATION SYSTEM (WIS)

7.1 Introduction

The Terms of Reference (Annex II, item 5) provides specific direction to the Lead Reviewers to explore and suggest means of ensuring the efficient relationship of WHYCOS with other relevant initiatives and international programmes, especially its integration with the WIGOS and WIS. This chapter provides a brief overview of the

WMO Integrated Global Observing Systems (WIGOS) and WMO Information Systems (WIS) initiatives, the WIGOS Development and Implementation Plan (WDIP), and the SADC-HYCOS pilot project as part of this plan. Some observations are made that could assist in the integration of the WHYCOS programme with the WIGOS and WIS initiatives.

Over the years, WMO has organised and fostered the creation of global observing networks and systems supporting a wide range of applications such as weather prediction, climatology and hydrology serving climatologic, environmental, aeronautical, marine, agro-meteorological, hydrological and water resources applications, among others. It is understandable that many of these observing networks have developed rather independently with considerable duplication and potential redundancy and differences in system standards, management practices, and in support mechanisms, such as facilities and programs for calibration inter-comparison.

Cg-XV (WMO, 2007) agreed that enhanced integration between WMO observation systems should be pursued as a WMO strategic objective. It was noted this would generate important benefits for WMO members, their NHMSs, and for the organization as a whole.

7.2 Concept

There is a broadly recognised need for a comprehensive, coordinated and sustainable system of global observing systems. Many international agencies have to administer systematically similar diverse sets of observations and have developed data policies to meet their needs. WIGOS is the organisational response of WMO to this need; and therefore it is committed to the very strong cooperation that is needed among all partners to accomplish these broad objectives. In order to achieve its goals WIGOS has developed a WIGOS Development and Implementation Plan (WDIP) to allow a logical transition from initial to full operational capabilities.

WIGOS is based on all WMO programmes' observational requirements. It insures availability of required data and information; and it facilitates access through the WMO Information System (WIS) according to identified temporal, geographical and organisational requirements, including those for real, near real-time and delayed modes to all required information. In doing so, it respects all data sharing policies. The surfaces and space-based components of WIGOS include: weather observing networks (e.g. WWW/GOS, AMDAR, ASAP, etc); atmospheric observing networks (e.g. GAW); radiation observing networks (e.g. BSRN); hydrological observing networks (e.g. observing components of WHYCOS etc); and the various atmospheric hydrological, oceanographic and terrestrial observing systems contributing to the Global Climate Observing System (GCOS).

WIGOS development and implementation will proceed in parallel with the planning and implementation of the WMO Information System. The combination of both efforts will allow for an integrated WMO end-to-end system of systems designed to improve members' capability to effectively provide a wide range of services and to better serve research programme requirements.

The concept of WIGOS is based on the premise that the general standards and recommended practices, as agreed-upon for WIGOS, will apply to all WMO and

sponsored observing systems and programmes. All WIGOS observational data metadata and processed observational products will:

- Be exchanged via WIS using agreed upon data and metadata representation forms and formats;
- Use WIGOS compatible hardware and software;
- Adhere to WIGOS standards for instruments and methods of observation as well as standard observing network practices and procedures ; and
- Be archived in WIGOS approved forms.

As a system of observing systems, integration will be accomplished at three levels. These include:

- Standardisation of instruments and methods of observation;
- Common information infrastructure, (WIS data level); and
- End-product quality assurance.

7.3 Purpose

The purpose of WIGOS is to provide the effective and sustainable organisational, programmatic, governance and procedural structures that will significantly improve the availability, usefulness, quality and use of observational data and products through a single focus for the operational and management functions of all WMO observing systems, as well as providing a mechanism for interactions with WMO co-sponsored observing systems.

7.4 Objectives

WIGOS will provide the opportunity to better make use of existing and emerging observing capabilities, thus facilitating any required changes over time. In particular, it is expected that WIGOS will:

- Develop strategies to guarantee systems interoperability, including meeting documented standards for data quality of observing systems and instruments;
- Evaluate existing and emerging capabilities before developing, acquiring, and/or deploying new observing systems or sensors, and in the design of cost-effective composite observing systems;
- Develop strategies to satisfy observing requirements of WMO programmes and international partners through the WMO RRR process;
- Develop a strategy for the production, editing and management of metadata, including instrumentation/platform and data discovery;
- Promote exploitation of existing platforms and employment of the multi-sensor platform concept to the maximum possible extent; and
- Coordinate the response to requirements, plans and activities with all WMO technical commissions, regional associations and programmes.

7.5 The WMO Information System (WIS)

The WMO Information System will:

- be used in the collection and sharing of information for all WMO and related international programmes;
- provide a flexible and extensible structure that will allow participating centers to enhance their capabilities as their national and international responsibilities grow;
- be implemented building upon the most successful components of existing WMO information systems in an evolutionary process;
- be developed paying special attention to a smooth and coordinated transition;
- be based on a communication network building on communication links used within the world weather watch (WWW) for distribution of high priority real-time data; and
- use international agreed-upon standards for protocols, hardware and software.

7.6 Initial WIGOS Development and Implementation Plan (WDIP).

The WIGOS preparatory phase had been completed. Four implementation phases until end of 2011 are under implementation. While an overarching WDIP will be the crucial center piece of the planning and implementation of WIGOS, Cg-XV (WMO, 2007) felt that undertaking at the earliest possible stage several WIGOS pilot projects would be useful to address major issues in the integration process and would help in elaborating the WDIP. Pilot projects will emphasise the role and contributions to be made by the technical commissions. The technical commissions identified five pilot projects. One of them is the project "Initiation of Global Hydrological Network Addressing a GCOS Requirement." Following this, the Hydrological Cycle Observing System for the Southern African Development Community (SADC-HYCOS) has been selected as one pilot under the supervision of Commission for Hydrology.

7.7 SADC-HYCOS Pilot Project

The SADC-HYCOS and the Southern African Region Flash Flood Guidance System (SARFFGS) are integrated as one of the pilot projects under WIGOS/WIS, under supervision of the Commission for Hydrology (CHy). The general purpose of this pilot project is to develop a tool that improves the effectiveness of both the SADC-HYCOS project and the SARFFGS, by means of the integration of the flux of real time data from the SADC-HYCOS project, the SARFFGS products which are time sensitive and the products generated by numerical weather prediction from the Severe Weather Forecasting Demonstration Project. Such opportunity will offer a show-case of the WIGOS/WIS, as far as the hydrological aspects are concerned.

It is expected that the integration of SADC-HYCOS and SARFFGS will provide a standardized platform for provision of information for developing flash flood guidance and flood forecasting and warning services for several river basins in the SADC Region. The SARFFGS products, which are time sensitive, will be part of WIS and should be distributed to all NMHSs for further dissemination.

