STATUS OF WATER DATA COLLECTION, PROCESSING AND MANAGEMENT: SRI LANKA

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ABSTRACT

Economic growth and development needs are exerting pressure on Sri Lanka's natural resources. The Government of Sri Lanka in its effort to monitor and ensure the exploitation of natural resources within the environmental concerns has recently established requisite environmental legislation. The government has identified the long-term planning of water resources development within a river basin framework as a prime need and has developed an action plan. One aspect of this action plan developed to strengthen the water resources sector management in Sri Lanka is the upgrading of the information systems.

This work pertaining to the present status of collection, processing, and management of water data in Sri Lanka was carried out for the Water Resources Secretariat (WRS) of Sri Lanka coming under the Ministry of Finance and Planning. The study, which falls within the review and upgrading of information systems in the water sector, included a survey on water data, based on interviews of staff within each agency dealing with data collection, data management, and data usage. A questionnaire was prepared and interviews were conducted to capture the existing data collection networks and to assess the expected water-sector data and information needs. Questionnaire-interviews were conducted in the areas of data collection, data management, data coordination, and data sharing and exchange. The survey on water data was carried out on all data-collection programs being undertaken by government agencies including research organizations, boards, corporations, consultants, businesses, and universities. A survey of existing databases and data-collection programs and procedures was also performed with a view to identify strategic gaps in water-resources data. During interviews, members of the agency staff were asked their opinions on the adequacy of the current programs. Similar inquiries were made of data users such as research and consulting organizations.

The survey results identified the existing data-collection networks, the ongoing activities for water-data processing and management, and the status of water-data pricing. It was identified that a high level of data collection is currently taking place but that due to the high demand for data and information, there is a need for coordination, planning, improved access to, and publication of the data.

INTRODUCTION

In common with much of South Asia, economic growth and development needs are exerting pressure on Sri Lanka's natural resources. This growth and development signify an increasing

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demand on water for irrigation, for hydropower generation, and for other uses such as industrial, domestic, and recreational purposes. In addition, large investments in the water-management infrastructure have created high and ongoing operation costs for the government, which in its effort to monitor and ensure the exploitation of natural resources within the environmental concerns has recently established the requisite environmental legislation. The government has also identified long-term planning of water-resources development within a river basin framework as a prime need and had developed an action plan (GOSL 1994) to integrate this planning with broader water-industry objectives. Two of the more important consequences of the complex issues involved in integrating river-basin planning and management are, first, the need for sound policies and strategies covering major issues in natural resources and, second, the growing need for information on which to base decisions.

Resources managers are demanding more reliable, accessible, and timely information together with sound, clearly defined policies to assist in their decision making. Recent technological developments in data collection, data processing, and information technologies provide opportunities that can dramatically improve data dissemination to decision makers and to the community. To strengthen the water-resources management sector, the water data and information systems should be strengthened. As such, it is necessary to acquire adequate information pertaining to the present status of water-data collection, processing, and management in Sri Lanka.

OBJECTIVES

Based on the overall objective of strengthening water-resources information systems, a survey of data archives and user interviews were undertaken to identify the status of data collection, data coordination, sharing, pricing, and data gaps and the desirable options for new technology and change.

To achieve this overall objective, the following specific objectives were identified:

- Describe the current data collection for the monitoring of hydrometric, groundwater, water quality, and climate data including the identification of agencies undertaking such data collection.
- Carry out a survey of existing databases and data-collection programs and procedures with a view to identifying strategic gaps in water-resources data.
- Review information technologies being used for water-resources data collection, management, and dissemination in relation to their efficiency, ability to interface with existing water-resources information systems, and suitability to meet foreseen requirements.

WATER DATA SURVEY AND USER INTERVIEWS

The information collection for the study targeted all water-data collection programs being undertaken by government agencies including research organizations, boards, consultants, businesses, and universities. This investigation was planned to be based on interviews of appropriate staff within each agency dealing with data collection and data management.

In keeping with the above objectives, the following were undertaken to fulfill the information collection:

- a *water-data survey* to determine the effectiveness of the data-collection programs administered by various agencies
- a *user interview* to identify issues of access, sharing, utilization, and appropriateness of current collection programs from the data-user perspective

Anticipated outputs from the water-data survey and user interviews included:

- the objective of the major data-collection programs being conducted
- a list of data types collected by agencies
- the amount of data available and how they are stored
- data management: hardware, software, data dissemination methods, quality coding, pricing policies, and services
- field monitoring procedures, equipment, and related issues
- instrument support facilities
- an inspection of typical monitoring sites and discussions with agency field staff

Questionnaire

A detailed questionnaire was prepared to cater to both the water-data survey and the user interview requirements and these were undertaken simultaneously. In this survey, "data" is the term given to both measured and derived variables, while the term "water resources information" embodies both descriptive and analytical information.

