Water Statistics in the Mekong River Basin

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The Mekong River Commission (MRC) holds significant amounts of hydro-meteorological and water quality time-series data, and maintains networks for regular collection of historical and operational hydro-meteorological, and water quality data.

These water statistics are used for:

- Flood forecasting
- River monitoring
- Environmental assessments
- Comprehensive studies for development of the Basin Development Plan on water utilisation
- For the determination of patterns that govern hydrological and meteorological events such as floods and droughts.

The hydro-meteorological database comprises more than eight hundred stations, and data from as early as 1910 are kept.

MRC monitors water quality at 100 sites along the Mekong. Samples are collected and analysed by national laboratories, but validated and kept at MRCS. A specific problem for water quality statistics is quality control of the analyses.

In water balance modelling, water usage is one significant input. Due to limitations in water demand statistics, domestic/industrial and irrigation demands were estimated; based on rate per capita and using crop models and model input such as crop irrigation area and crop pattern/calendar.

Reliability, timeliness and continuity of data collection, linked to sustainability of existing networks, are pertinent issues. Technical and human resources and capacity in the region needs improvement, to fulfil future demands on data quantity and quality. Institutional strengthening and training of riparian staff in data collection and management, analysis, QA/QC etc will address these issues.

1 Introduction

The Mekong River Commission (MRC) was established on 5 April 1995 by the Agreement on The Cooperation for The Sustainable Development of The Mekong River Basin [MRC, 1995]. The MRC member countries are Cambodia, Lao PDR, Thailand and Viet Nam. MRC maintains regular dialogue with the two upper states of the Mekong River Basin, China and Myanmar. The MRC member countries agree to co-operate in all fields of sustainable development, utilisation, management and conservation of the water and related resources of the Mekong River Basin, such as navigation, flood control, fisheries, agriculture, hydropower and environmental protection.

MRC's work in these fields feeds into four core programmes (Basin Development Plan, Water Utilisation Programme, Environment Programme and Flood Management and Mitigation Programme) facilitating joint planning and development between the four member countries of the Lower Mekong Basin. MRC also has four sector programmes (Fisheries; Agriculture, Irrigation and Forestry; Navigation; Hydropower) and one support programme (Integrated Capacity-Building).

Figure 1 – Mekong River Basin

The MRC consists of three permanent bodies: The Council, the Joint Committee (JC) and the Secretariat. The National Mekong Committees (NMCs) act as focal points for the Commission in each of the member countries and are served by the respective National Mekong Committee Secretariats.

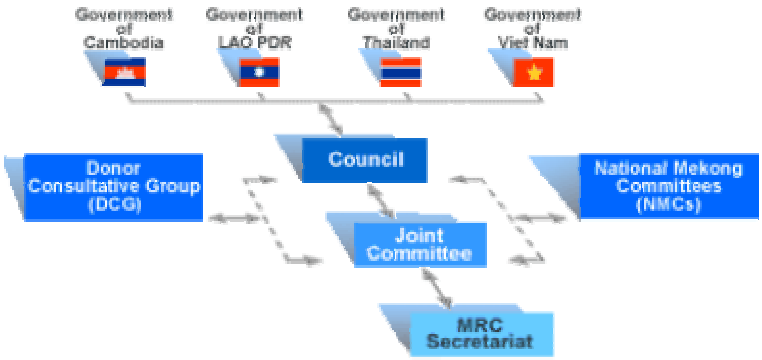

Figure 2 – MRC's organization

The MRC Secretariat (MRCS) is the operational arm of the MRC. It provides technical and administrative services to the Council and the Joint Committee. The main counterparts for MRC activities in the four member countries are the NMCs.

As directed in the 1995 Agreement, MRC shall "regularly obtain, update and exchange information and data necessary to implement this Agreement." MRC therefore, amongst several other categories of data, holds significant amounts of hydro-meteorological and water quality time-series data. MRC also maintains data collection networks and regularly collect historical and operational hydro-meteorological data, as well as water quality data.

Data is commonly collected in close cooperation with member country line agencies, with national level coordination by the respective NMCs, often relying on regular national data collection activities. Several datasets have also been consolidated from the 30 years of surveys and studies done by MRC's predecessor, the Mekong Committee. The MRC also works closely with many organizations with data and information exchange, including UN agencies such as UNDP and UNESCAP, the World Wildlife Fund and the World Conservation Union (IUCN).