The objectives of the pilot project will be complimented with those of the Zambezi River Basin Flood Forecasting and Early Warning project, whose implementation started in July 2009. A regional consultation meeting for the project was organized from 1st to 5th December 2009 in Maputo, Mozambique as the first activity of the project and part of the meeting was dedicated to the development of WIGOS/WIS Pilot Project and to identify potential contribution from other major projects in the region.

The development of the pilot project will take the following issues into account: identifying data links among participating centers; standardising equipment and data formatting, processing and transmission; searching the existing Zambezi Water Information System in order to prevent duplication, if applicable; introducing FFGS products that are time sensitive as part of WIS, and distributing them to NHMSs for further dissemination; exchanging experiences to improve communication and dissemination of data and information; improving forecasting skills; preserving skilled personnel; acquiring updated forecasting tools; and expanding the data collection network.

7.8 Observations

Some issues will likely need to be addressed by the WHYCOS programme for the successful implementation of WIGOS/WIS initiative. These are:

- The bottlenecks identified in the pilot project of the SADC-HYCOS are very likely to happen in other river basins and HYCOS applications.
- The WIGOS/WIS requirements must be met by every HYCOS component if the full fledged global WIGOS/WIS initiative is to be successfully implemented for the WHYCOS programme.
- A second pilot project involving another regional HYCOS component would likely identify additional problems that need to be taken into consideration for the successful implementation of WIGOS/WIS initiative at the global level. Therefore, it would be prudent to add one regionally based HYCOS component as a WIGOS/WIS pilot to identify possibly a broader set of issues that need to be resolved. The second pilot would also help systematise the approaches needed within HYCOS components to conform to the WIGOS/WIS requirements. These approaches should be documented so that they may be reflected and adhered to within all HYCOS components and in the design of future project implementation plans.
- There likely will be a need to revise the WHYCOS Guidelines, some technical regulations, and possibly some standards to make the WHYCOS programme fully compatible with all WIGOS/WIS requirements, particularly on the following three levels:
 - Standardisation of instruments and methods of observation;
 - Common information infrastructure, (WIS Data Level); and
 - End product quality assurance, (Product Level).

As well, during site visits to three regions implementing HYCOS components and in the questionnaires that were completed, there is very little to no knowledge of the WIGOS and WIS initiative, the WDIP, or the pilot project regarding SADC-HYCOS. A lot of effort undoubtedly remains to fully understand and to develop the appropriate linkages and features such that WIGOS and WIS are able to transmit and integrate

data, information and products of the WHYCOS programme, and for the WHYCOS programme to develop the necessary documentation, protocols, procedures and standards and other necessary items to meet the requirements of WIGOS and WIS initiatives. The community implementing HYCOS components should be made aware of the initiatives and also of the requirements to which they may be asked to implement.

8. CONCLUSIONS AND RECOMMENDATIONS

The Terms of Reference (Annex II, item 4) provides specific direction to the Lead Reviewers to make conclusions and recommendations with respect to the future directions of WHYCOS and the individual HYCOS components, including remedial actions, development and sustainability of the WHYCOS programme and its components, and the need for establishing new HYCOS projects. The Terms of Reference (Annex II, item 6) provides additional specific instructions to make recommendations with respect to the future Terms of Reference and Composition of the WIAG. Chapter 8 provides the response on the future directions of WHYCOS, its individual HYCOS Components, WIAG and other matters.

The original concept of the WHYCOS programme remains valid. The intent was to support regional institutions and NHSs in discharging their relevant regional and national responsibilities in water resources management. There is a growing recognition of the need for mitigation to combat the effects of natural disasters such as floods and droughts, and the need to achieve sustainable development (Bruce, 1992). The WHYCOS programme allows the strengthening of the capacity of NHSs such that countries can more effectively respond to the needs of its citizens and the environment. The WHYCOS programme also provides an effective mechanism for bringing donors and recipients together to achieve success for the common good.

The WHYCOS programme basically has two prongs, one to strengthen the regional institutions and NHSs' abilities to acquire and share hydrological data, and the second to strengthen their capacity to develop value-added products and services from which outcomes and societal impacts are derived. There is a symbiotic relationship between collection of data and its use that allows the generation of benefits to accrue. Without data, benefits cannot be derived. Without value-added products and services, benefits cannot be attained, nor is valorisation made of the collected data.

Most efforts to date with the WHYCOS programme through its HYCOS components have been directed to the first prong, with little attention being given to the second, for a variety of reasons. It seems to be a regular occurrence that there are delays in obtaining all of the necessary agreements to commence implementation of the HYCOS component. The delays usually results in a shortening of the timelines afforded the implementing agency. This is most detrimental to achieving the objects of the WHYCOS programme and the specific HYCOS component. On occasion, the budget acquired from donors and other sources has not met the financial requirements of the detailed project document, requiring re-profiling of activities within it. Not surprisingly, the re-profiling of the component usually results in attention not being given to training and education as well as achieving outcomes through value-added product development.

Experience through the application of HYCOS components has also been acquired, with the stark realisation that sustainability of the investments made are in jeopardy of being either lost totally or reduced quickly over time. Member countries in many

cases do not seem willing to invest the human and financial resources necessary to maintain the initial investments made principally by donors. Some have argued that this might be due to the little derived benefits attained from the almost singular focusing of the component on acquiring data. If countries were able to see the derived benefits of timely warnings of pending flooding, were better able to increase food supply and more effectively implement irrigation, and make better use of its water resources, the countries may find it in their interests to make the additional investment. Nonetheless, the WHYCOS Guidelines stipulates (WMO, 2005b, p. 6) that "there must be committed long-term national participation in WHYCOS and participating countries should ensure the sustainability of HYCOS components." This is clearly not occurring in many cases.

Experience has also illustrated that implementing a project without a clear plan for sustainability for post-project maintenance is short-sighted and likely will lead to a rapid loss of the donor's investment. Measures must be taken before the commencement of the field implementation stage to reasonably ensure sustainability of the planned investment. The country's commitments should cover both the Project implementation stages and the Post-project stage.

It is apparent that for various reasons the priorities of individual NHSs are not always reflected in the project concept document, and NHSs are typically not fully engaged in project implementation, a possible negative reflection on the implementation process described in the detailed project document. Without being engaged, ownership of new HYCOS sites or refurbished existing sites is less likely to occur, and sustainability of outputs and outcomes will be doubtful.

It has become clear from the fact finding that there are systematic problems that persist from HYCOS component to HYCOS component and also exist within the WHYCOS programme. It is rather troubling that many of these issues have not been addressed over time. These include: the rather lengthy delay in obtaining the necessary agreements so that implementation can commence, thereby at times shortening the implementation period; the need for new tendering processes for equipment and software purchases for every HYCOS component -- not having an "international approved list of equipment and software" nor having an "international standing offer" on items within the approved products list; several recurring problems with implementation of training; the lack of a capacity building plan and the inability to broaden the concept of capacity building for NHSs within HYCOS components; and the lack of quality assurance of data that should be addressed through the implementation of a Quality Management System by participating NHSs.