The questionnaire focused on the data ownership, collection and standards, the current arrangements for exchanging data including cost recovery, dissemination of data to users and the community, development of information from the data, maintenance of databases on water-resources information, and overseeing and coordination of the integration, and sharing of data.

The questionnaire is also targeted to provide:

- a snapshot view of existing water-data information in Sri Lanka
- recognition of data gaps and deficiencies
- opportunity for refinement of strategies for current data collection and data management processes

Surveys and Interviews

Surveys and interviews were undertaken of staff at 22 different water groups and reports of the interviews were prepared (GOSL 1998). The results have been summarized into tables to provide information on the work being undertaken by each agency and the types of data that are collected for the various water resources activities. The list of agencies and contact personnel is given in table 1.

Table 1. List of contacted agencies.

1	Meteorology Department (MetD)
2	National Aquatic Resources Agency (NARA)
3	International Irrigation Management Institute (IIMI)
4	Natural Resources Energy & Science Authority (NARESA)
5	Water Resources Board (WRB)
6	Irrigation Department (ID)
7	Central Environment Authority (CEA)
8	Water Management Secretariat, Mahaweli Authority of Sri Lanka (WMS-MASL)
9	University of Moratuwa
10	National Water Supply and Drainage Board (NWS&DB)
11	Ceylon Electricity Board (CEB)
12	E.A.1 Project/Ministry of Environment
13	Sri Lanka Land Reclamation & Development Corporation (SLLRDC)
14	National Building Research Organisation (NBRO)
15	Central Engineering Consultancy Bureau (CECB)
16	University of Colombo
17	Agriculture Development Authority (ADA)
18	Ceylon Institute of Scientific & Industrial Research (CISIR)
19	Department of Agrarian Services (DAS)
20	Institution of Fundamental Studies (IFS)
21	Environment & Forest Conservation Division, Mahaweli Authority of Sri Lanka (EFCD of MASL)
22	Lanka Hydraulic Institute (LHI)

The authors carried out interviews that provided the opportunity for comment and discussion on issues, which are viewed as important to improving the overall management of water-resources data in Sri Lanka.

The survey identified data types currently being collected. These were compared with lists of data, which are known (from industry practice), to be a requirement for future water-resources planning and management activities, such as integrated river-basin planning.

Emphasis was given in the survey to water-resources assessment, data, and information. Comment was made, however, on the importance of related natural resource and environmental information when this was considered necessary. A schedule of these data classes was developed, which also includes the data needs for other specified water resources planning activities such as river basin planning.

Members of agency staff were asked their opinion on the adequacy of the current programs in terms of methods, instruments, frequency, quantity, quality, etc. Similar enquiries were made of data users such as research and consulting organizations.

SURVEY RESULTS

Results of the survey indicate that a high level of data collection is currently taking place. However, the demand for data and information on the resource is extensive with over 40 data-user organizations identified. The data collection, storage, and management methods require refinement since these activities are at present carried out mostly ad hoc. An analysis of the survey and interview material was carried out in the areas of data collection, data management, data coordination, and data sharing and exchange. The following are the key observations made from the survey results.

Data Collection Networks

Data on Surface Water. *The Irrigation Department (ID) and the Meteorological Department (MetD) are collecting extensive hydrometric and climate data on a long-term basis. These organizations operate islandwide long-term monitoring programs for which records are kept in both computer and hardcopy formats.*

The surface water network, which is operated by the ID, was established to meet the project, operational, and management needs of that agency. Although these data are being used for overall surface water assessment of the country in general and of different projects in particular, the network was not designed with this as the primary objective. A comparison of the current station densities of both the ID and the MetD using World Meteorological Organisation (WMO) guidelines showed them as satisfactory (table 2). However, it was observed that only a few stations were in the northern and eastern regions of Sri Lanka.

Data collection is based mostly on manual daily readings with little use of modern digital recording systems. Continuous data, recorded on a small number of analogue recording charts by both the ID and MetD, have to be extracted and processed manually as no 'digitizing systems' are available.

Operational Data. Daily operational data on reservoir levels and river levels are used extensively by the WMS, the CEB and the ID. The data required for these purposes are viewed, by these agencies, as being satisfactory for current operational requirements. The data are read

Table 2. Station densities compared with WMO standards.

