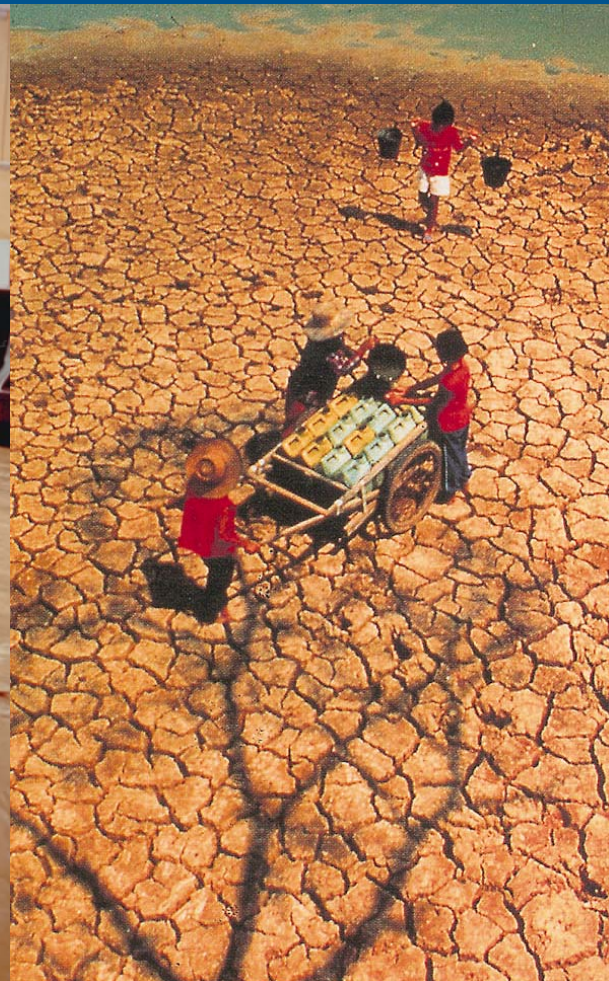
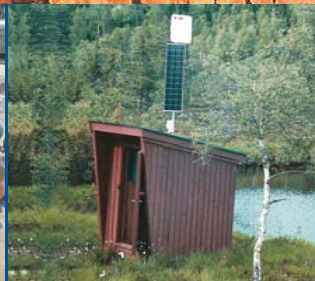


Hydrological information systems for integrated water resources management

WHYCOS Guidelines



**World
Meteorological
Organization**
Weather • Climate • Water



World Hydrological Cycle Observing System (WHYCOS)

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Hydrological information systems for integrated water
resources management

Hydrology and Water
Resources Department

WHYCOS Guidelines

For development, implementation and governance



**World
Meteorological
Organization**

Weather • Climate • Water

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October 2005

World Hydrological Cycle Observing System (WHYCOS)

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FOREWORD

Integrated water resources management (IWRM) calls for an informed participation of different stakeholders concerned with sustainable development. Timely, accurate and comprehensive information about water resources derived from hydrological information systems forms the basis for effective water resources management. Agenda 21, the blueprint for sustainable development, recognizes that the monitoring and assessment of water resources, in terms of both quantity and quality, require adequate meteorological, hydrological and other related data. Also, the 2005 World Summit called for assistance to developing countries' efforts to prepare IWRM and water efficiency plans as part of their national development strategies.

Unfortunately, the capability to collect and manage water resources-related information within countries remains inadequate in many parts of the world. This situation often arises from a lack of adequate financial support from national governments in view of demands from other competitive sectors. As a result, data collection networks are deteriorating, and the ability of National Hydrological Services (NHSs) to provide information on the status and trends of water resources is declining. The effect of these shortcomings is that water resources development options are not explored to their full potential, with the consequent sub-optimal use of both physical and financial resources.

In order to address these issues, the World Meteorological Organization (WMO) launched the World Hydrological Cycle Observing System (WHYCOS) concept in 1993 to overcome such obstacles that hinder the achievement of sustainable development. WHYCOS operates at global, basin and local level. It is made of regional components known as the Hydrological

Cycle Observing System (HYCOS). Owing to the central role of water within the Earth system and in human activities, observation of the global water cycle has both direct and indirect benefits. It helps detect climate change and variability through the observation and analysis of trends in precipitation, stream flows and other water cycle variables.

At the basin and regional levels, water cycle information contributes substantially to various elements of sustainable development and poverty alleviation such as water resources assessment and planning; ecosystem and water quality monitoring; flood forecasting and drought monitoring and prediction; agriculture development and fisheries management; and human health.

At the local level within a country, it brings together various agencies and builds the capacities of institutions involved in the observation and monitoring of such data and development of protocols and standard procedures for the exchange of information. Common national water information systems allow confidence building among various users and stakeholders.

WHYCOS, an umbrella programme of WMO, is a combined effort of its partners, participating countries, regional and basin institutions, international agencies and financial partners.

In light of the experience gained from the implementation of regional HYCOS projects, the WHYCOS International Advisory Group (WIAG), which is the coordination mechanism of the programme for policy guidance, has called for a common approach to the development and implementation of HYCOS components. The Guidelines presented here are therefore

aimed at ensuring that each project remains consistent with the WHYCOS objectives, while responding to local needs, realities and changing situations. The Guidelines set out the roles played by different partners for the successful implementation of WHYCOS. The system is a unique tool for the protection, use and management of water resources in a sustainable manner. As such, it contributes to poverty alleviation.

The Guidelines should help achieve the objectives of the International Decade for Action "Water for Life" (2005–2015). They are designed to serve as guidance for the main stages of project formulation and implementation including initiation, development,

realization and management, as well as monitoring and evaluation, of HYCOS projects. It is expected that the information in this brochure should allow for the exchange of experience, data and information among development projects and activities and thereby help in developing and improving the implementation of HYCOS components.

(M. Jarraud)
Secretary-General

1. INTRODUCTION

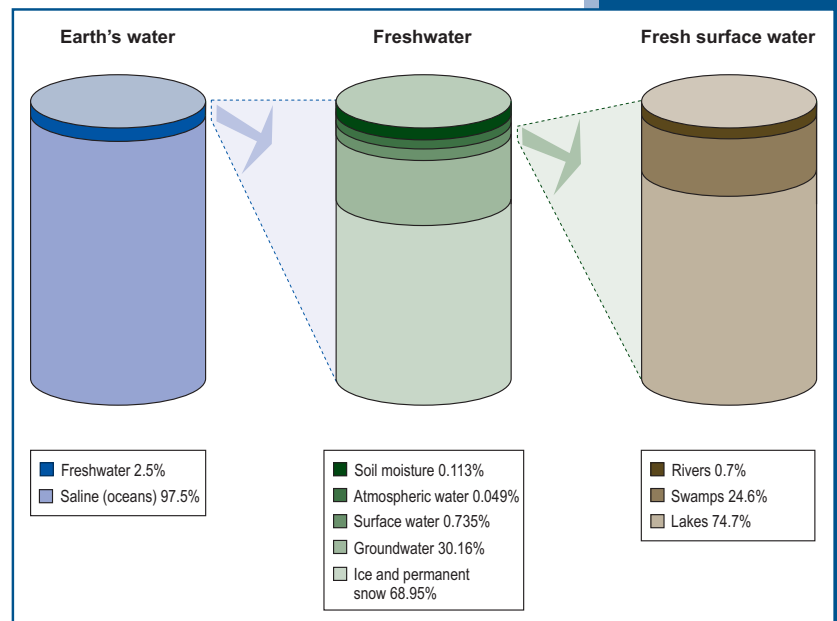
Water is one of the most highly valued natural resources. It exerts an enormous influence on a nation's economy, and almost every aspect of development is closely linked to the proper utilization of water. It is the key element for both environmental conservation and economic development and as such should be managed through an integrated approach to land use, water supply and waste management. With due attention to all the parallel uses of water in nature and society, as well as the evident linkages between upstream land, water use and downstream opportunities, the most evident unit of such integration should be the catchment or river basin.

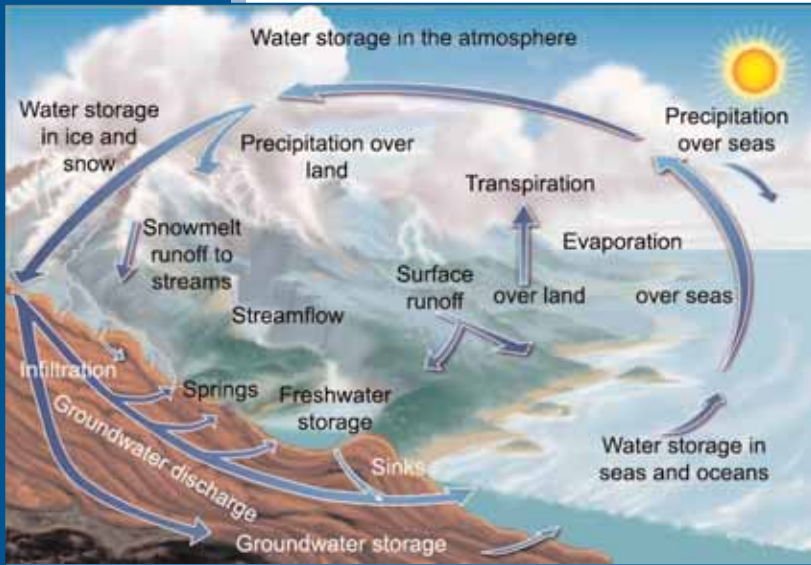
Given the uneven distribution of water resources globally, it is evident that water scarcity is not a global problem but has strong regional connotations. Water resources can only be understood within the context of the dynamics of the water cycle. When one calculates the amount of freshwater available for human use, what counts is not the total sum of global freshwater resources, but the rate at which freshwater resources are renewed or replenished by the global hydrological cycle and how they are harnessed and sustained. There is an enormous disparity between the huge volume of salt water and the tiny fraction of freshwater. Some 97.5 per cent of the total volume of the world's water is estimated to exist in the oceans and only 2.5 per cent as freshwater. Nearly 70 per cent of this freshwater is considered to occur in the ice sheets and glaciers in the Antarctic, Greenland and in mountainous areas, while a little more than 30 per cent is estimated to be stored as groundwater in the world's aquifers (see figure opposite). In order to assess the level of water availability, adequate meteorological, hydrological and other related data are needed on the gross amount of water available in a basin. This requires a better understanding of the water cycle by which

water evaporates from oceans and other water bodies, accumulates as water vapour in clouds, is transported by wind, and returns to oceans and other bodies of water as rain and snow, surface runoff or groundwater (see figure overleaf).

According to the World Water Development Report (March 2003), rapid growth of the world's population has been one of the most visible and dramatic changes in the world over the last hundred years. Population growth has huge implications on various aspects of water resource use. Although water is a renewable resource, it is only renewable within limits, and the extent to which increasing demands can be met is finite. On a global level, water supplies per capita decreased by a third between 1970 and 1990, and there is little doubt that population growth has been, and will continue to be, one of the main drivers of change in patterns of water resource use. This increasing demand

Distribution of water on Earth





The hydrological cycle

for water can also increase the chance of conflicts among different users and riparian countries. Many countries are trying to balance their water supplies with the demands of a rapidly growing population.

It is important to investigate and analyse the issues surrounding water in the global and regional context. The world is changing at an ever-increasing pace. Many of these changes are having an impact on how we, humans, utilize the world's water. Short-circuiting of the land phase of the hydrological cycle by increasing the amount of evaporation and reducing the amount of water reaching seas has a significant impact on the circulation of the ocean currents, which has likely consequences on the regional activities of the hydrological cycle.

The global climate change scenario has the potential to have a significant impact on the availability of water resources both in time and space. Climate variability and change are increasingly affecting the water resources of most countries. High temperatures and decreased precipitation as predicted by the Intergovernmental Panel on Climate Change (IPCC) climate change scenarios not only lead to decreased water supplies but also cause deterioration of the ecosystem. This,

together with land degradation, has a serious impact on the already fragile water resources.

The increasing frequency of floods results in the loss of lives and property, causes widespread crop destruction and affects economic development in many parts of the world. Drought and desertification are also threatening human survival in many regions of the world. Apart from human suffering, damage is inflicted on the watersheds, parts of which are left at the mercy of the climate after the natural vegetation has been stripped away by human activity. It is estimated that before 2050, when the global water demand will have doubled, a quarter of the total average flow of all the rivers in the world will have been committed to use. Under these circumstances, planning and decision-making on all water-related issues must achieve new levels of sophistication, reliability, and acceptance at national, basin and/or regional levels. Regional and global cooperation must be improved above all in the field of data and information gathering and dissemination. Such cooperation in the area of floods, droughts and other natural disasters is imperative if the global community is to reduce, mitigate and, in some cases, prevent the impacts of natural disasters.