The Mekong Committee were in the early days collecting data mainly as an essential prerequisite for planning, design and operation of water resources development projects in the basin. These days MRC puts great emphasis into collection, management and dissemination of data covering the entire lower Mekong basin for use for a wide range of purposes. Water statistics are fundamental to MRC and is used by its Programmes and Projects e.g. in flood forecasting and river monitoring, in comprehensive studies for development of the Basin Development Plan and on water utilisation, environmental assessments for protection of the environment and maintenance of the ecological balance, and for determination of patterns that govern hydrological and meteorological events such as floods and droughts.

2 Hydro-meteorological data collection and use

The hydro-meteorological data regularly collected in the MRC are water level, discharge, rainfall, synoptic and sediment data. These data can be classified into two categories: 1) *historical data* e.g. for the Mekong Hydrologic Yearbook publication; and 2) *operational data* used e.g. for flood forecasting and river monitoring activities.

2.1 Historical data

Historical data collected from the network in the MRC member countries are regularly published in The Mekong Hydrologic Yearbook. This has been published and disseminated to its member countries annually in hard copies from 1962 until 1998, and on CD-ROM thereafter.

A Hydrologic and Meteorologic Database was established already in 1985. At present, the database processing software HYMOS from WL | Delft Hydraulics is used for archiving of hydro-meteorological data, both at the MRC Secretariat and the riparian countries. A wealth of data, in some stations from as early as

1910, is kept in this database. By the end of April 2005, the MRC's hydro-meteorological data collection network comprises 849 stations as summarised in table 1 below.

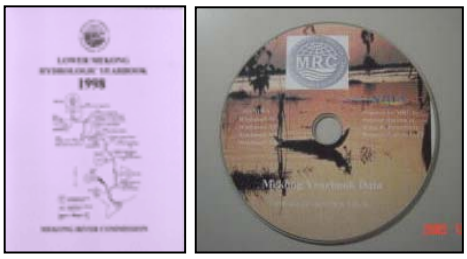

Figure 3 - The Mekong Hydrologic Yearbook in hard copy and CD-ROM

Data	No. of stations
Water level and discharge	242
Rainfall	503
Synoptic	44
Sediment	60
Total	**849**

Table 1 – Summary of holdings in MRC hydromet database

2.2 Operational data

Near real-time water level and rainfall data, as summarised in table 2, are sent from line agencies in riparian countries to the MRC Secretariat by e-mail, daily during flood season (June to October) and weekly during dry season (November to May). The data are stored in the operational database for input into regional forecasts, but is also disseminated to forecasting agencies in member countries for use in their national forecasts.

Item	Flood season (Jun - Oct)	Dry season (Nov - May)
Water level Data (stations)	44	19
Rainfall Data (stations)	44	19
Data delivery to MRC Secretariat	Daily	Weekly
Forecasting activity	Flood Forecasting	River Monitoring
Forecasting point	21	19
Day-ahead forecast	5-day forecast	7-day forecast

Table 2 – Near real-time hydromet data sent regularly to MRCS

The MRC Flood Forecasting Team members also carries out interpretation and analysis of other available weather data such as satellite images, rainfall estimation and forecasts from various sources, including those from US Geological Survey/National Oceanic and Atmospheric Administration (USGS/NOAA), Tropical Rainfall Measurement Mission (TRMM) and the Thai Meteorological Department (TMD).

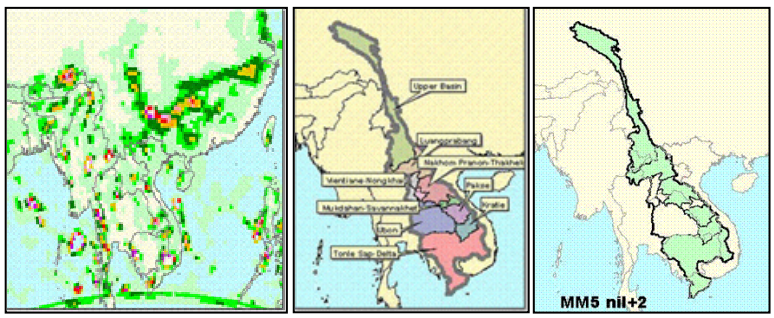

Figure 4 – Rainfall estimation and forecasts from USGS/NOAA (left: rainfall estimation and forecasts from USGS/NOAA; middle: Mekong sub-basins; right: rainfall forecast in each sub-basin)