Organization	Network type	No. of stations	Effective area (km^2)	Station density (km^2 per station)	Respective WMO standard density km^2/ station	WMO inforhydro 1991 standard	Satisfactory by WMO standards	Remarks
ID	River gauging (after 1994 /95 Water Year)	48	65,531	1,365	1,875 (For interior planes and hilly areas)	1,000	Yes	Very few stations in northern and eastern areas
MetD	Daily rainfall (non-recording)	350	65,531	187	575 (For hilly areas)	200	Yes	Very few stations in northern and eastern areas
	Automatic rainfall gauging stations (recording)	22	65,531	2,979	5,750 (For interior planes and hilly areas)		Yes	Very few stations in northern and eastern areas
	Evaporation (Agromet)	38	65531	1725	50,000 (For interior planes and hilly areas)		Yes	Very few stations in northern and eastern areas

manually and transmitted by telephone, radio, or facsimile to operations centers within the respective agencies, to help water sharing, especially in the Mahaweli river reservoir system.

Water Quality Data. *There is no nationwide monitoring program for water quality data. Current collection of data by the CEA is undertaken in specific areas to address local needs and for local development projects. Other research and consulting organizations also collect water quality data on a project basis. There is no annual 'state of the rivers' reporting on water quality or environmental health of rivers across the nation, although specific research studies are undertaken by organizations such as the Institute of Fundamental Studies (IFS).*

Groundwater Data. There is no baseline-monitoring program for groundwater quantity or quality for resources assessment and utilization. Both the WRB and the NWS&DB collect geological and spatial data on bores, agro-wells, and water supply wells, which they construct, and maintain databases of hydrogeological information. Both organizations carry out

drilling programs and there is opportunity for rationalization of these activities. At the moment, there is no monitoring of groundwater level data or groundwater quality data islandwide for long-term assessment or for resources planning and management.

Data Processing and Management

Hydrological Data. The ID has the majority of its hydrological records such as river water heights, rating tables, rainfall data, and station details stored in hardcopy format at its Head Office in Colombo. There is presently approximately 2,400 station years of primary record in this hardcopy format, which could be destroyed through fire damage or other forms of loss. Only a small percentage of these data (daily flows) is in computer format. There is currently a 10-year backlog in the entry of flow data into the existing computer system. Software development is undertaken in-house and the whole system is desperate for overhaul and for the introduction of modern hydrological database software.

Climate Data. The MetD is storing its climatic data on the WMO 'CLICOM' database system. The majority of the records at MetD are stored in computer format that is readily available for data processing and analysis. The data can be exchanged with other computer systems. Some upgrading of existing software to the latest release is required. However, the data are secure and proper data security and backup procedures are in place. The data are yet to be digitized and included in this database.

Water Quality Data. The CEA collects and analyzes water quality data and information to meet the agency's licensing requirements, for project work, and for dealing with complaints concerning water quality. There have been earlier suggestions and proposals for a national water quality monitoring program but this has not materialized. Laboratory sample data are stored in a laboratory management system. For quantitative modeling and analysis studies, data are output and stored in spreadsheets.

There are other organizations such as universities, IFS, private companies, and NGOs that possess project-specific water quality data.

Water Usage Data. A significant portion of the surface water and groundwater used in Sri Lanka is for irrigation, hydroelectric, industrial, and domestic purposes (table 3). In comparison, water resources utilization for recreation, tourism, transport, and fishing could be considered as small. However, a recent conflict with respect to an attempt to use water for hydroelectric generation, depleting major waterfalls, reflected the growing concerns of the usage for recreation, tourism, and others.

Groundwater usage is mainly for industries and water supply schemes but islandwide there is a heavy reliance on groundwater to fulfill the domestic water requirements. The Agricultural Development Authority is presently executing a significantly large program for the

Table 3. Status of water usage data.

Purpose	Organizations involved in promotion/ management/ administration	Water Source	Water usage data collection
Irrigation	ID	Surface water	Some schemes
	Department of Agrarian Services	Surface water	None
	Provincial Irrigation Department	Surface water	None
	Mahaweli Authority	Surface water	Some schemes
	Agricultural Development Authority	Groundwater	None
Hydropower generation	CEB	Surface water	Yes
Domestic water supply	NWS&DB	Surface water Groundwater	Yes Yes
Industrial use	Local Government	Surface water Groundwater	Yes None
	NWS & DB	Surface water	Yes
	Board of Investment	Surface water Groundwater	In industrial zones None

development of agro-wells for irrigated agriculture in the dry zone of Sri Lanka. Agro-wells are shallow, large-diameter wells dug to harness groundwater.