2. BACKGROUND

Aware of the increased pace in the demand for water, as well as an increased realization of the importance of the environment, the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, produced Agenda 21 as a blueprint for the future. The chapter on freshwater (chapter 18) in Agenda 21 recognized that knowledge of the hydrological cycle, in terms of quantity and quality, forms the essential basis for effective water resources management. There has also been the realization that the need for monitoring systems, data storage and archives, resources assessment and pollution protection and control are slowly being pushed to the back stage. As a result of a lack of hydrological information, numerous water resources development schemes cannot be designed optimally, with a consequent wastage of financial resources. Their sustainability depends largely on adequate and accurate basic information on the state of water resources. Country reports of the United Nations Development Programme (UNDP)/World Bank Sub-Saharan Africa Hydrological Assessment highlighted the decline of monitoring networks, absence of computer-based archives and lack of qualified staff as a result of cuts in funding to hydrological services. This situation is true for many countries, including a number of developed countries, and is not confined only to Africa.

Indeed, the availability of hydrological information for the work of international scientific programmes which require water-related information, such as research into the global hydrological cycle, and those related to climate variability and change, such as the World Climate Programme (WCP) and the Global Climate Observing System (GCOS)¹, has been far from satisfactory. Globally, hydrological data have been assembled at hydrological data centres such as the Global Runoff Data Centre (GRDC) in Koblenz, Germany, and the International Groundwater

Resources Assessment Centre (IGRAC), in the Netherlands. Regional data sets are also assembled under the auspices of the FRIEND project, implemented by the United Nations Educational, Scientific and Cultural Organization (UNESCO). It has been found that these data sets are also not spatially representative and often lack quality.

To address these problems, the World Meteorological Organization (WMO), with the support of the World Bank, launched the World Hydrological Cycle Observing System (WHYCOS) in 1993, as a worldwide network of key stations linked by satellite with an associated quality-controlled database. It consists of a number of regional components known as HYCOS. Each HYCOS project, while following common guidelines and standards, is tailored to meet the needs of the participating countries. One decade after launching the WHYCOS concept, and equipped with the experience gained from the implementation of the regional HYCOS projects, there is a need to bring a common approach to development and implementation and ensure that each project remains consistent with the WHYCOS objectives, while responding to local needs and constraints and allowing the exchange of experience, data and information among other components.

The present Guidelines should help develop and improve the implementation of future HYCOS components. They aim to enable the development and implementation of components adapted to local realities and changing situations, whilst pursuing overall WHYCOS objectives. These Guidelines are designed to serve as guidance for the main stages of initiating and implementing HYCOS components.

¹ World Meteorological Organization (2000): *Establishment of a Global Hydrological Observation Network for Climate* (WMO/TD-No.1047), Geneva.

AGENDA 21 (excerpt from chapter 18)

PROTECTION OF THE QUALITY AND SUPPLY OF FRESHWATER RESOURCES: APPLICATION OF INTEGRATED APPROACHES TO THE DEVELOPMENT, MANAGEMENT AND USE OF WATER RESOURCES

18.1. Freshwater resources are an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods and droughts, which in some regions have become more extreme and dramatic in their consequences. Global climate change and atmospheric pollution could also have an impact on freshwater resources and their availability and, through sea-level rise, threaten low-lying coastal areas and small island ecosystems.

18.2. Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. Innovative technologies, including the improvement of indigenous technologies, are needed to fully utilize limited water resources and to safeguard those resources against pollution.

18.3. The widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. Such integration must cover all types of interrelated freshwater bodies, including both surface water and groundwater, and duly consider water quantity and quality aspects. The multisectoral nature of water resources development in the context of socio-economic development must be recognized, as well as the multi-interest utilization of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities. Rational water utilization schemes for the development of surface and underground water-supply sources and other potential sources have to be supported by concurrent water conservation and wastage minimization measures. Priority, however, must be accorded to flood prevention and control measures, as well as sedimentation control, where required.

18.4. Transboundary water resources and their use are of great importance to riparian States. In this connection, cooperation among those States may be desirable in conformity with existing agreements and/or other relevant arrangements, taking into account the interests of all riparian States concerned.

18.5. The following programme areas are proposed for the freshwater sector:

- (a) Integrated water resources development and management;
- (b) Water resources assessment;
- (c) Protection of water resources, water quality and aquatic ecosystems;
- (d) Drinking-water supply and sanitation;
- (e) Water and sustainable urban development;
- (f) Water for sustainable food production and rural development;
- (g) Impacts of climate change on water resources.

The Guidelines are addressed to all those who are currently, or might soon become, interested in developing HYCOS components, including, but not limited to, policy and decision makers, the National Hydrological Services (NHSs) of participating countries, external support agencies (ESAs), transboundary river/lake basin organizations, local basin councils and commissions, scientific communities, other relevant international organizations and programmes as well as those who will be in charge of preparing new projects and evaluating their performance.

3. WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM

WHYCOS is a framework programme, consisting of HYCOS components on the regional and/or basin scale. As a bottom up approach, from the country to the global scale, the HYCOS components should primarily focus on strengthening the technical and institutional capacities of NHSs through regional and basin projects. They should support the NHSs to better fulfil their responsibilities, **by improving the availability, accuracy and dissemination of water resources data and information through the development and implementation of appropriate national water resources information systems, thereby facilitating its use for sustainable socio-economic development.**

3.1 THE INITIAL CONCEPT OF WHYCOS

The WHYCOS concept was born in response to the absence or obsolescence of accurate and timely accessible data and information in real or near real time on freshwater resources in many parts of the world, particularly the developing countries. WHYCOS is a WMO programme with the ultimate objective to promote and facilitate the collection, exchange, dissemination and use of water-related information, using modern information technologies. A number of regional HYCOS components collectively form the building blocks to constitute the WHYCOS programme, through which hydrological and meteorological variables are captured and transmitted via satellite to regional databases established at the Regional Centres (RCs). The WMO Global Telecommunication System (GTS) or the Internet were considered to be the media for data transmission. WMO ensures implementation and maintenance of the global concept provided that the data are consistent with and conform to the standards outlined in the WMO *Technical Regulations* (WMO-No. 49) and the *Guide to Hydrological Practices* (WMO-No. 168).

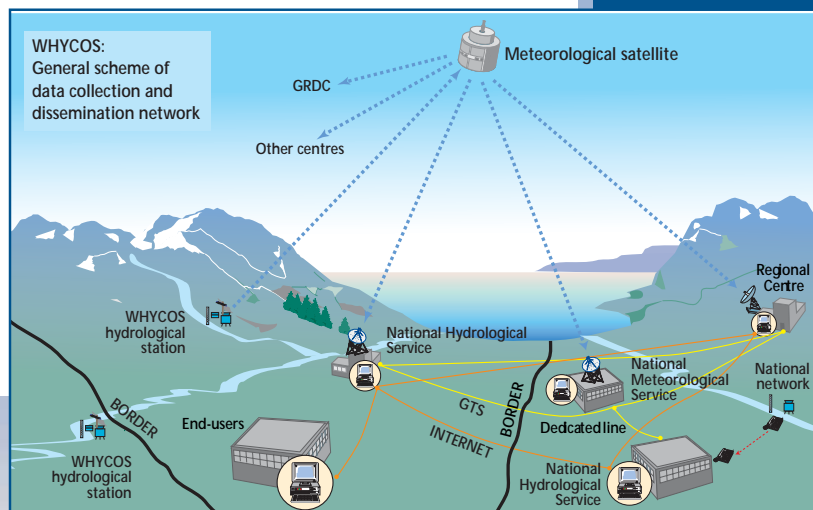
3.2 EVOLVING CONCEPT OF WHYCOS

While the initial concept of WHYCOS with its sound objectives and principles remains the same, a slightly different approach to its implementation, based on the experience of practical application, has been followed for quite some time and is recommended for the future.

To begin with, emphasis had been placed on the concept of a global network of 1 000 stations and a global water information system to capture data and information on the hydrological cycle. It is argued that, to a certain extent, this focus was at the expense of what should have been a major thrust of the WHYCOS concept, in a bottom up approach, by supporting regional and country HYCOS components. This gave rise to scepticism in certain circles about the objective of capturing data at regional and national level. Questions were raised as to whose interests were being served – those of the country or region, or the global demand for data? The issue is addressed in these Guidelines by emphasizing that the primary objective of the programme remains country or basin based, while meeting global needs, which, in turn, support water resources management at the basin level.

Further, based on the experience gained from implemented projects, a revision of

*World Hydrological
Cycle Observing
System (WHYCOS)*





Mt Kenya GAW station

the emphasis on modern instrumentation, modern information technologies and reliance on the Internet as the sole vehicle for data transfer is required. The original approach was not very successful owing to weak telecommunication infrastructure, especially in the developing countries. Unfortunately, automated and unattended stations experienced vandalism and theft and this hindered the full, successful implementation of HYCOS projects.

3.3 MISSION OF WHYCOS

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, thereby improving water resources assessment and management and promoting regional and international cooperation in data collection, sharing and research."

3.4 WHYCOS OBJECTIVES

The main objectives of WHYCOS are:

- (a) To establish a global network of national hydrological observatories that provide

information of a consistent quality, transmitted in real or near real time to national and regional databases, via existing telecommunication systems, such as the GTS, and the Internet;

- (b) To promote regional and international cooperation in pursuing research in climate change and its impact on water-related issues by improving the quality of data collection and sharing at all appropriate levels;
- (c) To promote and facilitate the dissemination and use of information technology on water-related issues.

3.5 WHYCOS PRINCIPLES

WHYCOS stipulates the following principles:

- (a) WHYCOS complements and supplements the existing national data collection, processing and product preparation capacities.
- (b) There must be committed long-term national participation in WHYCOS, and participating countries should ensure the sustainability of HYCOS components.
- (c) There should be a free exchange of data among all the participating countries and the international community at large.
- (d) Monitoring sites should be selected in such a way that data so collected can cover the widest possible use.
- (e) The participating countries should, as far as possible, contribute to the establishment of new stations under the WHYCOS programme, in addition to maintaining existing ones.

3.6 REGIONAL HYDROLOGICAL CYCLE OBSERVING SYSTEM

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. They are all considered in a

global perspective and should follow common guidelines and standards during the identification, preparation and implementation stages.

3.6.1 Primary objectives of a HYCOS component

The primary objectives of a HYCOS component are to collect data on the hydrological cycle to improve the accuracy, availability, dissemination and ease of use of water resources data and information needed by planners, decision makers, scientists and the public through the development and implementation of appropriate national water resources information systems on the basin scale at national and regional level. In addition, it provides hydrological data and information in real or near real time for the early warning and mitigation of impacts of water-related natural disasters. The objectives of each HYCOS component have to be clearly defined at the project proposal stage. The primary objectives could be one, or a combination, of the following:

- (a) To support regional institutions and NHSs in discharging their relevant regional and national responsibilities in support of:
 - (i) integrated water resources management (IWRM);
 - (ii) water resources assessment;
 - (iii) flood forecasting and warning;
 - (iv) groundwater monitoring and assessment;
 - (v) water quality monitoring;
- (b) To strengthen and build the capacity of regional institutions for cost-effective and sustainable water resources information systems and data dissemination by NHSs;
- (c) To supplement existing hydrological observing programmes, especially in terms of observation networks;
- (d) To improve the quality of hydrological and related data and information by adopting international standards;
- (e) To support development, implementation and maintenance of appropriate modernized regional and national databases;
- (f) To support greater efficiency in the acquisition and dissemination of water-related information, and development of regional and national water resources information systems by encouraging and facilitating

CLIMATE CHANGE AND FLOODS

It has been determined that long-term climatic changes (Pleistocene ice ages) have been caused by periodic changes in the distribution of incoming solar radiation due to the variations in the Earth's orbital geometry. However, it has been considered that the major potential mechanism of climate change over the next few hundred years will be the warming of anthropogenic greenhouse gases. A number of gases that occur naturally in the atmosphere in small quantities are known as "greenhouse gases". Water vapour, carbon dioxide, ozone, methane and nitrous oxide trap solar energy in much the same way as do the glass panes of a greenhouse or a closed automobile. This natural greenhouse gas effect has kept the Earth's atmosphere some 30°C hotter than it would otherwise be, making it possible for humans to exist on Earth. Human activities, however, are now raising the concentrations of these gases in the atmosphere, thus increasing their ability to trap energy. The enhanced greenhouse gas effect is expected to cause a high temperature increase globally (1 to 3.5°C) and this is expected to give rise to changes in hydrological systems (globally, the greenhouse gas effect is expected to elevate average precipitation by 5 to 15 per cent and evapotranspiration by 10 to 20 per cent). This hydrological change, as with the change in climate variables, will vary regionally around the globe, raising the risk of extreme events such as floods or droughts. Impact studies on local and regional scales are needed to assess how different regions will be affected. The impact of expected climate change will affect almost all sectors of human endeavour.

cooperation among countries sharing the same water resources.