The Flood Forecasting and Early Warning activities of the MRC are gradually improved. During dry seasons from November to late May in years 2002 - 2004, seven-day river monitoring and low flow forecasts have been being conducted and updated weekly on the MRC River Monitoring Web Page (http://www.mrcmekong.org/info_resources/ffw/overview.htm). Starting from June to October 2004, near

real-time hydro-meteorological data from 44 stations, including two Chinese stations, are transmitted to MRCS for making five-day flood forecasts for 21 key stations along the Mekong mainstream.

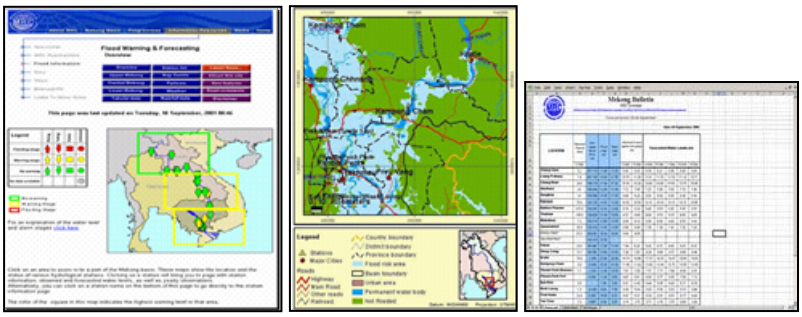

Figure 5 – Examples of forecast products on MRC website

MRC Secretariat currently uses a variety of flood forecasting tools: the SSARR model (Streamflow Synthesis And Reservoir Regulation) for the upper part of the basin (from Chiang Saen to Pakse), regression models for the lower reach of the delta with over bank flow (from Stung Treng to Tan Chau/Chau Doc) and the hydrodynamic model MIKE-11 is used for flood mapping in Mekong Delta.

Improvement of flood forecasting operations is a process which require continuous efforts in many fields, including river monitoring network, data collection, transmission and processing; development of advanced forecasting techniques, communication network and assessment of forecasts. To improve the river monitoring network, data collection and transmission system, the Mekong hydro-meteorological network is now being rehabilitated and improved, strengthening the operation and maintenance of the existing network. These are medium and long-term measures which directly contribute to the accuracy and reliability of data acquisition and provision.

Currently, the MRC Appropriate Hydrological Network Improvement Project (AHNIP) is upgrading 18 hydrological stations on the Mekong mainstream and equipping them with automatic water level recorders. 15 stations will be linked to GSM network for real time data transmission, whereas the remaining 3 stations, of which two are in southern China, will use a satellite communication system. Complementary to the AHNIP, a Mekong Hydrological Cycle Observing System (Mekong-HYCOS) project is now being formulated in cooperation with the World Meteorological Organization (WMO). This project aims to establish a near-real time basin-wide hydro-meteorological information system, spatially covering the mainstream and main tributaries of the Mekong river system.

3 Water quality statistics

The MRCS water quality network has operated since 1985 collecting monthly samples at approximately 100 sites throughout the lower Mekong basin. At present data are collected on approximately 20 parameters. The network has recently been revised, and parameters are currently being reviewed with possibility that several will be discontinued and others added.

Water quality analyses are conducted under contract by designated laboratories in each of the four member countries and data forwarded to the MRCS which acts as the data warehouse. The frequency of data forwarding was formerly annual, but is now being altered to quarterly.

There are several procedures operating or being put in place for water quality data quality assurance. Data are checked on receipt at the MRC secretariat for absurd values, which are queried and/or deleted. In addition several quality assurance procedures involving sample checking have been operating for at least 5 years. Anion-cation balances are checked for concordance [APHA, 1998], and measured EC and calculated EC are compared with ion sums for concordance.

More recently performance evaluation testing has been commenced with round-robin and standard sample testing. In the round robin tests single samples are split and analysed by all four laboratories to check for concordance of results. These tests indicate whether laboratories are producing similar results, but not whether results accurately reflect concentrations in the samples. With standard sample testing samples

distributed through a quality assurance programme established through the GEMS water quality network are being tested in all four laboratories. The laboratory results will then be compared with the known concentrations of analyte in the samples to determine the accuracy of the laboratory analyses.