There has also been an inability to take advantage of opportunities that broaden the utility of the WHYCOS programme into the domain of outcomes through value-added products. The WHYCOS concept has not fully embraced within capacity building the concepts of institutional, organizational, and human resources development, but has almost entirely concentrated on equipment and software acquisition and associated skills development. At the same time, there has been a strong tendency to have administrative delays occurring usually resulting in the sacrificing of the development of value-added products within the HYCOS components. More effort is required to fast track administrative arrangements so as to not impede the success of the HYCOS components.

It is common that the detailed project documents identify a number of objectives to be undertaken, such as: enhancing natural disaster mitigation capabilities through the provision of flood forecasts and warnings; strengthening water resources management capabilities; developing technological capabilities by promoting

institutional capacity building; and promoting the exchange of information, technology and experience by developing hydrological data bases and organising seminars and workshops. When the document is analysed in-depth and evaluations are undertaken, it is usually observed that the majority of effort has been directed to the implementation of advanced hydrological monitoring systems and associated data bases and training, with little attention paid to the value-added products required to attain many of the objectives. WMO, National Hydrological Services and donors need to embrace much broader approaches to strengthening the capacity of the National Hydrological Services within the WHYCOS programme and its HYCOS components.

Evolving Concept of WHYCOS/HYCOS

Recommendation 1: *The concept of WHYCOS needs to further evolve to make operational, within its HYCOS components, institutional, organizational, and human resources capacity development to allow the attainment of sustainable outcomes and societal impacts.*

Recommendation 2: *The concept of WHYCOS and its HYCOS components be designed to give adequate attention to achieving outcomes, such as the provision of water resources assessments and flood forecasts and warnings, and not solely outputs such as the acquisition and distribution of hydrological data.*

Recommendation 3: *Agreements with each country should be signed at the highest levels clearly defining the financial and human resource commitments of the country towards the project implementation and post-project stages of the component. Such an agreement should be made before commencement of the field implementation stage to ensure participation of the country and long-term sustainability of the investment. If such an agreement cannot be satisfactorily concluded, then the implementation stage should not go forward.*

Recommendation 4: *All project stages, namely the Project initiation stages, the Project implementation stages and the Post-project stage, should maximise, to the practicable extent possible, the engagement of NHSS' personnel in the development and implementation of all activities.*

WMO Institutional Aspects

As "owner" of the WHYCOS programme and as supervising agency on HYCOS components, WMO should carefully monitor and ensure common pitfalls are avoided and mechanisms are put in place to prevent them. This is a large, complex programme that requires staff dedicated solely to the management and implementation of the programme. WMO and WIAG need to increase their focus on overcoming the recurring issues. To do so, WMO as "owner" of the programme and in its supervisory capacity needs to be an active leader as the "real" supervisor or "overseer" of the programme in its entirety. It should be providing technical evaluations and advice on an ongoing basis and has to have subject-matter experts attending HYCOS meetings, thereby increasing the value of advice and assistance in setting direction on how to deal with operational issues of a technical nature.

Recommendation 5: *WMO needs to redefine and reinvigorate its leadership role of the WHYCOS programme and its HYCOS components. WMO should be taking a much more proactive role in providing oversight and technical assistance by increasing its ability to provide advice and guidance on the operational implementation of on-the-ground projects such as HYCOS components.*

Recommendation 6: *WMO needs to create a WHYCOS Office dedicated to the total management of the WHYCOS programme and its HYCOS components thereby focusing Secretariat leadership, having the delegated authority to respond to operational requirements in a timely fashion, and to take advantage of opportunities as they arise. The Office needs to promote awareness of the programme, facilitate donor involvement, and focus on the operational delivery of the programme. The Office may also include a Help Desk on the programme to assist in this process, particularly the provision of technical assistance to NHSs in implementing the components, particularly during the Post-project stage.*

Recommendation 7: *WMO may need to invest in acquiring and developing its staff to be subject-content experts so they can more effectively provide advice and undertake analyses associated with operational aspects of HYCOS components and the WHYCOS programme in general.*

Recommendation 8: *As owner of the WHYCOS programme, WMO should be playing a more significant role in mid-term and final evaluation reports that should also address the state of technical outcomes. WMO should also be undertaking a review of the post project stage approximately three years after completion of the project implementation stages. WMO should be paying more attention to understanding the causes of issues and in preventing their recurrence, particularly if they are common pitfalls.*

The role of WIAG as an advisory body is most important, as it formulates policy, assists in the coordination of HYCOS components, and identifies issues of concern. There is evidence that it has lost its ability to provide advice due to having met only twice in the last eight years. WIAG meetings need to be focused on pragmatic issues with only the necessary people present, noting that the current composition in Annex VI remains appropriate. The last two meetings were held in conjunction with workshops that reduced the amount of time allotted for WIAG to address its core functions and involved a large number of additional people that had participated in the associated meetings. Holding of such meetings, although being positive, are not seen to be conducive to allowing WIAG to fulfil its mandate.

Recommendation 9: *WIAG needs to hold regular meetings comprising only essential participants to be an effective coordinating body and to provide recommendations to the Secretary General on policy and programme development so that the programme can more rapidly respond to issues and be adjusted over time. WIAG, among its other duties, should focus on defining the persistently recurring issues associated with the Project implementation stages and Post-project stage and should assist the WMO Secretariat and its WHYCOS Office in developing strategies and approaches to resolve them. WIAG, through its coordination function, should monitor the development of issues and should assess the effectiveness of the strategies and approaches employed to overcome them.*

The WHYCOS Guidelines were last published in 2005 (WMO, 2005b) and are widely used as they provide detailed information on the WHYCOS programme, its policies and the necessary steps to successfully undertake a HYCOS component. The Guidelines also describe the managerial structure and the roles and responsibilities of the various parties. It would be opportune to review and revise these Guidelines. Revisions to policy and how the overall approach is implemented are needed, particularly to reflect the growing concerns of sustainability of investments. The WHYCOS mission statement should also be revised as should the philosophy throughout the Guidelines that predetermines modern technology is the most appropriate solution that best meets the needs of all participating countries. It also

infers that real or near real time data, which is achievable using the new technology, is required in all cases. As well, many feel the current management structure described is overly complex, could use revision, and further clarification, and simplification of roles and terminology is warranted.

Recommendation 10: *The WHYCOS Guidelines should be reviewed, revised, reissued and widely distributed. Compendiums of: lessons learned; WHYCOS and WIAG policies and procedures; WIAG recommendations; and minutes of WIAG and WCG meetings should be developed, regularly maintained and placed on the WHYCOS website for all to see.*

Over time it has become clear that many, but not all, countries participating in the HYCOS components have permitted the free and unrestricted exchange of data at the regional level consistent with the WHYCOS Guidelines (WMO, 2005b, p. 10) and as extolled by Resolution 25 (Cg-XIII). The WHYCOS principles (WMO, 2005b, p. 6) stipulate that "there should be a free exchange of data among all the participating countries and the international community at large." An imperative requirement for participation in a HYCOS component should be the agreement of the country to allow unrestricted and free access to its data. WMO should be taking a much more proactive role in advancing the exchange of data through WHYCOS and its HYCOS components and in tracking the state of the exchange of data within the WHYCOS programme and globally in general.