3.6.2 Secondary objectives of a HYCOS component

The secondary objectives of HYCOS components are to:

- (a) Support international efforts to understand the global hydrological cycle and the global atmospheric processes;
- (b) Provide improved knowledge on the status and trends of the world's freshwater resources, as a basis for setting priorities and planning international action and providing advisories to governments;
- (c) Serve global scientific interests in terms of characterizing hydrological variability, detecting climate change and developing the ability to predict impacts of climate change, thereby helping



Hydrometeorological stations during winter and spring measuring water quality parameters, water flow and basic meteorological parameters

evolve a sustainable adaptation strategy for water resources management in the countries;

- (d) Strengthen cooperation between NHSs and National Meteorological Services (NMSs), which are key players in providing relevant information in the field of sustainable water resources management and early warning and forecasting of water and related hazards through sharing physical, financial and human resources and integration of the information for better efficiency.

3.6.3 Associated HYCOS components

A number of networks or projects for which hydrological observation is a key element already exist or are being developed and implemented at the initiative of regional or basin institutions without the involvement of WMO. These networks/projects, if they fulfil the following criteria, should be recognized formally as associated HYCOS components (A-HYCOS). The criteria for a system to be recognized as an associated component of WHYCOS are:

- (a) Fulfilment of the above-stated concept and objectives;
- (b) Compliance with prescribed standards or guidelines;
- (c) Addressing of regional issues in IWRM;
- (d) That requests for regional cooperation should emanate from an appreciable percentage of countries, or from countries comprising a significant portion (more than three-quarters of countries or area) of a particular basin or group of basins;
- (e) That funding shall be provided according to a basin or regional grouping approach and not to individual countries;
- (f) Commitments made by governments as regards the ownership and maintenance of the HYCOS infrastructure after project implementation (sustainability principle).

4. DEVELOPMENT OF HYCOS COMPONENTS

4.1 PROJECT STAGES

A number of preliminary activities are necessary for the successful development and implementation of a HYCOS component and its long-term sustainability. Such a project shall be developed in stages involving WMO and all the potential partners and participating countries, with each stage requiring closer cooperation, wider acceptance and funding. HYCOS components go through various stages as defined in the following paragraphs.

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

WMO will provide financial support for the initiation stages to ensure the preparation of a concrete proposal that is attractive to donors and assist in seeking funds from ESAs for the implementation stages.

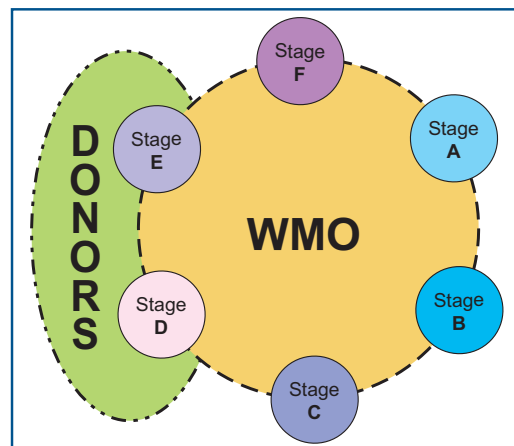
4.1.1 Request stage

A regional institution or river basin authority recognizing the need for cooperation in water resources or strengthening hydrological services can make a request for the development of a HYCOS component under the umbrella of WHYCOS. After receiving the request from three-quarters of the countries sharing the basin or countries within whose jurisdiction more than three-quarters of the basin area falls (at least two countries), it should

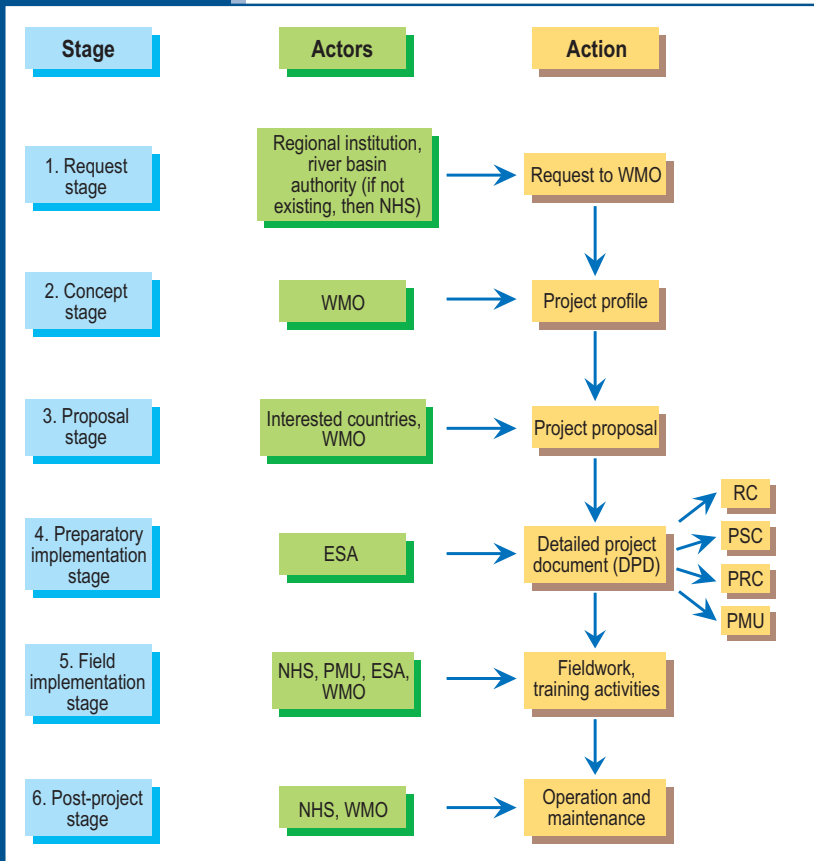
convey its intentions to WMO through an official written request. Should no formal regional grouping or river basin organization exist, the NHSs of the countries sharing a basin can approach WMO individually; WMO will then investigate the feasibility of the project as a basin or regionally based HYCOS.

4.1.2 Concept stage

At the concept stage, a project profile is prepared and presented as a short project concept document (PCD), as an expression of intent of the countries to work together and develop a HYCOS component. It is essentially based on consultation or preliminary discussions between WMO or its representative and the requesting institution(s). It should mainly describe the current status of hydrological networks, the issues that need to be addressed, and should clearly identify the objectives of the project. The concept document should contain the general agreement of NHSs from the interested participating countries to broadly concur to work under the principles of cooperation incorporated in these Guidelines (see annex I). The WMO



The project cycle



endorsed at a senior decision-making level and cover the following points:

- The primary and secondary objectives to be met, which, amongst others, will determine the kind of data to be collected and the information required by end-users;
- Criteria for the selection of sites to be included in the HYCOS network, according to the stated objectives;
- Establishment of the RC and its role and responsibilities and the way in which the RC will finally be selected by the countries;
- Data and information dissemination policy. An agreement among the NHSs participating in the project on sharing the hydrological data and information generated by the project is a prerequisite for the implementation and execution of all the subsequent project activities; this should take account of WMO Resolution 40 (Cg-XII) and Resolution 25 (Cg-XIII) (see annex II).

After receiving commitments from the interested participating countries in the form of a preliminary agreement to work in accordance with these Guidelines, WMO, in collaboration with the countries or a regional institution, will prepare a project proposal. The project proposal is to be developed based on consultations with all the interested participating countries and the regional institution(s) initiating the component. The participating countries are expected to provide input in the form of the status of the existing hydrological network, the existing gaps therein, the desired objectives and expected needs of the countries with respect to the network and capacity-building. The project proposal should contain the preliminary agreement among the participating countries committing themselves to the project. The proposal should identify links between the HYCOS component and the ongoing related projects in the region. It should also specify the proposed activities, expected results and input from the countries themselves as well as those expected from external sources. The document should provide a rough estimate of costs as well as the schedule for implementation once the

Secretariat will then prepare the project profile in collaboration with the interested countries or regional institution(s). Preparation of the project profile is funded by WMO as an activity under the Hydrology and Water Resources Programme (HWRP) of WMO.

4.1.3 Proposal stage

The successful implementation of the activities listed below is seen as a prerequisite for the preparation of a project proposal and later identification of ESAs and establishment of a HYCOS component.

Based on the project profile, the interested countries should reach a preliminary agreement to proceed with formulating the project proposal and further establishing a HYCOS. Such a preliminary agreement should be

project proposal finds financial support. The document should serve as a basis for soliciting financial support from ESAs. WMO provides the necessary technical and financial support and input to ensure an acceptable project proposal.

4.1.4 Preparatory implementation stage

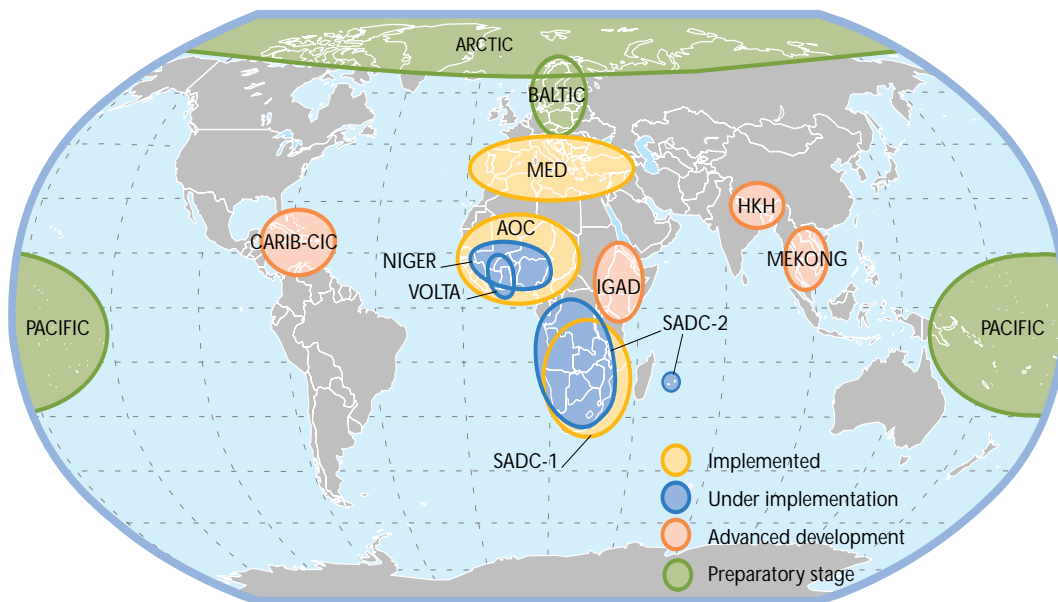
The implementation stages of a HYCOS project call for intensive funding over a long period of time and are taken up after identifying a potential financial partner who may express interest in funding one or both of the implementation stages of the project. In the former case, after formulation of the detailed project documents (DPDs), other ESAs will be solicited to participate and support the project.

The preparatory implementation stage involves the development of a DPD. The preparation of such a document calls for extensive consultations with all the participating agencies and stakeholders and is essentially seen as an activity that is financially supported through extrabudgetary resources and goes on to identify the ESAs. Ideally, the stage has to be funded by an ESA

that has interest in financing the full implementation stage, as this is essentially the preliminary stage of project implementation. The format of such a document should closely relate to the requirements of the ESA.

It should be kept in mind that the unit for the integrated sustainable development and protection of surface freshwater resources is a basin. Therefore, networks and related water resources information systems should be designed accordingly. However, for a number of reasons – especially political, administrative and financial reasons – some HYCOS components have been, and might be, designed and implemented on a regional basis and go beyond one basin or cut across basins; this situation should be avoided as far as possible. It shall be possible, therefore, for a country sharing more than one river basin to participate in more than one HYCOS project.

While preparing the DPD, it should be remembered that it is being developed primarily as a vehicle for promoting appropriate, robust and affordable technology and should be able to create national ownership, the requirements of which have to be clearly identified and officially endorsed at different levels



WHYCOS is implemented in the form of regional HYCOS projects



of responsibility and interest: political, economic, scientific and technical. At the detailed project preparation (DPP) stage, WMO contributes through identifying the training and capacity-building needs of the countries to ensure that the long-term sustainability of the project is ensured.

The DPD will cover all the technical and administrative details and field activities, such as the network to be strengthened, the sites to be equipped and the type of equipment to be installed, with a detailed budget and work plan. The preparatory implementation stage is devoted to initiating activities for the implementation of the project. It will include identification of a Project Steering Committee (PSC) and a Project Regional Centre (PRC) and the establishment of the Project Management Unit (PMU) and the administrative and financial arrangements with the RC. Various elements of the project should be prepared with due consideration for the issues raised in the following paragraphs.