The water quality data are maintained in several data bases, as raw data (all data as submitted by the laboratories) and corrected data following the checking outline previously. The main database within the Environment Programme is maintained as an Excel file.

Data has been used to examine spatial patterns and trends in water quality within the basin. The 2003 State of the Basin Report [MRC, 2003] contained an analysis of trends in 4 parameters at all 100 sites over the period of record. More recently analyses have been conducted of 6 parameters over a 5 year period in 10 sub-basins of the lower Mekong for use in the Lower Mekong Basin River Health Report card (MRC in prep). Data have also been provided to several outside agencies and individuals for use in various research projects.

4 Water use in the Lower Mekong Basin as applied in the Decision Support Framework

Water usage has become a large concern for the MRCS and its member countries. Agriculture is the largest water user in the basin, to which an estimated 80% of available resources are abstracted. Before implementation of the WUP, no detailed studies of water use had been carried out by MRC. Presently, under WUP water use has been become a very important module of the basin simulation model, which provides comprehensive results to help the member countries and MRCS in formulation rules for water utilization. Here we describe briefly the work that has been conducted to estimate water usage by sector (Irrigation, Domestic and Water Supply, Storage regulation) from Basin Development Plan Sub-areas and by country in the Lower Mekong Basin.

The Basin Modelling and Knowledge Base project is a core component of the Water Utilization Programme (WUP) of the Mekong River Commission. The aim of this component is to provide MRCS and its member countries a set of comprehensive tools (known as the Decision Support Framework, or DSF) for water resources development planning and management.

The development of the basin simulation model is based on the technical requirements set out in the Terms of References of The Basin Modelling and Knowledge Base project. Four of the important requirements of the model's technical capabilities are:

- Integrated effects of range of water resources development on water quantity and quality;
- simulate all consumptive demands on water resources of the basin, including irrigation areas, domestic and industrial water supply;
- accurately represent offtakes, diversion and return flows; and
- prioritize demands so that available resources are always directed to the most important areas.

To meet the needs for the whole DSF and Basin Development Plan (BDP) planning tool, three separate models have been developed, so that the water demands for irrigation and domestic and irrigation (D&I) water supply could be estimated consistently across the Lower Mekong Basin.

1) Basin Simulation Model Upstream of Kratie
2) The IQQM Great Lake Demand Model
3) Delta Demand Model

The Basin Simulation Model Upstream of Kratie is the main model, covering the Mekong Basin from the Lao-China border down to Kratie in Cambodia. The Great Lake Demand Model covers the part of the Mekong Basin from Kratie down to the Cambodia - Vietnam border, whereas the Delta Demand Model covers the part from Cambodia –Vietnam border to the sea.

Harvested crop areas by provincial basic were assigned for use in model calibration and crop demand models. Crop areas of different crop types were aggregated within each sub basin. The distribution of the crop areas were made according to the size for projects with known area, whereas for those with unknown area were calculated by (SWAT Sub basin/Province Area) proportion.

The IQQM irrigation demand model has been applied in the estimation of irrigation water usage. Volume and time series of water used for irrigation were estimated base on the SWAT model sub basin and then aggregated to the BDP sub areas. The method for estimation of the irrigation water in IQQM is FAO 56 but has been upgraded in response to additional needs of the Mekong System. The major upgrades were: (1) allowing the simulation of multiples rice crops, and (2) estimation of irrigated crops that could have been sustainability grown under a particular flow regime.

Domestic and Industrial supply has been estimated using population data and per capita water estimates. Populations at provincial level for the year 2000 were provided by MRC BDP staff. Per capita water usage was estimated from reports at MRCS and the Internet (e.g., WHO and ADB websites).

A similar method to that adopted for distributing irrigated crops was used for distributing population. Uniform population was assumed across the sub basins, and also assumed constant for the full calibration period. Although this assumption is demonstrably not correct, the small percentage of total urban water usage compared with irrigation water usage, did not warrant collecting detailed population estimates for every year.