Recommendation 11: *To fulfil the global concept of WHYCOS and to fully embrace the spirit of Resolution 25 (Cg-XIII), data collected through the HYCOS components must be exchanged in an unrestricted and free fashion by the participating countries in a timely fashion. If a country does not agree with the unrestricted and free exchange of data, it should not be part of the HYCOS component. WMO, through its WHYCOS Office, should be tracking the state of data exchange within the HYCOS components to ensure compliance with this recommendation and should provide its findings to WIAG.*

Initiatives are underway within WMO that have the potential to generate benefits to WMO Members, NHMSs, and the organization as a whole. Cg-XV (WMO, 2007) agreed that enhanced integration between WMO observation systems should be pursued as a WMO strategic objective. This objective is to be achieved through the WMO Integrated Global Observing Systems (WIGOS) and WMO Information Systems (WIS) initiatives. A WIGOS Development and Implementation Plan (WDIP) has been prepared and includes a pilot project involving the SADC-HYCOS component, and it also involves the WMO Commission for Hydrology. It is evident from initial meetings and analyses undertaken that there are a number of issues that will need to be overcome within the WHYCOS programme and its HYCOS components so that they may benefit from the WIGOS and WIS initiatives. However, it is also not clear at this stage if the proposed benefits outweigh the costs of implementing changes to the existing HYCOS components or the WHYCOS programme in general.

Recommendation 12: *WMO and its WIGOS, WIS and WHYCOS programme should carefully analyse and clearly determine what specific efforts will be necessary and what costs and benefits will be incurred for HYCOS components to take advantage of the WIGOS and WIS initiatives and for the WHYCOS programme in general. Efforts should be undertaken to document these in as clear and concise a fashion as possible, as well as the costs and benefits that would likely accrue through the integration of the WHYCOS programme with WIGOS and WIS.*

If the outcomes of recommendation 12 indicate overall positive benefits versus costs for the hydrological and water resources community, then it would be advantageous for the WHYCOS programme to proceed with taking advantage of the WIGOS and WIS initiatives. Recommendation 13 would then be appropriate.

Recommendation 13: *WMO and the WHYCOS programme should ensure that all documentation such as the WHYCOS Guidelines reflect the requirements to comply with the WIGOS and WIS initiatives. WMO and the WHYCOS programme should also focus on increasing awareness of the WIGOS and WIS initiatives, and more importantly on the requirements they place upon the WHYCOS programme and its HYCOS components. Efforts at increasing awareness should be made as broadly as possible through the hydrology and water resources communities that may consider undertaking a HYCOS project. WMO and the WHYCOS programme should develop a strategy to assist existing HYCOS components in taking advantage of the WIGOS and WIS initiatives.*

Countries and Donors

There is a growing collaborative movement of recipient countries and donors to improve the effectiveness of aid in building capacity and achieving desired results. This has been reflected through the "Paris Declaration on Aid Effectiveness" (OECD, 2005), and the commitments expressed therein are most relevant to the WHYCOS programme.

Recommendation 14: *Countries and donors should adopt the "Paris Declaration on Aid Effectiveness" (OECD, 2005) when working with the WMO on implementing the WHYCOS concept through its HYCOS components. This would include, inter alia, simplifying donor policies and procedures, increasing flexibility to better reflect the amount of time to implement components, and aligning components within national priorities.*

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RESOLUTION Res. 3.4/3 (Cg-XVI) - WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM (WHYCOS)

THE CONGRESS,

Noting:

- (1) Resolution 20 (Cg-XII) on the World Hydrological Cycle Observing System (WHYCOS),
- (2) Resolution 25 (Cg-XIII) on the Exchange of hydrological data and products,

Appreciating:

- (1) The continuing potential benefits of enhanced exchange of hydrological data and information within shared river basins and aquifers,
- (2) The successful implementation of the WHYCOS programme through eight regional HYCOS components that have been implemented or are presently under implementation,
- (3) The financial support of around CHF 23 million provided by the Governments of the Netherlands, France and Finland, the European Commission, and the African Water Facility for the implementation of the regional HYCOS components in the last financial period,
- (4) The continued interest of these partners in continuing their support,
- (5) The positive impacts of implemented HYCOS components on the strengthening of technical and institutional capacities of National Hydrological Services (NHSs) in a number of countries, including improved international cooperation in transboundary and international rivers basins,

Considering:

- (1) That WHYCOS is one of WMO's basic responses to the recommendation of the United Nations Commission on Sustainable Development to strengthen efforts towards a comprehensive assessment of freshwater resources,
- (2) That WHYCOS is a significant contribution to water resources assessment on global, regional, and national scales, supports the assessment of the impacts of climate variability and change on water resources and assists in identifying appropriate mitigation and adaptation measures under the changing climate,
- (3) The continuing need for strengthening the capabilities of NHSs in hydrological and hydrometeorological data collection and management and in the development and dissemination of information products, particularly in developing countries,

- (4) The contribution that WHYCOS can make to the strengthening of these capabilities,
- (5) That WHYCOS provides a vehicle for implementation of the Quality Management Framework-Hydrology through applying best practices in measurements, enhanced quality of observations and development of water resources information systems,
- (6) That WHYCOS can provide essential data to several programmes, such as GCOS, GTOS, GOOS and GTN-H,
- (7) That WHYCOS, as a strong contributor to WIGOS, will benefit from the development and implementation of WIGOS and WIS,

Reaffirms the importance of WHYCOS as a priority activity within the WMO Hydrology and Water Resources Programme with the main objectives of:

- (1) Strengthening technical, human and institutional capacities of NHSs of Member States in hydrological data collection and management and in the development and dissemination of information products;
- (2) Promoting regional and international cooperation in the sharing of hydrological data and the management of shared water resources;
- (3) Adaptation to the impacts of climate variability and change,

Also reaffirms the ownership by WMO of WHYCOS and its HYCOS components and the central role of the Secretariat as a provider of technical and scientific support with a view to ensuring the achievement of the programme goals, consistency among components and the transfer of data, tools and expertise;

Invites Members and national and international aid agencies:

- (1) To continue and broaden their financial support for the implementation of ongoing and planned HYCOS components;
- (2) To coordinate with the WMO Secretariat in the implementation of the regional components, in order to maximize benefits from collaboration with, and transfer of tools and products from other projects;
- (3) To encourage other countries in the regions to, where relevant, join a HYCOS component;

Urges Members and regional institutions involved in the implementation of HYCOS components:

- (1) To actively support the project implementation, by, inter-alia, making available the required staff for field activities and training courses, ensuring timely implementation of project activities at the national level (including custom clearance and installation of equipment), performing quality control and validation on data collected in the framework of the project;
- (2) To ensure the long term sustainability of the project outcomes through the provision of adequate human and financial support to their continuing operation,

Requests the Secretary-General:

- (1) To carry out an independent external evaluation of the WHYCOS programme, as a follow up to the one carried out in 2005;
- (2) To review the mandate, composition and functioning mechanism of the WHYCOS International Advisory Group, to make it better respond to the new challenges facing the WHYCOS programme in particular by focusing on:
 - (a) Reviewing and assessing the concept, objectives and progress towards them, expected benefits/costs, and future development of WHYCOS and proposing strategies for any necessary remedial action to possible shortcomings;
 - (b) Ensuring the efficient relationship of WHYCOS with other relevant initiatives and international programmes, especially its integration with the WIGOS and WIS;
 - (c) Coordinating with stakeholders, especially national and regional partners and donors, the implementation of the various HYCOS component and WMO inputs;
- (3) To invite other international organizations to cooperate with WMO to contribute to WHYCOS implementation, and make use of its products;
- (4) To provide all possible support to WHYCOS development from available resources and to seek additional resources for this purpose from external sources;

Requests the president of the Commission for Hydrology to ensure that the Commission provides WHYCOS with the technical advice that it requires.

Note: This resolution replaces Resolution 20 (Cg-XII) on the WHYCOS

**REVIEW OF WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM (WHYCOS)
REVISED TERMS OF REFERENCE**

The Terms of Reference for the review of WHYCOS are:

- (1) To review and comment on the current status and progress in the implementation of the WHYCOS Programme, fulfilment of its objectives and its effectiveness in raising the extra-budgetary resources;
- (2) To review the individual HYCOS components, the fulfilment of the desired objectives at the components level, the adequacy of HYCOS projects to meet current and future (identified) demands;
- (3) To examine, review and comment on the performance of completed phases of and sufficiently advanced HYCOS components based on available reports and interviews and discussions with Project managers, including aspects of the benefits and costs of the projects, including review and comment on:
 - (a) the effectiveness of hydrological data transmission and hydrological information systems;
 - (b) the adequacy of instrumentation, telecommunication and data management systems;
 - (c) the integration of HYCOS data in routine forecasting services and water resources management, as appropriate;
 - (d) access to HYCOS data and data sharing at regional and global levels;
 - (e) the types of data collected and the quality of this data;
 - (f) the effectiveness of the Project Regional Centres (PRCs);
- (4) To make conclusions and recommendations with respect to the future directions of WHYCOS and the individual HYCOS components, including remedial actions, development and sustainability of the WHYCOS programme and its components, and the need for establishing new HYCOS projects;
- (5) To explore and suggest means of ensuring the efficient relationship of WHYCOS with other relevant initiatives and international programmes, especially its integration with the WIGOS and WIS;
- (6) To review and comment on the terms of reference and membership of the WIAG, comment on its effectiveness, and make recommendations with respect to the future Terms of Reference and Composition of the WIAG, and should it not be sufficient, to propose mechanisms to improve coordination with stakeholders, especially national and regional partners and donors, the implementation of the various HYCOS components and WMO inputs; and
- (7) Any other related issues.

Review Mechanism

The Lead Reviewers will:

- (1) Draw on the various WHYCOS/HYCOS related reports available;
- (2) Hold consultative meetings with the Associate Members as required;
- (3) Undertake site visits as appropriate and in consultation with the WMO Secretariat (limited to visiting two representative HYCOS Projects per Lead Reviewer and the WMO Headquarters in Geneva);
- (4) Review the reports of the WIAG meetings; and
- (5) Provide a report by 23 November 2011 for submission to WIAG in early December 2011.

CURRENT STATUS OF HYCOS INITIATIVES

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
Implemented Projects (Category 1¹)				
MED-HYCOS	Albania, Algeria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Jordan, Lebanon, Malta, Morocco, Romania, Serbia and Montenegro, Slovenia, Spain, The former Yugoslav Republic of Macedonia, Tunisia, Turkey (20 countries)	Donor: World Bank Grant: US\$ 1,700,000 Pilot Regional Centre (PRC): Institut de Recherche pour le Développement - IRD (France) Executing Agency: WMO	Enhanced cooperation among participating countries Establishment of a network of 31 DCPs Development of a Mediterranean hydrological Information system accessible via the Web Training for the staff of the participating NHSS	Implementation: 1997-2001
SADC-HYCOS (phase I)	Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, United Republic of Tanzania, Zambia, Zimbabwe (11 countries)	Donor: European Commission Grant: US\$ 2,400,000 PRC: Department of Water Affairs and Forestry - DWAF (South Africa) Supervising Agency: WMO	Installation of a network of 43 DCPs, Development of an Internet based Hydrological Information System Training for the staff of participating NHSS Enhanced cooperation among participating countries	Implementation: 1998-2001 Funded by the European Commission
SADC-HYCOS (phase II)	Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho,	Donor: European Commission (PRC support), The Netherlands (Project	Consolidation/redesign of the regional observation network, Development of the sub-regional and	Implementation: 2005-2009. Jointly funded by EU and

¹ Category 1 - Implemented projects (external funding ended)

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
	Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, United Republic of Tanzania, Zambia, Zimbabwe (13 countries)	support) Grant. € 4,500,000 PRC: Department of Water Affairs and Forestry - DWAF (South Africa) Supervising Agency: WMO	national water resources information systems, Development of hydrological products of regional interest, Training and awareness building.	The Netherlands Government.
AOC-HYCOS (pilot phase)	Burkina Faso, Cape Verde, Chad, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal (11 countries)	Donor: France Grant: FF 2,000,000 PRC: AGRHYMET and Niger Basin Authority - NBA (Niger) Executing Agency: WMO role:	Consolidation of the development of the Regional Hydrological Observatory of Western and Central Africa Support to the data collection activities of participating countries Enhanced cooperation among participating countries.	Implementation: 1999-2002
Volta-HYCOS	Bénin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Togo (6 countries)	Donor: France Grant: € 1,000,000 PRC: Ecole Inter-Etat d'Ingénieurs de l'Equipement Rural – EIER (Burkina Faso) Executing Agency: WMO	Developing a regional infrastructure for data collection, management and exchange (16 DCPs). Support the development of a regional cooperation framework Enhanced cooperation among participating countries	Implementation: 2005-2009
Niger-HYCOS Phase I	Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, Nigeria (9 countries)	Donor: France Grant: 3,000,000 PRC: Niger Basin Authority - NBA (Niger) Supervising Agency: WMO	Reinforcing national data observation and collection capacity (49 DCPs) Developing national hydrological information systems Establishing a regional information system Training Enhanced cooperation among participating countries	Implementation: 2005-2010