4.1.5 Field implementation stage

This stage is devoted to fieldwork and includes procuring equipment, upgrading,

strengthening and installing new stations, establishing a regional database and information system and training activities. NHSs will be fully responsible for the fieldwork at national level in their country. They will provide financial support for the installation costs of the stations and other logistic support required. The PMU will facilitate and coordinate the field activities. The ESAs will financially fully support all activities during this stage including the running costs of the PMU and the costs of the executing, supervising agency. The implementation of the project will be supervised by WMO through regular monitoring, mid-term evaluation (to be submitted to the PSC) and training activities. A detailed governance and management structure for the implementation stages is described in section 6. WMO, with the support of the PRC and the PMU, 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.

4.1.6 Post-project stage (operation and maintenance)

Once the project period comes to an end and the donors fulfil their financial commitments, the participating countries will maintain the network and continue the activities under the project to ensure its sustainability. At this stage, participating countries should agree and decide on the continuance of the existence and functioning of the RC and the regional database. They should also continue their cooperation in the exchange of data and information. Through its continuous association with the NHSs, WMO should support the countries in this effort.

Post-project evaluation should be carried out three years after the closure of the project; this should form part of the commitment by the donor agencies at the DPP stage.

5. IMPLEMENTATION OF HYCOS COMPONENTS

The following paragraphs provide broad guidelines for the DPP stage. A somewhat detailed discussion is provided for certain cases with a view to work towards long-term sustainability (section 5.5) of the project from the detailed project formulation stage and is based on the experience gained from HYCOS components already implemented under WHYCOS. The activities of a HYCOS project generally consist of the following categories:

- (a) Improvement of national and regional hydrometric networks;
- (b) Establishment of a data collection and transmission system;
- (c) Development and implementation of a regional water resources information system;
- (d) Capacity-building.

The work plan for the project and the project implementation plan form part of the project itself and should be drawn up by the implementing agency or the PMU and endorsed by the PSC.

5.1 IMPROVEMENT OF NATIONAL AND REGIONAL HYDROMETRIC NETWORKS

It must be kept in mind that WHYCOS does not replace existing hydrological observing programmes, especially in terms of observation networks, but supplements them. An analysis of the existing network has to be carried out in accordance with the procedures laid down in the *WMO Guide to Hydrological Practices* (WMO-No. 168) and the gaps identified in relation to the overall water resources assessment and management in the participating countries. The existing network should also be evaluated for any deficiencies. Based on these studies, and keeping in view the overall primary objective and overall scope of the project, the hydrological stations to be

included in the project network should be selected. The selected network stations should fulfil the agreed common objective of the project. To ensure the sustainability of the system, it is recommended that all available equipment be studied and that the most suitable data collection and transmission system for the region be selected.

5.1.1 Site selection for new stations

The selection of hydrological stations should be governed by the principles of network design (chapter 20 of the *WMO Guide to Hydrological Practices*) and the proposed use of the data. The location of a particular station should be guided by the criteria laid down in the *Guide*. In addition, the following requirements should be met when selecting the site for setting up a data collection platform (DCP):

- (a) The site is readily accessible for the installation and operation of the DCP;



MED-HYCOS DCP in Croatia

- (b) Facilities for telemetry or satellite relay can be made available, if required.

5.1.2 Upgrading and modernizing existing stations

Analysis of the existing networks may necessitate the modernization of some important existing stations that are vital to the overall objectives of the HYCOS component and can provide the regional database with the required data for archiving. When choosing a selected HYCOS network station, in addition to responding to identified needs and in accordance with criteria set by the WMO *Guide to Hydrological Practices* and ISO standards, it should meet the following requirements:

- (a) A long historical record should be available;
- (b) A stable rating curve should be available;

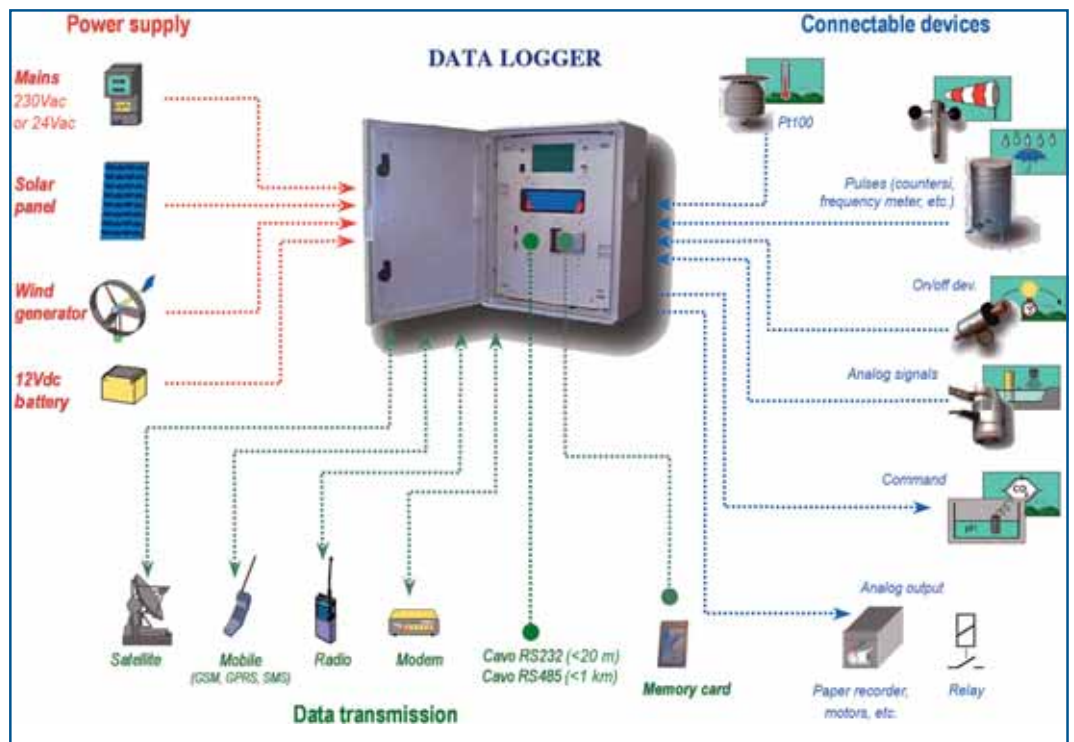
- (c) Time series should be homogeneous and stationary (the absence of which may indicate major consumptive water use);
- (d) Access should be easy;
- (e) Data collected should, as far as possible, reflect not too diverse a hydrological and climatic regime.

5.1.3 Instrumentation

Parameters

A HYCOS hydrological network station should be equipped for measuring the following set of variables:

- (a) Precipitation;
- (b) Temperature;
- (c) Humidity;
- (d) Water level:
 - (i) in rivers: to be converted to flow rate via a calibration table;



Multi-purpose data logger and interfacing devices

- (ii) in lakes or reservoirs: for environmental and/or management objectives;
- (iii) groundwater: in observation boreholes or wells;
- (e) Water quality (if guided by the objective).

Wherever required, and possible, additional variables such as wind speed and direction and solar radiation can be included.

Detailed specifications for the instruments should be established while preparing the DPD.

Data collection platforms

All sensors should be connected to a DCP forming an “intelligent” data collection system and on-site data logger. The main advantages of such a system as compared to other solutions are:

- (a) Elimination of human error in the reading of instruments;
- (b) Minimization of gaps caused by observation failure;
- (c) Avoidance of errors in reading or digitizing from graphical recording charts or paper tapes;
- (d) Direct transfer of the digital data into electronic databases;
- (e) Modulation of the rhythm of data acquisition according to the dynamics of each of the variables measured and the real needs.

These instruments should be compatible with the GTS as regards frequency and format.

Appropriate technology

Successful and sustainable HYCOS implementation requires the use of appropriate technology for a particular site. The instruments to be installed should be standard, simple, maintainable at a reasonable cost and appropriate for their intended functions, with a high level of demonstrated reliability and robustness. Variations in climatic conditions

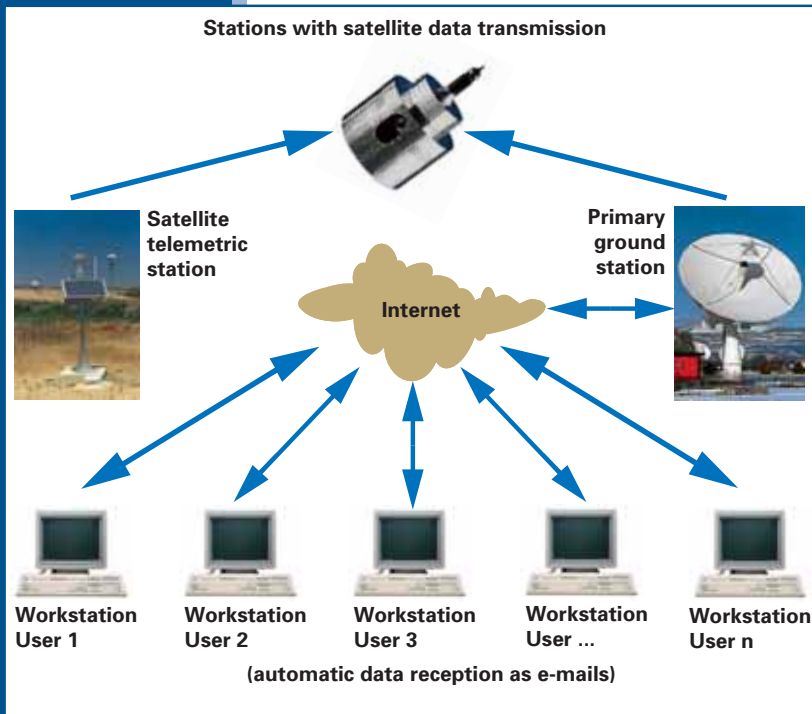
and technological and infrastructure facilities available in the participating countries have to be given due consideration while selecting the project equipment. Although WMO promotes the utilization of modern equipment for monitoring, with the resultant speedy access and dissemination of data, because of vandalism experienced in certain parts of the world, an alternative approach may be required.

Threats to the performance of instrumentation may be classified as (a) instrument failure; (b) natural hazards such as floods and lightning; or (c) theft or vandalism. It must be realized that instrumentation is fragile and does not tolerate errors in installation or electrical coupling beyond its tolerable limits. The possibility of theft and vandalism should be considered when selecting instruments and the location of stations. The most successful protective measure to combat theft and vandalism is to deploy a local observer to watch over the station who also takes gauge plate readings at regular intervals as a cross-check. Such control readings are useful as a quality check of the data. Moving away from automated modern equipment and communication systems towards older or basic technologies, however, introduces greater levels of human intervention. It may also be difficult to implement such a system in very remote places, and human error in readings may affect the quality of data and slow down data transmission. Although not desirable, this is more acceptable than a vandalized system with complete data breakdown.

It is, therefore, recommended that, in the detailed project design, preference be given to the utilization of modern technology, with recourse to older or basic technologies being made only when equipment security is a major concern. In such a case, it is obligatory to have a written agreement or memorandum of

Water-resources
monitoring





International water resources information system

understanding (MoU) between the participating country or river basin authority and the PRC regarding the frequency of data transmission and the maximum acceptable time lapse between reading and transmission of data to the project network. Although more difficult to implement, it is possible to use such a 'mix' of technologies to obtain greater sustainability.

Water quality

Measurement of water quality variables, such as conductivity, dissolved oxygen and turbidity, is optional, but has great value for early warnings of accidental pollution events. Water quality stations should be established in consultation and cooperation with the national agency primarily responsible for water quality monitoring. Fixed water quality instrumentation (such as conductivity probes) prove to be unreliable in certain hostile environments. Two possible options are the use of portable water-quality instrumentation and/or cooperation with the national or basin

authority water quality monitoring programme. If well designed, structured and operational, the latter option is advisable. If this is not the case, the HYCOS project should provide the necessary support to the appropriate national agency to implement a water quality monitoring network, which should form part of the stakeholders' group at the national level. Alternately, or in addition, identified water quality variables should be monitored by hydrologists or technicians from the national service, basin authority or PRC using portable instrumentation. This may not be the ideal solution when accidental pollution monitoring is one of the prime objectives.

5.2 DATA COLLECTION AND TRANSMISSION SYSTEM

5.2.1 Data transmission in real time

HYCOS stations should transmit data in near real time if the primary objective of the network so dictates and should therefore be equipped with an appropriate transmission system. The transmission of data in real or near real time is a prerequisite for the early warning and management of floods and accidental pollution events. Satellite technology has the greatest advantage despite the initial capital outlay for the equipment. The latest advances in instrumentation in terms of low power consumption are very attractive. Use of satellite telemetry through meteorological satellites and the GTS of WMO is of great advantage since it is provided free of charge for registered WMO programmes such as WHYCOS.