The water demand of year 2000 that was calculated from the crop area, water supply and infrastructure of year 2000 was accepted as demand of the base line for comparing with development scenarios. Based on the base line scenario and its models, several scenarios on different scales of water use and levels of development have been created and analysed for Basin Development Plan and Integrated Basin Flow Management.

The result of water use analysis of the baseline scenarios and development scenarios providing options to the member countries for their perspectives on water resources projects in the future, as well as paving the way to negotiation on rules of water use in the Lower Mekong Basin.

Below are figures showing some of the estimated water demand of the year 2000 Base line condition.

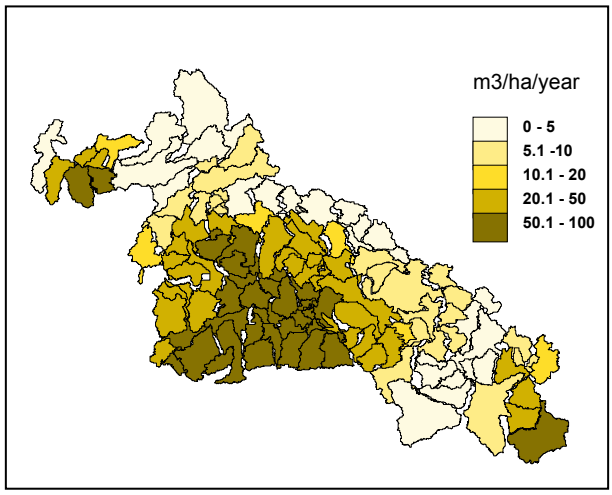

Figure 6: Domestic and irrigation water demand upstream Kratie

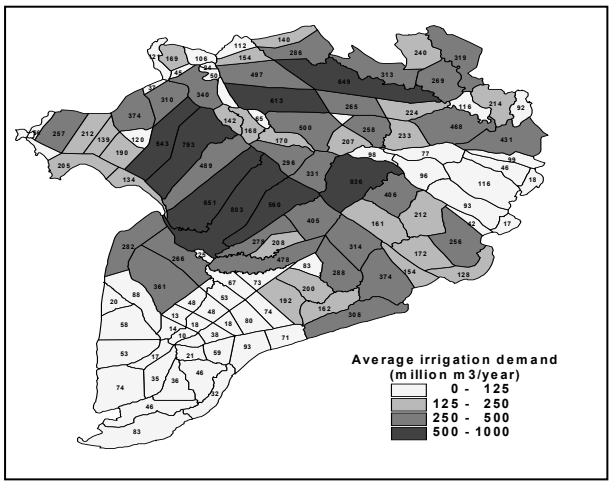

Figure 7: Average irrigation demand in Mekong Delta

5 Issues for sustainable data collection

MRC data collection relies on cooperation with the member countries, and thus to a large extent on their resources and capacity. Lack of technical and human resources and capacity in the region is a general issue affecting all data collection activities. In order to fulfil future demands on data quantity and quality there is a clear need to build technical and human capacity. Unavailability of funds for these activities is a limiting factor, and strong donor support is required if this is to be successful.

Other general issues in data collection and sharing are related to institutional organization and cooperation within the member countries, and to some extent also to interest and willingness to share and exchange data. Data is sometimes seen as a commodity not to be exchanged and shared freely, even between agencies within the country. The understanding and mutual trust required to change this situation could take a long time to build. Strong technical and institutional mechanisms are also important aspects in this regard.

Reliability, timeliness and continuity of data collection, linked to sustainability of existing networks, are pertinent issues related more specifically to collection of water statistics.

MRC is planning for a Decision Support and Information Management Programme, which will address in a broad sense the issues relating to sustainable data and information management, including capacity building and institutional strengthening.

In the sections below, some of these issues are elaborated on.

5.1 Establishment of technical and institutional mechanisms

MRC has been working since its start to improve the conditions for open and efficient sharing and exchange of data and information between the member countries and MRC. In 2001, the Council approved the Procedures for Data and Information Exchange and Sharing (PDIES) [MRC, 2001a], thereby setting up the framework for operationalization of data and information exchange among the four MRC member countries.