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
Pacific-HYCOS Phase I	Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Nauru, New Caledonia, Niue, Palau, Papua New Guinea, Marshall Islands, Solomon Islands, Tonga, Tuvalu, Vanuatu (14 countries)	Donors: European Union Grant: € 2.525M SOPAC in-kind: € 1.0M PMU and PRC: SOPAC	Establishment of national capacity in water resources assessment. Establishment of basic hydrological monitoring and data capture systems Establishment of hydrological databases and information systems	Implementation: 2006-2010
Projects under Implementation (Category 2²)				
Carib-HYCOS (CIC)	Barbados, Cuba, Dominican Republic, France (Guadeloupe and Martinique), Haiti, Jamaica, Trinidad and Tobago (8 countries)	Donor: France Estimated budget: € 3,000,000 PRC: IRD in Martinique Supervising Agency: WMO	Modernization and strengthening of national activities in WRM Establishment of a network of about 40 – 50 DCPs Promotion of international cooperation among small island states Promotion of the exchange of information, technology and experience Installation of the data base software and training for installation and maintenance	Partial funding contributed by donor, for project preparatory phase (completed in 2008). Project document prepared. Implementation: 3 years (starting 2005) Project still under way – current expected completion date June 2012. Phase II proposed.
HKH-HYCOS	Bangladesh, Bhutan, China, India, Nepal, Pakistan (6 countries)	Donor: Finland Budget for phase I: 2,3 million EURO Supervising Agency: WMO	Establishment of a regional network of 18 DCPs Establishment of a regional Flood Information System; Provision of near real-time meteorological and hydrological information (especially flood	Project under implementation 2009 until 2012

² Category 2 - Projects under implementation (field implementation started or funds already committed by donor(s))

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
			forecasting). Enhanced cooperation among participating countries	
IGAD-HYCOS	Djibouti, Eritrea, Ethiopia, Kenya, Sudan (north and South), Uganda, Burundi, Rwanda (9 countries)	Donor: European Commission Grant € 4,600,000 Preparatory Phase: € 923,000 Implementing Agency: WMO	Establishment of a regional network of 50 DCP's Creation of a regional information system Promotion of national capacity in water management Enhanced cooperation among participating countries	Preparatory Phase: 2011-2012 Implementation Phase: 2012-2015
Mekong-HYCOS	Lao PDR, Thailand, Cambodia, Viet Nam (4 countries)	Donor: AFD, France. Budget: 2.5 million EURO Supervising Agency: WMO	Establishment of a real time data collection and transmission system based on a network of 60 hydro and 40 meteo DCPs Strengthening of the capability of NHSs to provide timely and accurate monitoring and forecasting services Enhancement of regional cooperation;	Project under final stages of implementation. Duration has been 5 years, extended into May 2012.
Niger-HYCOS Phase II	Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, Nigeria (9 countries)	Donor: France Grant: 2 017 193 € PRC: Niger Basin Authority - NBA (Niger) Supervising Agency: WMO	Part of GIRE 2 project First Steering Committee meeting September 2011	Implementation: 2010-14
Senegal-HYCOS	Mali, Mauritania, Senegal, Guinea (4 countries)	Donor: France, Grant 170 000 € Implementing agency: OMVS Supervising Agency WMO	Preliminary phase Kick off meeting September 2011 Project document by March 2012	Implementation: 2011-12

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
Projects in Advanced Development Stage (Category 3³)				
SADC-HYCOS (phase III)	Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, United Republic of Tanzania, Zambia, Zimbabwe (13 countries)	Donor: The Netherlands Government had expressed initial support. PRC: Department of Water Affairs and Forestry - DWAF (South Africa) Supervising Agency: WMO	Consolidation/redesign of the regional observation network, Improvements to the sub-regional and national water resources information systems – focus on rating curves, Continues development of hydrological products of regional interest, Training and awareness building.	Implementation was to be 2010-2014, but now on hold.
Congo-HYCOS	Cameroon, Central African Republic, Congo, Democratic Republic of the Congo	Donors: EU (598 488 €), AFDB Implementing agency: CICOS Partners OIEau		OIEau grant request to EU approved after a preliminary screening. Some activities complementary to Congo-HYCOS proposal
Projects in Preparatory Stage (Category 4⁴)				
Baltic-HYCOS (frozen)	Belarus, Czech Republic, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russian federation, Slovakia, Sweden, Ukraine (12 countries)	Estimated budget: € 2,360,000 Executing Agency: WMO (proposed)	To establish a system to acquire, manage and disseminate water resources and water-related environmental data and information (40 DCPs). To foster the adoption of standardized practices of data and information management and dissemination. To enable the international exchange	Project proposal available, submitted for funding to the European Commission (FP5) but not retained Period of implementation is expected to be 3 years

³ Category 3 - Advanced development stage (detailed project document available or partial funding already committed by donor(s))

⁴ Category 4 - Preparatory stage (project proposal available, funded by participating countries and/or WMO)

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
			of water-related data and information To enhance cooperation among participating countries	
Pacific-HYCOS phase II	Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Nauru, New Caledonia, Niue, Palau, Papua New Guinea, Marshall Islands, Solomon Islands, Tonga, Tuvalu, Vanuatu (14 countries)	Under development	Under development, but continuation of phase I.	Limited interest from Donors. Stronger national commitment required.
Projects in Conceptual Stage (Category 5⁵)				
Nile-HYCOS	Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, United Republic of Tanzania, Uganda (10 countries)	Estimated budget: US\$ 2,500,000 Executing Agency: WMO (proposed)	Improvement of data collection, management, storage and exchange Reinforcing hydrological forecasting (floods and droughts) and water management Promoting integration of hydrological data with socio-economic and environmental data Enhancing cooperation among participating countries	Countries committed Project brief prepared, suspended during institutional reform process of regional institution Period of implementation is expected to be 2 years
Amazon-HYCOS	Bolivia, Brazil, Colombia, Ecuador, Peru, Venezuela (6 countries)	N.A.	Promoting the knowledge about hydrological processes through the use of new technologies and reinforced human resources.	Project brief prepared, waiting for countries' commitment

⁵ Category 5 - Conceptual stage (country commitment received and project brief prepared, funded by participating countries and/or WMO)