However, it may be appropriate to point out that the choice of telemetry is not necessarily related only to the degree of urgency of data required at the receiving point. Two other functions of telemetry have to be kept in mind while making the choice. One of the main reasons for using telemetry is to secure and speed up data transmission and to permit remote monitoring of the status of the condition of the instruments and the DCPs, thus reducing the requirement for

Technology	Equipment and installation costs	Cost of maintenance and operation	Reliability during floods	Form of data at point of measurement	Advantages/ disadvantages and comments
Observer and flood warning officer	Negligible (gauge plates and communication medium)	Salary of observer	Acceptable	Analogue	The officer fulfils two important duties
Landline telephone	Low	Low	Not acceptable	Analogue/digital	Prone to breakdowns during floods
Radio	Expensive (repeater stations required)	Medium to high (technician for maintenance required)	Risky but acceptable	Digital	Lightning protection compulsory. Theft and vandalism
Cellular telephone	Low	Low	Risky	Digital	Prone to overloading. Emergency channel required. Theft and vandalism
Meteorburst	Very expensive	Medium to high (technician for maintenance required)	Acceptable only for very large catchments	Digital	Requires master stations and service provider. Theft and vandalism
Satellite	Expensive	Low	Acceptable	Digital	Theft and vandalism

regular visits for data collection. The system should be selected to best meet needs and to cope with the ground conditions and available infrastructure.

5.2.2 Data transmission in near real time

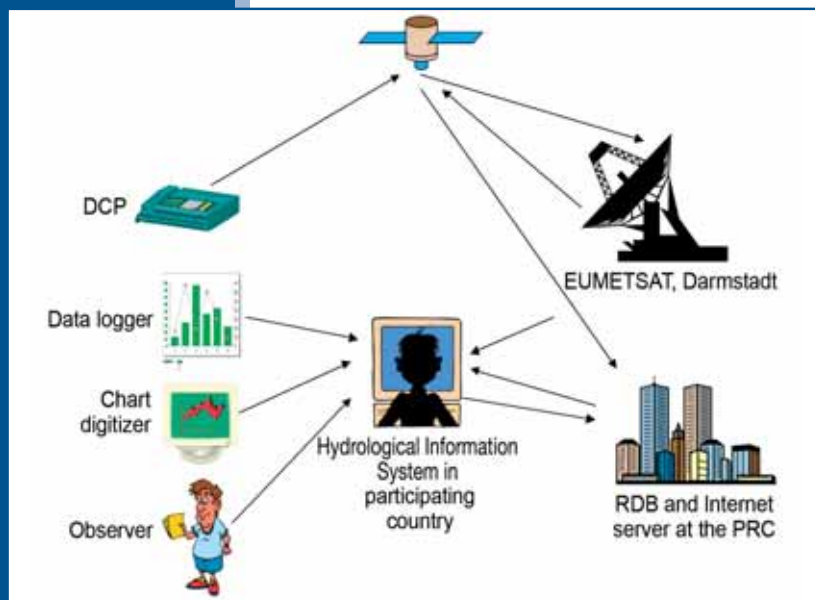
It is important to note that data transmission from the field to a national data centre (NDC) need not necessarily be in real time. For certain normal operational purposes, such as the management of reservoirs and hydroelectric plants, near-real-time data may suffice. The table above lists various technologies, which may be considered and evaluated for use in HYCOS for obtaining data in near real time.

These options range from a very basic system, utilizing the services of an observer who can also operate as a flood warning officer, to more advanced satellite-based systems. A basic system, if considered appropriate for the primary objective of the component, may be considered for incorporation into a HYCOS if other communication means for the transfer of data from the field

to an operational centre are not available. In such a case, the data will have to be converted from analogue to digital form at the centre. The main disadvantages of such a system are reliance on the human element and a longer delay between measurement and final use or archiving. Ancillary advantages of such a basic system are the creation of jobs, duality of reasonable responsibilities of the observer (data capturing and flood warning officer) and protection against vandalism and theft.



Data transmission station in Turkey



Data communication

Use of older communication technology, such as a radio system, should also be explored. A land-based radio system is restricted in terms of distance, but repeater stations may be utilized. A number of local observers may report to a central node equipped with satellite transmission technology. At such a node, all the information can be integrated and further transmitted via satellite to a regional or national centre. Observations can either be carried out manually or by using electronic instrumentation and sending them to a satellite base where they are converted into a digital format and transmitted to the project network. The main disadvantages of such a system are the number of nodes within a data chain and the possibility of failure caused by human intervention. It is possible that, after closer analysis, 'mixed technology' solutions, such as use of cellular or radio transmission systems in conjunction with the satellite transmission, may be feasible.

However, only generalized statements in terms of cost and operation can be made at this stage. An in-depth analysis and investigation of circumstances in the country; policies to combat poverty; availability of supporting technologies such as landlines,

GSM systems in remote places, and so on, should be carried out at the detailed project formulation stage, and the best solution should be adopted.

It is recommended that an MoU be drawn up between participating NHSs and the RC, addressing the issues of maintenance of equipment, calibration of stations and validation/verification of data.

5.3 DEVELOPMENT AND IMPLEMENTATION OF A REGIONAL WATER RESOURCES INFORMATION SYSTEM

The establishment of a regional data bank (RDB) is one of the main activities of any HYCOS project. An information system includes the following sub-activities:

- (a) Establishment of NDCs;
- (b) Establishment of an RDB;
- (c) Preparation of information (products);
- (d) Dissemination of information.

5.3.1 National data centres

Each country is expected to validate all raw data and maintain all related information and products of concern to the country at the NDC. A HYCOS project presents a unique opportunity to create data storage and archives for the existing NHS databases through data storage and retrieval systems. When electronic data banks do not exist, or are being developed by the NHSs, assistance should be provided for either upgrading or replacing the databases under the project. The possibility of using a standard database for the HYCOS components should be explored as the project provides advantages of economy of scale and immediate availability of a tried-and-tested appropriate database for national use and thereby avoids the development of a number of different databases.

For this purpose, NDCs at the NHSs participating in the project should be equipped with

appropriate computing equipment and e-mail and Internet connection in order to ensure a swift and reliable channel for receipt and exchange of data and products during the implementation of the project, and afterwards. The responsibility of processing all the data from the HYCOS stations within the country will lie with the NHSs of the country. The NHSs should regularly update rating curves and other relevant metadata for the stations in the HYCOS network. Sets of software for processing and analysing raw data should also be made available.

Additional equipment, such as routers, modems and dedicated data receivers, may be required for computer networking, links to the WMO GTS or use of cellular phones or radio transmission for the hub. Each participating NHS has to be provided with the necessary equipment and receive relevant training for its operation and maintenance. Training on using and adapting such programmes for the local environment should also be encouraged.

5.3.2 Regional data banks

An RDB is essentially for the storage and distribution of data related to the meteorological, hydrological and other related water resources information for all the participating countries through the NDCs, which act as nodes. The hub of the RDB shall be set up under the PRC. The computer storage system at the NDC located within the NHSs of the country shall be connected to the hub. To guard against accidents and attacks by viruses, a mirror image of each country's database will be maintained in the RDB computers at the PRC. Products and information, which are transboundary in nature, will be provided using the RDB.

Whatever data transmission system is selected, the RDB should be able to receive the raw data directly from the Internet or GTS (in the case of near-real-time data transmission) which must be replaced later by quality-checked validated data and data from

other stations not included in the HYCOS network.

The RDB should ideally be integrated with Web application software to enable the creation of a dynamic web site. The NHSs participating in the project and the RC should ensure easy data exchange by choosing logical or compatible data formats and data fields within the RDB. Automatic routines should be developed to facilitate the exchange of data with databases which may have different formats. Compatibility with existing databases developed under other HYCOS components should also be taken into account in the database design.

5.3.3 Preparation of information and products

National and basin-wide/regional products should be developed to support sustainable socio-economic development in the countries, to provide sound information for the sharing of water in transboundary river basins, forecast water-related hazards and issue warnings. These products should be identified during the project proposal phase. These could include regular information on the current situation and the trends of water resources, forecasts of natural hazards, statistical analysis of hydrometeorological data, spatial distribution of

*Information dissemination
via satellite*



hydrological parameters, physical characteristics of the river basins, etc. (see annex III). It has the advantage of informing the public as well as national and international organizations of the current state of the river. Such knowledge of the river dynamics of a region has the advantage of creating awareness, understanding and cooperation.

As far as possible, a comprehensive list of data products and information needs shall be assessed at the DPP stage and included in the work plan of the implementation stage. All product development activities should be undertaken in close consultation with the end-users, and their value and effectiveness continually evaluated using appropriate feedback systems.

5.3.4 Information dissemination

The IWRM concept, now universally adopted for sustainable development, requires a complete flow of information across various jurisdictional boundaries within a country and within the basin. To ensure this seamless flow, the available tools provided by information technology in the form of the World Wide Web should be effectively utilized. The development of a web site should be one of the sub-activities of each HYCOS project for the exchange of data and information among the various countries participating in the HYCOS and among various users within the country. The level of information to be placed on the Internet should be decided during the detailed project formulation stage, in consultation with the countries. These consultations should take due consideration of the commercial interests of the participating organizations.

Web design should allow easy access to data on the RDB and fast dissemination of hydrological data and products in text and graphic format. The tools developed for this purpose in the framework of other HYCOS projects could provide a technical basis for possible specific development. Each HYCOS web site should be connected to the WHYCOS portal maintained by WMO for the exchange of

information and experience among various HYCOS components.

5.4 FINANCIAL ARRANGEMENTS

Data and information related to water are essentially a public good. This is more so in the context of the new IWRM paradigm, in which all stakeholders, including the general public, are expected to participate in the process. As such, basic hydrological data collection should be, and is generally seen as, providing a public service and is largely funded through public finances. However, during recent years, the move towards a market economy has blurred this concept and public funding for maintaining basic hydrological data is on the decline. The WHYCOS programme is an attempt to reverse this trend by providing initial support for an improvement of the existing network. However, the long-term responsibility for the sustainability of the network remains with the national governments. This section describes the financial arrangements envisaged for the development, execution, management and sustainability of the HYCOS components, including during project execution.

WHYCOS is one of the major programmes/projects undertaken to address these issues. It is a project undertaken under the Basic Systems in Hydrology subprogramme of the HWRP of WMO. Since the magnitude of the problem being addressed through this project is vast, it cannot be handled through the regular budgetary resources of WMO. Support from international and bilateral funding agencies to improve hydrological data networks forms one of the pillars of the WHYCOS programme.

5.4.1 World Meteorological Organization

As described earlier, the project cycle starts with interested countries making a request to WMO for the development of a HYCOS component. WMO assists the interested countries or regional institutions making the



River gauging station

request in the initial stages of the project by undertaking negotiations and other related activities from its regular budget. After receiving a commitment from the countries to comply with the WHYCOS Guidelines and an MoU to cooperate to develop the project, WMO prepares a project proposal for submission to potential donors. The cost of these activities is met by WMO, which also undertakes to assist the countries and the regional institutions in seeking funds for the project implementation stages.

WMO will supervise the project implementation stages to ensure that the project is implemented in accordance with the WHYCOS objectives and in line with these Guidelines and will contribute towards the preparation of DPDs and the regular evaluation and assessment of project implementation. The activities undertaken by the WMO Secretariat in performing its functions in the implementation stages are financed through project funds. The expenditure is categorized in two parts: a fixed unit cost component and a reimbursable component. The fixed unit cost is based on the man-months expected to be spent on supervising and providing technical support. The

reimbursable cost covers the activities that are actually carried out under the project such as travel expenditure in connection with the project activities, consultants engaged in carrying out project-related activities, etc. Both these costs are subject to overhead charges according to WMO financial rules.

5.4.2 External support agencies

Donors will supervise the financial aspects of the project. The role of ESAs (donors) in HYCOS components is to:

- (a) Provide financial support to the project;
- (b) Provide financial guidance and supervision to the executing agency (EA), the project implementing agency (PIA) and the PMU;
- (c) Ensure that the expenditure and tendering procedures of the project are carried out according to the rules and financial regulations of the donor agency.

By definition, a HYCOS component generally covers large areas and activities involving a number of countries, and the implementation of the project may continue over a period of several years. Thus, the cost of the project implementation stage is substantial and may not fall within the interest zone of a single donor. In such a case, it would be necessary to pool resources from different donors through different channels (international, regional, bilateral). This also means that sometimes it might be preferable to limit the size of HYCOS components. However, as the number of funding sources increases, a number of constraints and problems arise, notably in the financing aspects (i.e. application of rules, eligibility of countries to grants, tendering procedures, etc.), which often differ from one donor to another. Moreover, for the sound evaluation of the cost-effectiveness of their contribution, some donors prefer to fund an identified stand-alone project rather than contributing in a non-differentiated manner to the support of

AFRICAN MINISTERIAL COMMITMENTS ON IMPLEMENTATION AND PARTNERSHIPS FOR ACHIEVING THE WATER AND SANITATION TARGETS

Too many preventable diseases and deaths and economic losses are caused by floods, droughts, pollution and other water-related hazards. Droughts, floods and storms are becoming more common and severe in Africa. The human and environmental costs of weather, climate and water related disasters have increased dramatically over the past 40 years. Equilibrium shifts are impacting the resilience of ecosystems, affecting water availability and creating increased water stress in many regions. Hydrological and meteorological data and information are essential for fundamental basis of IWRM.