This document also defines the MRC-Information System (MRC-IS), which is intended to provide data and information services to the MRC, its member countries, and projects and programs. Hence, through the development of the MRC-IS, the MRC Secretariat aims to play a key role as a regional information hub, which will link partners through information networks, and which will provide them information services and products. The objectives of the development of the MRC-IS are:

1. To develop integrated databases;
2. To develop models to generate information and knowledge;
3. To develop institutional and technical mechanisms for data and information sharing and exchange;
4. To enhance capacity in the fields of data and information management.

In order to serve as a mechanism to assist the MRC in the implementation of the PDIES, and serve as the forum for coordination between the MRCS and the NMCs for all matters relevant to the MRC-IS, a Technical Assistance and Coordination Team (TACT) was formed on recommendation from the Joint Committee. It is a permanent body within MRC with representatives from the NMCs, national Line Agencies (as data custodians) and MRCS and currently meets at least three times per year. TACT has in the last two years developed several documents in support of data and information exchange and sharing, e.g. MRC Guidelines on Custodianship and Management of the MRC Information System [MRC, 2002], Data Delivery Schedule, Operational Data Delivery Procedures, Data Quality Assurance Procedures and Metadata Standard. This comprehensive set of documents for data and information exchange and sharing has been approved by the Joint Committee, and focus can now be shifted from drafting of procedures to implementation and institutionalization of these within the member countries. This work will require continued support and assistance from MRC.

5.2 Quantity of water statistics

Although the hydro-meteorological data collection network comprises more than eight hundred stations and a wealth of data is archived, water statistics collection needs to be expanded in the future, in order to satisfy the ever increasing demands for data. The required parameters and data intervals to support the four MRC core programmes, taking the common water-related programmes and projects into account, are summarized as follows:

- Most applications require daily data, which is currently kept in the MRC hydro-met archive; monthly and annual data is computed from daily data
- Flood management and mitigation may require hourly basis data, especially on the tidal reach and in the flash-flood risk areas. These types of data are currently rather limited at the MRC.
- In addition, short-duration data, e.g. minute basis rainfall data, is required in urban drainage planning, however this is not really an issue in the MRC.
- Discharge data is frequently required in planning or operation/management of sites

The existing hydrological network in the major and medium-scale tributaries has not attained the minimum network density of 2,000 km^2/station recommended by the WMO [MRC, 2001b]. Historical data collected so

far from the whole MRC hydro-meterological network is merely sufficient in terms of quantity for model calibration and validation of different model components that MRC is currently developing under the WUP. Except for rainfall data, there is clear shortcoming of climate data in most of the member countries. Thus, increased network density and increased collection of climatic data is a desirable future direction.

5.3 Reliability of data

Several reviews of MRC hydro-met data archives have been conducted over the years, and it is clear that there are gaps and some inconsistencies in the data. However, the existing archiving database at the MRC Secretariat unfortunately provides little information on data quality and other metadata required for data analysis.

In the near future there will be a greater need for improved quality and more complete set of data for further models refinement. A comprehensive revision of the hydro-meteorological database of the MRC Secretariat is now being carried out, to assess quality and improve the existing hydro-meteorological database.

Analogous issues exist for the water quality data, and similar accuracy assessment activities are therefore also conducted on these data.

5.4 Timeliness in data delivery

Timeliness in data collection and transfer of historical hydro-met data is an issue, however mainly from stations that are not key stations on the Mekong mainstream. In some cases there is now more than a 2 year backlog. The Data Delivery Schedule, approved by the Joint Committee, and continued support to concerned line agencies will help in improving timely delivery of data to the MRC Secretariat. Similar issues also exist for the water quality data, and hence there is a need to also improve timeliness in delivery of these.

Real-time hydro-met data is an additional requirement e.g. for flood forecasting and navigation purposes. At present near-real time data from manual gauge stations, registered at 7 am and 7 pm (of previous day), are sent to the MRC Secretariat at 10 am. Thus there is a delay of at least 3 hours for this type of near real-time data. In the near future, data transmitted from the automatic telemetry stations developed under on-going AHNIP and future Mekong-HYCOS project will improve this situation markedly, with transmission of hourly or more frequent real-time data.

5.5 Operation and maintenance of data collection networks

Continued operation and maintenance of established data collection networks are closely related to sustainability of financial and human resources. The cost to operate and maintain these networks can be quite substantial.