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
			Stimulating the cooperation between hydrological services through the establishment of a information network and of a regional center Enhancing cooperation among participating countries	
Aral-HYCOS	Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan (5 countries)	Estimated budget: € 4,000,000	Developing a hydrological information system for the Aral Sea basin; Providing assistance to the participating countries in capacity building Enhancing collaboration with other projects and programmes in addressing environmental issues Enhancing cooperation among participating countries	Countries committed, project brief prepared, funding being negotiated with the Swiss Agency for Development and Cooperation (SDC) Period of implementation is expected to be 2 years
Arctic-HYCOS	Canada, Iceland, Norway, Russian Federation, USA (5 countries), in cooperation with international scientific programmes	Estimated budget: US \$ 1,230,000	Establishment of a basic network of hydrological stations in the Arctic drainage basin Establishment of a regional data bank for real time and historical data and uniformization of data practices. Harmonization and integration with other relevant international observation networks (GCOS, GTOS, GOOS, AMAP, etc.). Enhancing cooperation among participating countries	Countries committed Project brief prepared Part of WMO contribution to the International Polar Year (2007-2008). Period of implementation is expected to be 2 years
Black Sea-HYCOS (frozen)	Bulgaria, Georgia, Republic of Moldova, Romania, Russian	N.A.	Achieving better understanding of regional hydrometeorological processes and environmental trends	Countries committed Project brief prepared No further development

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
	Federation, Turkey, Ukraine (7 countries)		Promoting the exchange of standardized and consistent data; Providing transboundary co-operation especially in dealing with extreme events and in capacity building Enhancing cooperation among participating countries	due to lack of funding
Danube-HYCOS (frozen)	Austria, Bosnia Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Serbia and Montenegro, Slovakia, Slovenia, Republic of Moldova, Romania, Ukraine (13 countries)	Estimated budget: US\$ 2,150,000	Improved observing networks and data management facilities Improved data accessibility, exchange and dissemination; Improved forecast reliability and timeliness, and delivery of hydrological information products to support the Danube conventions. Enhancing cooperation among participating countries	Countries committed Project brief prepared No further development due to lack of funding Period of implementation is expected to be 4 years
La Plata-HYCOS	Argentina, Bolivia, Brazil, Paraguay, Uruguay (5 countries)	Supervising Agency: WMO (proposed)	Promoting the knowledge about hydrological processes through the use of new technologies and reinforced human resources. Stimulating cooperation between hydrological services through establishment of an information network and a regional centre.	Project brief prepared, waiting for countries commitment
Projects under consideration (Category 6⁶)				
Lake Chad-HYCOS	Cameroon, Central African Republic, Chad,	N.A.	N.A.	Project proposal prepared.

⁶ Category 6 - Countries requested WMO support for project development

Project	Status			
	Participating Countries	Funding and management	Achievements or Expected Outputs	Remarks
	Niger, Nigeria (5 countries)			Country request received. WMO assisting Lake Chad Basin Commission to identify donor(s) to provide financial support for the project
South East Asia HYCOS (SEA)	Indonesia, Malaysia, Philippines (3 Countries)			Awaiting commitment from countries before development of project proposal.

GANT CHART DEPICTING CURRENT STATUS OF ALL HYCOS COMPONENTS

Projects	YEAR																			
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Projects implemented or under implementation																				
MED-HYCOS	Implementation																			
SADC-HYCOS	Phase I Implementation						Phase II Implementation					Phase III Proposed - but not funded								
AOC-HYCOS		Implementation																		
Volta-HYCOS							Implementation													
Niger-HYCOS							Phase I Implementation					Phase II Implementation								
Pacific-HYCOS							Phase I Implementation					Phase II Proposed - No document								
Carib-HYCOS											Preparatory Phase	Implementation Phase								
HKH -HYCOS				Initial phase and feasibility testing									Implementation Phase							
IGAD-HYCOS													Prep. Phase	Implementation Phase						
Mekong-HYCOS												Implementation Phase								
Senegal-HYCOS													Prel. Phase							
Congo-HYCOS														Comp. Activities						
Projects in waiting																				
Lake Chad-HYCOS																	Document available - no funding			
Aral-HYCOS																	Brief available - country commitment - no funds			
Arctic-HYCOS																	Brief available - country commitment - no funds			
La Plata-HYCOS																	Brief available - country commitment - no funds			
Nile-HYCOS																	Brief available - need country commitment			
Amazon-HYCOS																	Brief available- need country commitment			
SEA-HYCOS																	Under discussion at country level			
Baltic-HYCOS																	Document available – in abeyance			
Black Sea-HYCOS																	Brief - country commitment - in abeyance			
Danube-HYCOS																	Brief - country commitment - in abeyance			

REVIEW OF WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM (WHYCOS)

Context: Questions regarding existing HYCOS Projects, National Hydrological Services and users.

INCLUDES 2011 REVIEW OF THE WHYCOS PROJECT
SUBMISSION PROFORMA PLUS ADDITIONAL QUESTIONS (identified by **)

1. **In what year was your National Hydrological Service formed?
2. **Would you please elaborate on the costs and benefits of the HYCOS Project, providing specific examples of each from both national and regional perspectives?
3. Describe the current status and progress in the implementation of the HYCOS Project in which you are involved.
4. Has the HYCOS Project in which you are involved met its desired objectives?
Would you please list the specific objective(s) and describe the aspects of the Project that have enabled this to happen or have hampered its achievement?
5. Has the HYCOS Project in which you are involved established a foundation to meet current and future (identified) demands for hydrological information?
If “yes”, describe the aspects of the Project that have enabled this to happen.
If “no”, comment on what could be changed to enable this to happen.
6. Comment on the following aspects of the HYCOS Project in which you are involved:
 - (a) the effectiveness⁷ of hydrological data transmission and hydrological information systems;
 - (b) the adequacy⁸ of instrumentation, telecommunication and data management systems;
 - (c) the integration of HYCOS data in routine forecasting services and water resources management; and
 - (d) contribution of and access to HYCOS data and data sharing at regional and global level.
7. **Do you develop rating curves (stage-discharge curves) using the Hydrological Information System (HIS), and how would you describe its capability in doing so? How would you assess the quality of your rating curves?
8. **Is your HIS missing any functionality or are there any aspects that you would like to see strengthened within the HIS?

⁷ Effectiveness – is the data transmitted in a timely manner and is it readily available from the database, is good quality data being delivered.

⁸ Adequacy – is the instrumentation fit for purpose and the operating environment, are the systems operational and being well maintained.