- To increase our funding to the institutions responsible for the maintenance and operation of the hydrological and meteorological networks in Africa and to enlist, for this purpose, the support of development cooperation partners and financial institutions.
- To foster data and information exchange as a baseline requirement to ensure improved early warning and forecast, especially in trans-boundary basins. To support the expansion of the World Hydrological Cycle Observing System (WHYCOS) and other networking mechanisms to cover all regions and river/lake basins in Africa.

Pan African Implementation and Partnership Conference on Water
(Addis Ababa, Ethiopia, December 2003)

a larger project. In such a situation, they are encouraged to fund specific activities of the project through WMO or directly. In such cases, the project should adopt WMO's financial regulations and procedures.

Nevertheless, it is extremely important to involve potential donors right at the beginning of the implementation process, i.e. from stage C (project proposal stage) and the preparation of the DPD. This would require a substantial effort by the regional institution involved and may require political initiative from the participating countries, with the support of WMO.

5.4.3 National Hydrological Services (NHSs – national implementing agencies)

NHSs will assist the PMU in the implementation process at national level. They will carry out all the installation activities inside the country and will provide logistic support for project implementation. The cost of these

activities will be covered by NHSs as national contributions to the project, unless otherwise specified in the DPD. They will coordinate and cooperate with the PMU, the RC and the RDB to ensure the successful implementation of the project. They will also run and maintain the project after donor support ends to ensure project sustainability.

5.5 PROJECT SUSTAINABILITY

The ownership of the project lies with the countries. The long-term sustainability of a HYCOS component once external funding ends is considered a prerequisite and should be addressed right from the initial stages and subsequently in the implementation stages of the project's development. Long-term sustainability of the project would depend on:

- (a) The commitment of the countries;
- (b) The robustness of the project elements;
- (c) The capacity of the country to absorb and maintain the technology.

5.5.1 Commitment

The commitment of the countries to continue supporting the participation of their NHSs in the day-to-day activities and smooth functioning, such as data collection, operation and maintenance of the network, quality control and primary processing of data, database updating, preparation of products, dissemination of data and information, etc., must be firm and persistent. This commitment should be demonstrated through the establishment of MoUs between the PRC and the governments to commit themselves to sustain the project in the medium and long term by including it in their national programmes. In return, the project must provide the countries with access to high-quality regional information truly relevant at national level. This includes the status (storage and use) and trends of water resources along international waterways, timely information on floods, droughts, accidental pollution, etc.

5.5.2 Robustness of the project elements

It is important to choose the right types of instruments and technology for HYCOS components which can withstand adverse extreme weather conditions in the participating countries. The technology used in the instruments should be such that it can be maintained in the long term by the countries. The issues discussed in section 4 should be kept in mind while preparing the DPD as well as when making final decisions on the choice of the instruments deployed in the project. Efforts should be made to ensure that instruments using the same technology as those already being used in the country (unless obsolete or outdated) shall be used. This will enable countries to obtain spare parts and keep expertise available for the functioning and maintenance of the instruments and equipment under the project in the long term. At the time of developing the project document or before

deciding the detailed specifications for the instruments and equipment, an overview of the available hydrometeorological equipment and technology being used by the countries should be considered, including the facilities, expertise and infrastructure available for its maintenance.

5.5.3 Capacity-building

Consistent information dissemination will foster cooperation among participating countries and thus fulfil an important secondary objective of WHYCOS. This can be achieved by capacity-building within the NHSs and ensuring interaction with other activities of the project and other relevant ongoing and/or planned projects.

To support the reinforcement of national capabilities in technical fields specific to the project, and to contribute to the long-term sustainability of the project results, specific training events should be included in the DPD and organized for the staff of the participating NHSs. The recommended subjects of the training courses would cover:

- (a) Installation, commissioning, operation, maintenance and troubleshooting of DCPs;
- (b) Use of GTS (if applicable);
- (c) Development and management of hydrological data banks;
- (d) Web-site development and use of Internet technologies (html, java, cgi, etc.);
- (e) Marketing of hydrological products, water resources management, etc.;
- (f) Data analyses and forecasting.

Capacity-building within the NHSs



6. GOVERNANCE AND MANAGEMENT STRUCTURE OF HYCOS COMPONENTS

Each HYCOS component is developed to meet specific regional and national needs and calls for cooperation and coordination among countries, institutions and organizations. For this purpose, it is essential to establish a governing structure for the project in order to oversee and synergize various activities, coordinate the execution of various elements of the project, monitor and evaluate progress and provide guidance wherever and whenever necessary. The management structure may have to be tailored to comply with regional and national conditions and needs. A general suggested management structure is described below.

6.1 GOVERNANCE – PROJECT STEERING COMMITTEE

The PSC will be the highest executive body of the project. Its role will be to ensure project coherence and oversee project policy, strategy and implementation. It will decide on any changes to the plan of activities as described in the project document and approve the annual work plan and budget. The Committee will consist of the following members:

- (a) A representative from each participating country (national implementing agency (NIA));
- (b) A representative of the implementing agency (regional/national institution);
- (c) A representative of WMO;
- (d) A representative of the donor(s);
- (e) A representative of the EA (regional economic or river/lake basin organization);
- (f) A representative of the PMU (project manager).

The PMU project manager can serve as secretary of the PSC. To ensure that the Committee is fully effective, it will be desirable to obtain

the commitment of the participating countries (through MoUs with the implementing agency) to make available representatives who will be able to devote the time needed for the work of the Committee.

The responsibilities of the PSC are to:

- (a) Ensure project implementation in accordance with the WHYCOS objectives and Guidelines;
- (b) Determine strategies to ensure that the objectives of the project are fulfilled during the implementation stages;
- (c) Approve the project implementation plan;
- (d) Approve the annual work plan and budget;
- (e) Ensure that the expenditure and tendering procedures of the project are carried out according to the rules and financial regulations of the donor agency;
- (f) Approve the selection of professional staff for the PMU;
- (g) Monitor and evaluate project implementation;
- (h) Approve any changes to the work plan or budget;
- (i) Manage problems or disagreements among participating countries or any of the partners related to the project and regional organizations;
- (j) Provide a communication channel with other regional bodies and HYCOS components.

6.2 MANAGEMENT STRUCTURE

The basic management structure for the implementation of the project usually includes the following:

- The NIAs – NHSS
- The PMU

- The PIA – regional/national institution (PRC)
- The EA
- The supervising agency (SA)
- The ESAs

The responsibility and role of each of these bodies need to be clearly defined in the plans for the project. One or more of the functions of the above bodies can be assigned to the same institution depending on the existing institutional set-up and agreement among project partners. These relationships need to be defined at the project proposal stage.

6.2.1 National implementing agency – National Hydrological Service

The participating countries will have national responsibilities for project implementation. To assure project success and to help ensure post-project sustainability, it is essential to have the agreement of participating countries to undertake these responsibilities, in the form of an MoU between NHSs and the EA/PIA. The partner countries should commit themselves to provide real-time data generated under the project as well as historical data essential for the expansion of the regional database and the development of hydrological products. The likelihood of project success will be increased if funds can be provided to the NIA/NHS to cover their project-related costs.

The responsibilities of the NIA are to:

- Coordinate implementation activities at national level with the PIA;
- Provide support to missions by PSC members and staff from the PMU/PRC and contractors;
- Provide appropriately qualified staff to participate in project activities, as required;
- Manage any impediments to successful project implementation (e.g. land access and acquisition);
- Carry out installation and other work required to implement the national component of the project (the

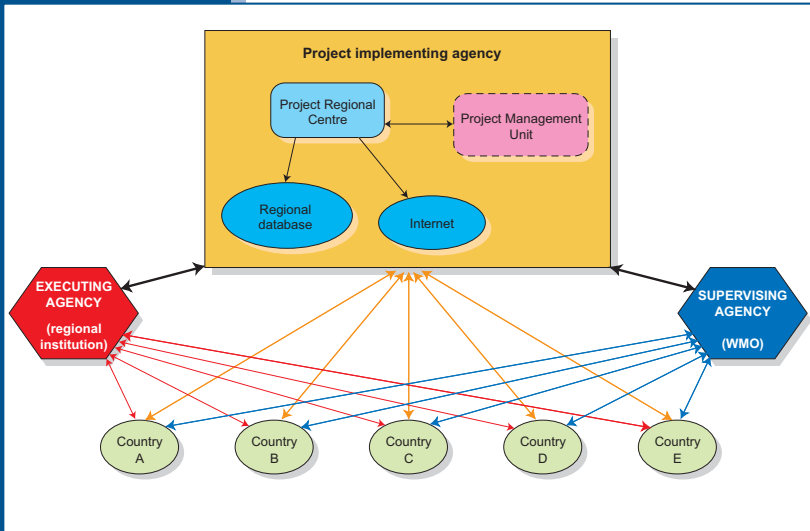
- sub-projects), with the assistance, where needed, of the PRC and contractors;
- (f) Validate raw data received at the NDC and provide it to the PRC regional database;
- (g) Perform ongoing, routine activities related to operational water resources assessment and monitoring, and the operation and maintenance of project installations;
- (h) Understand the users' data needs by organizing national workshops under the project;
- (i) Disseminate data and information to users, and to the PRC;
- (j) Provide information about the project to national bodies and the public.

6.2.2 Project implementing agency – Project Regional Centre

For each HYCOS component, the participating countries agree upon a PRC to be housed in a relevant existing regional or national institution of one of the participating countries to be designated as the PIA. The PIA will host the PRC and the PMU and should commit itself to maintain the PRC during the post-project period.

*ARGOS remote sensing
DCP*





Project management structure

The PRC is the dedicated structure within the implementing agency. It will act as a focal point to coordinate project activities implemented in, and by, the participating countries and provide a forum for the exchange of expertise. Besides creating and maintaining the spirit of cooperation among the participating countries, the PRC also plays a vital role in the implementation of the project. According to the circumstances, and depending on agreements reached by the countries in its terms of reference, its role can cover a varying range of project activities which include the management and updating of the regional database and the operation of the Internet server of the project. The duration of the PRC is a decision made by the countries, which might decide to transform it into a permanent structure for supporting IWRM, especially on the river basin scale. The institutional framework for hosting the PRC shall be based on an official commitment of the administrative and financial authority responsible for the hosting institution (national, regional, international) and shall notably include the institutional and administrative arrangements proposed (running costs, secondment of personnel, etc.).

The responsibilities of the PRC are as follows:

- (a) To monitor DCPs and forward data to NHSs that do not have direct access to satellite data;
- (b) To provide all services (training, ongoing assistance and advice, etc.) which are not provided under other contracts;
- (c) To manage a regional database and associated functions (data dissemination, etc.);
- (d) To foster regional, technical and scientific cooperation in the fields of water resources assessment, monitoring and management;
- (e) To provide a forum for the exchange of expertise and knowledge;
- (f) To develop and implement an information system;
- (g) To develop and maintain the web site of the HYCOS component.

The PMU will be established and hosted by the PIA to execute tasks identified in the DPD. The role of such a centre is crucial for the success of a HYCOS component. It will have the prime responsibility for day-to-day project implementation. The PMU should invariably be located in an existing regional or national institution selected on the basis of the terms of reference agreed on by the countries. The PIA shall, amongst others, make available premises, telecommunications (telephone, fax, Internet access) and other logistical support to the PMU.

The PMU can be part of the PRC or a separate entity within the PIA. However, the existence of the PMU is restricted to the duration of the project as its main function is to coordinate project activities implemented in, and by, the participating countries.

While identifying the PRC for a HYCOS project, it is recommended to consider co-locating HYCOS PRCs and WMO Regional Climate Centres (RCCs), to benefit from sharing common infrastructure, services such as training, association of skill sets in data management, Web development, shared

telecom needs, etc. Such an arrangement will help the development of climate-water products, and joint climate-water support for disaster prevention planners and the media, and eventual climate-water studies related to climate change, etc. Co-location can reduce costs within the regions, support integrated products and marketing, and make regional supervision easier. Further, this will help NHSs to participate in regional climate outlook forums.