Over the years, several hydro-met network improvement projects have been carried out in the Mekong Basin, with various degree of success. Resources for operation and maintenance were normally covered by donor support for the duration of the project, but due attention to sustainability of established resources after project end not always paid. After termination of the projects, the hydro-meteorological stations and responsibility for operation, maintenance and training of new staff etc were normally handed over to the countries. Because of severe constraints in the national budgets, they were however often unable to sustain these activities and only limited benefits of these projects now remain. This situation is not unique to the Mekong Basin, and many similar cases exist elsewhere.

Most of MRC member countries continue to have difficulties in securing the quite substantive funds required for operation and maintenance of the data collection networks. Supplemental budgetary resources are therefore required until the member countries are able to carry the costs themselves. MRC is recognizing these constraints. Therefore, operation and maintenance of networks or other resources established by MRC network improvement projects, such as by the ongoing AHNIP and the future Mekong-HYCOS, will need to be continuously supported and managed through MRC, in close cooperation with the countries. This will improve uninterrupted access to reliable and timely data for MRC.

5.6 Limitations in resources and capacity

Access to skilled staff and provision of sufficient funding are two critical elements in MRC data collection activities. Presently shortages in both staffing and funding, at MRC as well as in the country agencies, is a limiting factor and presents a challenge to sustainability of the excellent systems of data collection and management that has been established.

The region suffers from a general lack of skilled hydro-meteorologists, with sound knowledge on data processing, data management and modelling works. It should however be noted that large differences in this regard exist between the MRC member countries. A further challenge to availability of experienced staff is the MRC regulation that riparian professional staff can serve a maximum of two three year terms. MRCS is currently experiencing a high turnover of technical staff due to this regulation.

There is a clear need to build technical and human capacity in the region, in order to fulfil future demands on data quantity and quality. Building capacity requires a long term commitment and ample financial resources over a number of years.

Recognizing current limitations in resources and capacity and the clear need to strengthen data and information management, MRC is planning to establish a Decision Support and Information Management Programme, to facilitate access and use by member governments, policy and decision makers, institutional developers, the donor and investment community and other stakeholders to comprehensive, up-to-date and objective data, information and decision support tools necessary to promote and co-ordinate the sustainable development of water and related resources in the Mekong Basin. The work is yet in its initial stages, and donor support for both programme formulation and implementation is sought.

Four programme components are envisaged: 1) Data Exchange and Sharing: Promote and facilitate exchange and sharing of data and information necessary to support the strategies and decisions required to operate the Mekong Agreement; 2) Information Management: Ensure that primary data and information is up-to-date, quality assured, processed, stored and made accessible in a way that makes it readily available and used by member governments, policy and decision makers, institutional developers, the donor and investment community and other stakeholders; 3) Decision Support Systems: maintain the technical capacity and systems needed to analyse and interpret the primary data and results of models or scenario simulation, in order to provide value added information and decision support for the users; and 4) Capacity Building and Institutional Strengthening: Strengthen regional institutional capacity for efficient data and information collection, management and distribution, including implementation of technical support systems, procedures, guidelines, standards and best practices.

The programme is planned for two phases: The Preparation Phase, expected to run for nine months starting in second half of 2005, and the Implementation Phase which is planned to start in 2006, with an indicative budget of US$ 2 million/year.

6 Conclusions

MRC depends to a large extent on regional and national capacity for data collection and management. Lack of financial, human and technical resources and capacity for data and information management has been a limiting factor so far. Considering the limited resources available, MRC has however made substantial progress in data collection and management, especially in the last four years. Strong institutional mechanisms and a comprehensive framework of procedures, guidelines etc for data and information exchange and sharing have been developed, and there is a continuous dialogue between the MRC, NMCs and riparian line agencies involved in data collection. It is now time to move forward towards national implementation of the agreed framework.

MRC databases hold large amounts of water statistics, and historical and operational data are continuously collected. Data collection networks for water quality and real-time or near real-time hydrometeorological data have been established, and further extension of the hydro-meteorological telemetric network is planned. Sustainability of operation and maintenance of established networks is however a challenge, mainly due to lack of financial resources.

The planned MRC Decision Support and Information Management Programme will provide MRC and its riparian counterparts much of the resources required to strengthen regional data and information management, including collection of water statistics. The implementation of this comprehensive programme will be a major step forward towards sustainable management of reliable and accurate data and information.

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