9. **Please describe the adequacy of your office (e.g., computers) and field instrumentation (e.g., data loggers, data collection platforms, telecommunication system, pressure transducers, current meters, hand held field computers) and any inadequacies you have observed?
10. **Does your National Hydrological Service use Acoustic Doppler Current Profilers (ADCPs)? If so, how are they used (fixed in-situ, moving boat)? Do you have sufficient equipment to allow use of the ADCPs (e.g., boats)?
11. **Do you have what you consider to be sufficient spare parts in inventory, and if so, how many, and what is your supply source?
12. **Are your current meters calibrated, and if so, what is the duration between calibrations? Where and how (individual or batch ratings) are they calibrated?
13. **What procedures do you have in place to evaluate and ensure the quality of the data collected?
15. **Would you please indicate if the data collected are shared regionally and globally, and if so, how?
16. Please make suggestions for mechanisms or activities to improve use of data collected by HYCOS by stakeholders, thereby making the HYCOS components & WMO input more valuable to national and regional partners.
17. Comment on what you believe should be the future directions of WHYCOS and the individual HYCOS components, including remedial actions, and the need of establishing new HYCOS projects.
18. Comment on the long-term sustainability of the WHYCOS program and the individual HYCOS projects, and what areas may require attention to allow sustainability.
19. Comment on the relationship between WHYCOS and other relevant initiatives and international programmes, especially its integration with the WIGOS and WIS. (See: http://www.wmo.int/pages/prog/www/wigos/index_en.html and http://www.wmo.int/pages/prog/www/WIS/index_en.html)
20. Comment on the terms of reference and membership of the WIAG, including its effectiveness, terms of reference, and composition.
21. Would you please make suggestions for mechanisms to improve coordination with stakeholders, especially national and regional partners and donors, the implementation of the various HYCOS components and WMO inputs.
22. **Would you please describe the strengths and weaknesses of the Project Management Unit and/or the Project Regional Centre?
23. **Do you use any publications published by the WMO in the conduct of work by the National Hydrological Service or the PMU or PMC (e.g., Guide to Hydrological Practices, Manual on Stream Gauging)? What manuals or guidance materials do you use?

24. ** How would you describe the performance of the WMO Secretariat in exercising its supervisory role? What assistance do you appreciate receiving from WMO, and are there aspects that you would suggest removing or adding to its mandate?
25. **What changes would you like to see regarding your HYCOS Project to make it more useful to your National Hydrological Service or Regional needs?
26. **Is HYCOS still relevant to your country's or region's needs? What could make it more relevant?
27. **What is your discretionary budget (Operations and Maintenance not salary) for operational work?
28. **Have you received additional financial resources to operate the HYCOS stations following completion of the project?
29. **Have your financial resources (salary and Operations & Maintenance) increased since inception of the project?
30. **If financial resources have not been forthcoming, do you have any suggestions on the mechanism(s) or opportunities that could be used for acquiring them?
31. **Do you have any suggestions on improving the WHYCOS and HYCOS programme?

LIST OF PEOPLE MET BY EITHER OR BOTH LEAD REVIEWERS

Organization	Name	Position
Niger-HYCOS		
Niger Basin Authority, Niger	Abdou Guero	Directeur Technique/Technical Director
Niger Basin Authority, Niger	Brehima Coulibaly	Coordonnateur Régional Niger-HYCOS
Niger Basin Authority, Niger	Pierrick Fravel	Conseiller Technique/Senior Advisor
Niger Basin Authority, Niger	Zinsou Didier	Water Resources Specialist
Niger Basin Authority, Niger	Dessouassi Yrobert	Responsable de l'observatoire du Bassin du Niger
Water Directorate, Niger	Garba Radji	
ACMAD, Niger	Mohamed KHADI	Secrétariat Général
AGRHYMET, Niger	Abdou Ali	
Ministère de l'Énergie et de L'Eau, Mali	Alassane Bocoum	Directeur National Adjoint
Ministère de l'Énergie et de L'Eau, Mali	Navon Cisse	Directeur National Hydraulique
Direction Nationale de l'Agriculture, Mali	Hamadou Bengaly	Ingénieur du Génie Rural
Ministère de l'Énergie et de L'Eau, Mali	Mama Yena	Division Head
Direction Générale des Ressources en Eau	Jean Pierre Mihin	Chef du Service Suivi et Evaluation des Ressources en Eau et des Usages
Direction Générale des Ressources en Eau	Bouraima Kouanda	

Organization	Name	Position
Mekong-HYCOS		
Mekong River Commission, Cambodia	Erland D Jensen	Chief Technical Advisor
Mekong River Commission, Cambodia	Tran Van Tuan	Programme Coordinator
Mekong River Commission, Cambodia	Dr.Felix Seebacher	International Technical Advisor on Hydrology
Mekong River Commission, Cambodia	Dr KHEM SOTHEA	Operational Hydrologist
Department of Meteorology and Hydrology, Laos	Sithanh Southichack	Acting Director General
Department of Meteorology and Hydrology, Laos	Khanmany Khounphonh	Head of Technical Management Division
Cambodia National Mekong Committee	TE NAVUTH	Secretary General
Ministry of Water Resources and Meteorology, Department of Hydrology and River Works, Cambodia	YIN SAVUTH	Deputy Director
Ministry of Water Resources and Meteorology, Department of Meteorology, Cambodia	OUM RYNA	Acting Director
Carib-HYCOS		
Pôle de recherche agro-environnementale de la Martinique	Patrick Quénehervé	Directeur de recherche
Institut de recherche pour le développement	Jean- Pierre Bricquet	Coordinateur Caraïbe-HYCOS
Météo France - Prévision	Jean-Noël Degrace	
Direction de	Pascal Marras	Chargé de Mission

Organization	Name	Position
l'Environnement de l'Aménagement et du Logement de la Martinique		Hydrométrie
Conseil général - Réseau Hydro	Renaud Saint-Cyr	
Caribbean Institute for Meteorology and Hydrology	David Farell	Director
Caribbean Institute for Meteorology and Hydrology	Shawn Boyce	
Barbados Water Authority	Jamie Paul	
Barbados Water Authority	Alex Ifill	

WHYCOS INTERNATIONAL ADVISORY GROUP - TERMS OF REFERENCE AND COMPOSITION

Terms of Reference

The WHYCOS International Advisory Group (WIAG) shall (taking WHYCOS to mean the overall Programme, its component parts, and the mechanisms for coordination among them):

1. Consider and advise on the concept, objectives, expected benefits/costs, and future development of WHYCOS.
2. Review and assess the status of WHYCOS, and of progress towards its objectives, and propose strategies for any necessary remedial action.
3. Review the relationship of WHYCOS with other relevant international programmes, particularly from the point of view of coordination and avoidance of overlap, and propose any necessary actions.
4. Identify and evaluate constraints on and potential risks to the future implementation and sustainability of WHYCOS, and propose strategies to minimise those risks. Risks include, *inter alia*, those of a financial, technical, operational, and institutional/political nature.
5. Consider and propose plans for effective marketing of WHYCOS, and ways and means to assure its future sustainability and appropriate expansion.
6. Review and advise on the Terms of Reference and Composition of the WIAG.

Composition

The WHYCOS International Advisory Group shall be composed of:

1. The President of the WMO Commission for Hydrology (chairperson)
2. One representative from each operational HYCOS
3. One representative from each active investor/donor
4. One representative of the Advisory Working Group of the WMO Commission for Hydrology

The Director, Hydrology & Water Resources Division of WMO, shall act as secretary to the WIAG.

Other persons may be invited from time to time to participate in the work of the WIAG, as observers and informants, including:

- Regional Hydrological Advisors
- Representatives of prospective investors/donors
- Representatives of prospective HYCOSs

- Representatives of other international programme, and regional groupings
- Representatives of other WMO programmes.

COMPOSITION OF WIAG