6.2.3 Project executing agency

The project executing agency (PEA) will coordinate and facilitate the project's regional activities and foster regional cooperation in the field of water resources management among the participating countries. It will provide regional support to the project and will ensure that the regional aspects of the project are fulfilled. It is desirable to have one of the existing regional economic institutions or river/lake basin organizations as the EA for the project. The responsibilities of the PEA are as follows:

- (a) To provide regional support to the project;
- (b) To collaborate with WMO in initiating and implementing the project;
- (c) To discuss and negotiate with donors to secure funds for the project;
- (d) To provide necessary logistic support to the PSC;
- (e) To monitor, evaluate and support the project in close collaboration with WMO and through participation in the PSC meetings.

6.2.4 Project supervising agency

The project supervising agency (PSA) will supervise and facilitate technical aspects of the project and provide technical and scientific guidance. WMO, as the custodian of WHYCOS, will act as an SA, providing critical technical services to guide the PIA on the implementation of the project, ensuring that

the project reaps maximum benefits from lessons learned in implementing other HYCOS projects and ensuring its linkage with ongoing or planned HYCOS components and with the WHYCOS programme.

The responsibilities of the PSA are to:

- (a) Provide technical and financial support for the initiation stages of the project;
- (b) Prepare a project profile and project proposal;
- (c) Take a lead role in seeking funds for project implementation;
- (d) Supervise and facilitate technical aspects of the project to ensure successful implementation;
- (e) Provide technical support to the PIA and the PMU;
- (f) Support the preparation and evaluation of tenders for equipment and services;
- (g) Provide links with the meteorological community (NMS and EUMETSAT) to facilitate use of GMS satellite and exchange of data through the GTS and Internet;
- (h) Monitor, supervise, evaluate and support the project, through regular missions and participation in the PSC meetings;
- (i) Ensure sustainability of the component in the post-project stage;
- (j) Ensure links with other HYCOS components.

7. PROJECT MONITORING AND EVALUATION

Monitoring and evaluation are essential management functions that are interactive and mutually supportive. Monitoring and systematic reporting must be undertaken for all projects.

7.1 PROJECT MONITORING

The PRC and the PMU, in collaboration with the executing and supervising agencies, should produce a quarterly progress report on the implementation and operation of the project. The report should measure achievements against the original objectives and activities. Pertinent statistics on raw data and validated archived data will be supplied for all variables. Progress as regards the creation and use of hydrological products as well as the extent of usage of the project's web site, amongst others, should be reported on. These reports shall be tabled at the meetings of the PSC. The project monitoring should include a mid-term evaluation and, where necessary, redefine targets and review the strategy for achieving the overall targets and objectives of the project. As the PSA, WMO will submit yearly monitoring and evaluation reports.

7.2 POST-PROJECT EVALUATION

The post-project evaluation report captures and documents key project metrics at an appropriate point in time after project completion, for the purpose of comparing and validating the initial objectives, justification for the project and customer satisfaction.

The approach of the post-project evaluation uses project metrics and user surveys to determine the extent to which the project

satisfied countries' requirements and met all specified targets for scope, budget, schedule and quality. Also, the evaluation is intended to assess the effectiveness of the processes and methods used in the project, for the purpose of capitalizing on successes and ongoing continuous improvement. It should compare the initial project metrics from the initial project plan against the final project plan. Post-project evaluation should form part of the detailed project proposal, keeping in view requirements of the ESA associated with the project, and include the following:

- Scope parameters
- Budget (projected vs. actual)
- Benefits/return on investment
- Schedule

The project document should specify the post-project evaluation date and document the rationale for performing the evaluation at that time. A time lag between project deployment and post-project evaluation should be specified to allow for indicators, so as to have meaning while still being close enough to project deployment to have relevance.

WMO, in collaboration with the ESA and the EA, i.e. the basin or regional authority, should appoint an independent expert (or experts) for post-project evaluation. Specific focus should be given to the success of technology and knowledge transfer and an assessment of continuation of the project for a further term without support from a PMU. The need for the continuation of a PRC should be assessed. Indicators for measuring sustainability and efficiency once the project ends should be established. The cost of such an activity should be included in the project budget.

8. POLICY AND COORDINATION ISSUES

8.1 DATA EXCHANGE AND DISSEMINATION

The basic principle in implementing HYCOS components is that countries are the owners of the data and their NHTs are responsible for the control of these data in accordance with national regulations. Therefore, absolute priority must be given to the fact that all countries participating in a HYCOS project must be able to receive simultaneously and check the quality of data collected and transmitted by the network.

In order to develop a regional cooperation 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. WMO Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities, and Resolution 25 (Cg-XIII) – Exchange of hydrological data and products, constitute an internationally agreed framework for the formulation of such a policy.

The participating countries should undertake an agreement to share and ensure access to data, information and products. This agreement should address (i) the real-time data collected by the project; (ii) data collected at other monitoring sites not equipped with near-real-time transmission systems; and (iii) the corresponding historical data at the sites identified in (i) and (ii). Moreover, the countries should be encouraged to contribute data and information to global data centres such as GRDC, the Global Precipitation Climatology Centre (GPCC) and the Global Environmental Monitoring System-Water (GEMS-Water), not only from the stations established under the HYCOS projects, but also from additional

national monitoring stations for operational, research and documentation purposes on long time series, trends and hydrological extremes such as floods and droughts.

8.2 WHYCOS COORDINATION MECHANISM

To support and ensure successful implementation of the WHYCOS programme, it is recognized that its activities need to be adequately coordinated and an appropriate coordination mechanism established. The mechanism consists of two components, as described below.

8.2.1 The WHYCOS Coordination Group

The WHYCOS Coordination Group (WCG) serves as a WMO internal coordination mechanism to ensure that the inputs of the various departments concerned within the WMO Secretariat are linked to the WHYCOS programme.

The WCG is established with specific terms of references, namely to:

- (a) Ensure coordination of technical, scientific, legal and resource mobilization and



The WHYCOS web site



- policy aspects of the implementation of specific HYCOS components, including preparation of agreements;
- (b) Establish cost-recovery mechanisms for those HYCOS components in which WMO plays a supervisory role;
 - (c) Ensure coherence with other WMO projects and programmes.

The WCG consists of the Deputy Secretary-General (DSG) and the Directors of the World Weather Watch (WWW), Regional and Technical Cooperation Activities for Development (RCD), Resource Management (REM) and Hydrology and Water Resources (HWR) Departments. The Directors of the Education and Training (ETR) Department, WCP and GCOS and Directors of the Regional Offices can also participate, as appropriate. Meetings of the WCG which address overall policy aspects related to WHYCOS are chaired by the Secretary-General, while those concerning implementation issues are chaired by the DSG. The Group meets annually and D/HWR acts as the secretary of the Group.

8.2.2 The WHYCOS International Advisory Group

The WHYCOS International Advisory Group (WIAG) serves as an external coordination mechanism to ensure worldwide operational linkage among the various HYCOS components and to coordinate all technical aspects of the programme. It provides overall guidance to establish a common conceptual basis and ensure consistency of practice and results. For

this purpose, the WIAG has been established with specific terms of reference, namely to:

- (a) Undertake a periodical review and assessment of the status of development of the overall programme and its regional projects and recommend adjustments as necessary;
- (b) Discuss and recommend strategies for a coordinated development of the various WHYCOS components;
- (c) Consider and propose plans to improve the feasibility of the programme;
- (d) Explore and propose ways and means to sustain and expand the programme, notably through new financing mechanisms.

WIAG is composed of the president of the Commission for Hydrology (CHy), as chairperson, and representatives of the HYCOS Regional Centres, the member of the CHy Advisory Working Group responsible for WHYCOS, ESAs, the regional Hydrological Advisers concerned, the WMO Secretariat (HWRD) and other departments, as appropriate.

In addition, observers may be invited by the WIAG to participate in certain meetings, depending on the agenda, such as representatives of chairpersons of the Regional Associations Working Groups on Planning and Implementation of the WWW; relevant regional groupings (e.g. the Southern African Development Community (SADC), the Intergovernmental Authority on Development (IGAD), etc.); other ESAs; other related global programmes (GRDC, GEMS-Water, GCOS, FRIEND, etc.); international scientific and professional associations (the International Association of Hydrological Sciences (IAHS), the International Commission of Irrigation and Drainage (ICID), etc.); and other users. The WIAG meets once every year and D/HWR acts as the secretary of the Group.

8.3 COLLABORATING CENTRE

A collaborating centre is an institution designated by WMO on the basis of certain criteria to form part of an international collaborative

network carrying out activities in support of the Organization's programme at various levels. A department or laboratory within an institution or a group of facilities for reference, research or training activities belonging to different institutions may be designated as a collaborating centre. A collaborating centre plays an essential role in helping the Organization in implementing its work and programme priorities, in close coordination with HWRD, and assists in developing and strengthening the institutional capacity of countries and regions.

8.3.1 Criteria for a collaborating centre

The criteria for a collaborating centre are as follows:

- (a) A centre with activities related to water;
- (b) A centre with experience in WMO activities;
- (c) A centre with good facilities for training and research;
- (d) A centre with the ability to generate and raise funds;
- (e) A centre with good links with potential donors.

8.3.2 Tasks of a collaborating centre

Within the WHYCOS context, a collaborating centre may carry out the following functions:

- (a) To assist in preparing draft HYCOS project proposals;
- (b) To assist with project implementation through the introduction and monitoring of standard operating procedures and capacity-building;
- (c) To assist with the identification and development of hydrological products to meet specific national and regional needs;
- (d) To transfer technology among HYCOS Regional Centres;
- (e) To assist in mobilizing funds in support of the programme.

PRIORITY AREAS IN TRAINING FOR CAPACITY-BUILDING

Priority areas in training for capacity-building are divided into three categories: core activities, tools, and applications and management.

1. Core activities

- (a) Design and evaluation of hydrological networks;
- (b) Hydrological instruments: maintenance, upkeep and calibration;
- (c) Standard data collection methodologies (including water quality monitoring);
- (d) Discharge measurement techniques;
- (e) Installation, operation and maintenance of automatic stations;
- (f) Safety measures in hydrometry;
- (g) Data management (processing, storage, retrieval and dissemination);
- (h) Measurement of physiographic characteristics.

2. Tools

- (a) Water resources information systems;
- (b) Hydrological modelling;
- (c) Time series analysis;
- (d) Hydrological forecasting systems;
- (e) Flood forecasting techniques;
- (f) Remote sensing.

3. Applications and management

- (a) Water resources assessment;
- (b) Flood estimation, design and management;
- (c) Integrated water resources management;
- (d) Irrigation and agricultural drainage;
- (e) Environmental issues (impact assessment and ecological flow requirements);
- (f) Extreme event analysis;
- (g) Management of hydrological services;
- (h) Evaluation of national capabilities;
- (i) Project development and management;
- (j) Resource mobilization.

ANNEX I — EXAMPLE OF AN AGREEMENT BETWEEN THE PARTICIPATING COUNTRIES AND THE PROJECT REGIONAL CENTRE

INTRODUCTION

1. The _____ HYCOS project aims at the development of an efficient and easily accessible regional water-related information system for the _____ basin/region. The ultimate goal of the project is _____. To achieve this, the project will _____.

COOPERATION AND COLLABORATION

2. The _____, referred to hereinafter as “_____”, and the _____ representing the Project Regional Centre, referred to hereinafter as “_____”, agree that with a view to facilitating the implementation of the _____ HYCOS project, they will act in close cooperation with each other and consult each other regularly with regard to matters related to the implementation of the project. The _____ and the _____ also recognize and comply with the WHYCOS Guidelines for development, implementation and governance.

TASKS AND RESPONSIBILITIES

3. The _____ undertakes to:

- (a) Nominate the representative of the country in the Project Steering Committee;
- (b) Identify a focal point in the country to devote his/her time to collaborate with the Regional Centre for the field activities of the project in the country;
- (c) Coordinate the activities related to the project among various national agencies and end-users involved in the implementation of the project within the defined scope of the project and as modified from time to time by the Steering Committee;
- (d) Identify the products required by various stakeholders as deliverables from the project within its defined scope.

4. The _____ recognizes its responsibilities to facilitate the implementation of the field activities related to the project, in particular its responsibility to:

- (a) Undertake administrative approvals and arrangements for the import of equipment and services and construction activities in relation to the implementation of the components of the project;
- (b) Provide all relevant information for setting up the regional database, including the web site;
- (c) Carry out the civil works for the installation of the equipment.

5. The _____ recognizes the responsibilities assigned to the Regional Centre for the implementation of the project as laid down in paragraph 7 below. In particular, it recognizes the mandate of the Regional Centre to ensure that the data obtained in the course of the project are accurate and reliable. In this regard, the _____ undertakes to validate the data collected in the country. It also undertakes to comply with and adopt the common standardized procedures and methods as issued by WMO from time to time.

6. The _____ also recognizes the importance of WMO Resolution 25 (Cg-XIII) – Exchange of hydrological data and products, and agrees to share all the required data with the regional database at the Regional Centre to enable formulation of the regional hydrological products. Accordingly, the _____ and the Regional Centre will ensure together that data related to the Volta basin in general and the project in particular are properly archived on the regional and national databases through the project procedures.

7. The Regional Centre recognizes its responsibility for implementation of the activities planned under the project, in particular its responsibility to:

- (a) Act as focal point for coordinating the project activities carried out in, and by, participating countries;
- (b) Provide countries with the support and advice needed to successfully establish the network of data collection platform (DCP) stations;
- (c) Manage the network of DCP stations and transmit data to participating countries which do not have direct access to satellite transmission systems;
- (d) Develop, manage and update the regional database, taking into account tools already developed under other HYCOS projects;
- (e) Develop hydrological information products adapted to countries' needs and appropriate means for delivering them to end-users;
- (f) Develop, manage and update the project's web site;
- (g) Carry out all the activities specified in the project document which are not subcontracted out, such as training seminars, advice on how to manage the DCP network, etc.;
- (h) Encourage regional cooperation in water resources assessment, monitoring and management;
- (i) Act as a forum for sharing expertise and skills.

WORKING ARRANGEMENTS AND FINANCING

8. Appropriate arrangements shall be made from time to time for the implementation of field activities in the country.

9. The _____ will receive financial support from the project budget as identified in the project document to ensure timely and successful implementation of the project activities in the country.

10. This agreement shall come into force upon its signature by both parties.

ANNEX II — RESOLUTION 25 (Cg-XIII)

EXCHANGE OF HYDROLOGICAL DATA AND PRODUCTS

THE CONGRESS,

NOTING:

(1) Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities,

(2) The inclusion of dedicated observations of the climate system, including hydrological phenomena, as one of the four main thrusts of The Climate Agenda, which was endorsed by Twelfth Congress,

(3) That Technical Regulation [D.1.1] 8.3.1(k), states that, in general, the routine functions of National Hydrological Services (NHSs) should include, *inter alia*, "making the data accessible to users, when, where and in the form they require" and that the Technical Regulations also contain a consolidated list of data and product requirements to support all WMO Programmes,

(4) That the nineteenth Special Session of the United Nations General Assembly agreed, in its overall review and appraisal of the implementation of Agenda 21, that there is an urgent need to "...foster regional and international cooperation for information dissemination and exchange through cooperative approaches among United Nations institutions, ..." (A/RES/S-19/2, paragraph 34(f)),

(5) That the fifty-first session of the United Nations General Assembly adopted, by resolution 51/229, the Convention on the Law of the Non-navigational Uses of International Watercourses, Article 9 of

which provides for "regular exchange of data and information",

(6) That the Intergovernmental Council of the International Hydrological Programme of the United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted at its twelfth session Resolution XII-4 which dealt with the exchange of hydrological data and information needed for research at the regional and international levels,

CONSIDERING:

(1) The significance attached by the International Conference on Water and the Environment (ICWE) (Dublin, 1992) to extending the knowledge base on water and enhancing the capacity of water sector specialists to implement all aspects of integrated water resources management,

(2) The call of world leaders at the United Nations Conference on Environment and Development (UNCED)(Rio de Janeiro, 1992) for a significant strengthening of, and capacity building in, water resources assessment, for increasing global commitment to exchange scientific data and analyses and for promoting access to strengthened systematic observations,

(3) That the United Nations Commission on Sustainable Development (CSD) in its Decision 6/1 "Strategic Approaches to Freshwater Management" has strongly encouraged States to promote the exchange and dissemination of water-related data and information, and has recognized "the need for periodic assessments ... for a global picture of the state of freshwater resources and potential problems",

(4) The call by the nineteenth Special Session of the United Nations General Assembly "for the highest priority to be given to the serious freshwater problems facing many regions, especially in the developing world" and the "urgent need ... to strengthen the capability of Governments and international institutions to collect and manage information ... and environmental data, in order to facilitate the integrated assessment and management of water resources",

(5) The requirements for full, open and prompt exchange of hydrological data and products in support of various international conventions, such as the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and the Convention to Combat Desertification,

(6) The requirement for the global exchange of hydrological information in support of scientific investigations of world importance such as those on global change and the global hydrological cycle, and as a contribution to relevant programmes and projects of WMO, other United Nations agencies, the International Council for Science (ICSU) and other organizations of equivalent status,

(7) The opportunities for more efficient management of water resources and the need for cooperation in mitigating water-related hazards in transboundary river basins and their water bodies which depend on the international exchange of hydrological data and information,

(8) The increasing recognition through scientific and technical endeavours, such as the Global Energy and Water Cycle Experiment (GEWEX), of the importance of hydrological data and products in improving the understanding of meteorological processes and subsequently the accuracy of meteorological products,

RECOGNIZING:

(1) The responsibility of Members and their NHSs to provide for the security and well-being of the people of their countries, through mitigation of water-related hazards and sustainable management of water resources,

(2) The potential benefits of enhanced exchange of hydrological data and information within shared river basins and aquifers, based on agreements between the Members concerned,

(3) The continuing need for strengthening the capabilities of NHSs, particularly in developing countries,

(4) The right of Governments to choose the manner by which, and the extent to which, they make hydrological data and products available domestically and internationally,

(5) The right of Governments also to choose the extent to which they make available internationally data which are vital to national defence and security. Nevertheless, Members shall cooperate in good faith with other Members with a view to providing as much data as possible under the circumstances,

(6) The requirement by some Members that their NHSs earn revenue from users, and/or adopt commercial practices in managing their businesses,

(7) The long-established provision of some hydrological products and services on a commercial basis and in a competitive environment, and the impacts, both positive and negative, associated with such arrangements,

ADOPTS a stand of committing to broadening and enhancing, whenever possible, the free and unrestricted¹ international exchange² of

¹ "Free and unrestricted" means non-discriminatory and without charge. "Without charge", in the context of this resolution, means at no more than the cost of reproduction and delivery, without charge for the data and the products themselves.

² "Exchange", in the context of this resolution, means the movement of data and products between countries or, as is more likely the case in the field of hydrology, the movement of data and products from one country to another.

hydrological data and products, in consonance with the requirements for WMO's scientific and technical programmes;

FURTHER ADOPTS the following practice on the international exchange of hydrological information:

(1) Members shall provide on a free and unrestricted basis those hydrological data and products which are necessary for the provision of services in support of the protection of life and property and for the well-being of all peoples;

(2) Members should also provide additional hydrological data and products, where available, which are required to sustain programmes and projects of WMO, other United Nations agencies, ICSU and other organizations of equivalent status, related to operational hydrology and water resources research at the global, regional and national levels and, furthermore, to assist other Members in the provision of hydrological services in their countries;

(3) Members should provide to the research and education communities, for their non-commercial activities, free and unrestricted access to all hydrological data and products exchanged under the auspices of WMO;

(4) Respecting (2) and (3) above, Members may place conditions on the re-export³, for commercial purposes, of these hydrological data and products, outside the receiving country or group of countries forming a single economic group;

(5) Members should make known to all Members, through the WMO Secretariat, those hydrological data and products which have such conditions as in (4) above;

(6) Members should make their best efforts to ensure that the conditions placed by the originator on the additional

hydrological data and products are made known to initial and subsequent recipients;

(7) Members shall ensure that the exchange of hydrological data and products under this resolution is consistent with the application of Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities;

URGES Members, in respect of the operational and scientific use of hydrological data and products, to:

(1) Make their best efforts to implement the practice on the international exchange of hydrological data and products, as described in FURTHER ADOPTS (1) to (7);

(2) Assist other Members, to the extent possible, and as agreed upon, in developing their capacity to implement the practice described in FURTHER ADOPTS (1) to (7);

REQUESTS the Executive Council to:

(1) Invite the Commission for Hydrology to provide advice and assistance on technical aspects of the implementation of the practice on the international exchange of hydrological data and products;

(2) Keep the implementation of this resolution under review and report to Fourteenth Congress;

DECIDES to review the implementation of this resolution at Fourteenth Congress.

³ "Re-export", in the context of this resolution, means to redistribute, physically or electronically, outside the receiving country, group of countries forming a single economic group, or regional and global data centres, directly or through a third party.

ANNEX III — HYDROLOGICAL PRODUCTS FROM HYCOS PROJECTS

Among the outputs of the implementation of HYCOS projects are hydrological products. These can be in the form of data or result from the processing and analysis of the data and information collected from HYCOS stations. The table below lists twenty-two of the major products.

<i>Hydrological product</i>	<i>Description</i>
Hydrological Information System (HIS)	This is a useful tool for storing, accessing and exchanging hydrological data and information. It includes software for data archiving, analysis and retrieval. It is useful for planning and decision-making by various stakeholders involved in the IWRM process and should be readily accessible and easily comprehensible.
Mean annual precipitation	A map of the average annual precipitation that can be produced based on the observed time series of precipitation for a certain period (≈30 years). Such maps can be used for planning and designing development projects.
Variability of precipitation	Variability of precipitation in time and space is a useful input for assessing possible options for meeting various water needs. It can, for example, be of use in assessing the effectiveness of rainwater harvesting and choosing the associated technology.
Heavy convective storm data	Heavy convective storms occur when unstably-stratified air masses are transferred during convective precipitation events, often with thunderstorms and hail. These data can be produced as reports. This product is of most significance in small catchments affected by heavy convective storms and is useful in flash flood risk assessment.
Maximum observed daily precipitation	This is the highest amount of precipitation recorded in 24 hours and is useful in designing drainage structures.
Duration of dry spells	These are periods without, or with little, precipitation. They are of general interest especially because of their effect on hydrology and water management, agriculture, forestry and tourism.
Mean annual potential evapotranspiration	Potential evapotranspiration is the quantity of water capable of being transferred from the soil to the atmosphere by evaporation and plant transpiration when well supplied with water. It is useful in water balance calculations and assessment of irrigation needs.
Natural characteristics of rivers	These are important in determining stable river sections for locating hydrological stations or other engineering structures and their impacts on river behaviour. They are also important in determining streamflow, (unit) hydrographs in ungauged catchments, etc.
Minimum and maximum daily records (precipitation, runoff, etc.)	Smallest and highest values of daily series of precipitation, runoff, etc. They are useful in designing drainage structures and reservoir regulations.
Minimum and maximum annual records (precipitation, runoff, etc.)	Smallest and highest values of annual series of precipitation, runoff, etc. They are useful in assessing storage requirements for meeting needs.

<i>Hydrological product</i>	<i>Description</i>
Standardized mean specific flood discharges	These are flood discharges of a given return period. They are important for solving many problems in water resources management and design.
Rating curves	Rating curves show the relationship between stage and discharge in a river section. They are useful tools in calculating runoff from water level data in a river and can be used to determine hydraulic characteristics of the river reaches in the vicinity of the section.
Mean annual depth of runoff	Mean annual depth of runoff is a major component of the water balance. The runoff depth of an area includes surface runoff in rivers. It is an important variable for hydropower production, water supply, etc.
Low flow time series	Low flow time series are records of the lowest streamflow. They are useful for drought forecasting, river navigation, fisheries, etc.
Long-term trends of runoff	Long-term trends of runoff help in determining the location of sites for human settlements, agricultural development, dams and reservoirs, etc.
Mean annual fluctuations of groundwater table	Determined on the basis of regular monitoring of groundwater levels. These allow conclusions to be made on groundwater recharge based upon precipitation and exchange processes between groundwater and surface water.
Long-term trends of groundwater	Long-term trends of groundwater are used in groundwater exploitation. They also determine baseflow and low flows in perennial rivers.
Water balance	Water balance is the accounting of inflow and outflow of water within a basin for a given period of time (usually one year). It is used in all water management planning and is useful in assessing the availability of water for meeting demands.
Water quality of rivers	Water quality monitoring is carried out in rivers to determine the suitability of the water for various purposes, and to detect negative developments at an early stage. Information about the quality status of river water is the basis for evaluating existing or potential utilizations of water.
Hydrological forecasts	Hydrological forecasts are the predictions of streamflows and water levels in a river/stream based on precipitation and streamflow inputs monitored and reported on a real-time basis and can be made from various hydrological data obtained from HYCOS stations. They are important for issuing warnings of impending hydrological events like floods, droughts, storms, wind, etc., and in agricultural practices.
Flood forecasts	Flood forecasts are the hydrological forecasts of events that are likely to cause inundations beyond the normal stream limits. They are important in saving lives and property.
Technical maps (isohyetal, evapotranspiration, etc.)	Technical maps are very useful since they can provide abundant information within a small area. Data and information from HYCOS projects may be used to prepare technical maps showing rainfall distribution and depth, evaporation, evapotranspiration, temperature, drainage networks, etc.

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