Surface water is mainly tapped for the use of irrigation and hydroelectric generation. Water supply schemes and industries scattered around the country, which are mostly located closer to cities, extract surface water in significant quantities. The NWS&DB, which is a national organization, maintains water extraction data of surface water and groundwater sources for water supply schemes.

The CEB collects water release data from the major reservoirs. The irrigation water extraction data in some schemes are maintained either by the MASL or by the ID. Water usage data of the smaller irrigation schemes or of the agro-wells are not being collected.

The data are stored in both digital (spreadsheets) and hard copy formats. The general opinion expressed was that this was satisfactory for daily and seasonal operation decisions and for input to operational models.

Geographical Information. The monitoring, collection, collation, and management of natural resources data and information in Sri Lanka involve a complex arrangement of projects undertaken by government agencies, authorities, and boards and includes research, consult-

ing, and business organizations. The work is being supported by several donor-funded programs and through direct government projects.

During the interviews undertaken as part of this project, it was noted that many government agencies are developing geographic information systems (GIS). Policy and coordination are vitally important, particularly in relation to both reducing duplication of effort in data capture and adopting common standards for digitizing and processing. There appears, however, to be no clear strategy to define an overall policy for natural resources information management in Sri Lanka, or to coordinate this work between agencies.

Several projects, such as the GIS project at the Environment and Forestry Division of MASL in Kandy, have made substantial progress and it is understood that a national GIS Working Group has recently been convened to address some of these issues. This would lead to a coordinating body being appointed and custodian agencies undertaking specific areas of work.

Data Pricing

In general, water data in Sri Lanka are not priced by the agencies that collect such data except by the MetD and the ID. The MetD has a price structure for the rainfall data extracted from its digital database. The ID also has a price structure for its streamflow data. Price structures at both these institutions have been established by the respective institutions on behalf of the government. It is also noted that these agencies allow either special discounted rates or free of charge access for research, academic purposes, and for national projects.

No other organization in Sri Lanka sells any water data. The water data recorded in these agencies can be accessed by obtaining an approval from the concerned agency, indicating the purpose of usage. During the water user/collector survey it was revealed that the two holders of the groundwater data, namely the NWS&DB and the WRB did not have a pricing policy.

The CEA and the Agriculture Development Authority were of the opinion that the water data should be made accessible free of charge.

Data pricing policies for the dissemination and sale of water data have been determined on an agency-by-agency basis in Sri Lanka. Although the actual cost varies between agencies, data are generally sold at a price, which reflects the cost of dissemination only. There does not appear to be any attempt to charge for the cost of data collecting and primary processing or to charge for profit. Data are often made available to other government agencies or research organizations without any cost.

The user interviews indicated that there was general satisfaction with the price of data, the major concern being data availability, data quality, and the time it took to actually satisfy the individual data requests. The exceptions to this were university groups whose requests for information were often not addressed by the data collecting organizations.

Most of the user/collector personnel expressed the view that the basic data should be available to the users at a nominal cost but were of the feeling that the processed data should be priced to reflect the additional effort that would go into the data to satisfy specific user requirements.

SUMMARY AND RECOMMENDATIONS

General

At present, in Sri Lanka, water resources data and information are organized and managed in a traditional manner within various government agencies and with little attempt to integrate the various water data archives into a coherent water resources information system. There is no water database being developed, where all the data classes are brought together and integrated.

Significant gaps in data collection programs such as quality, technology, coverage, etc., were identified and recommendations made on how these could best be accounted for with revised monitoring programs. On the broader issue of natural resources data management, there does not appear to be a coherent strategy, at this point in time, for the management of natural resources data and information at government level in Sri Lanka.

There is a need for coordination, planning, improved access, publication, quality assurance and pricing of data, if full benefits are to be gained from the data already collected. The need for a group to undertake the coordination role was raised in many interviews. The user interviews identified concerns regarding the data availability, data quality, and accessibility.

Surface Water

Although satisfactory, in terms of station numbers, a review of the surface water monitoring network and procedures of the ID is overdue and should be undertaken in liaison with the MetD and the CEA.

It is observed that a large percentage of the fieldwork for an islandwide water quality-monitoring program could be undertaken with minimal cost, through agreement and cooperation with the ID. The first stage of such a program would be to collect water samples at river flow monitoring sites that are operated by the ID staff throughout Sri Lanka for analysis at a suitable organization. This is a practice adopted in many other countries and recommended in the WMO (WMO n.d.).

In the case of water quality there is a need to implement a national water quality monitoring program and link this program with other national water data monitoring programs for surface water and groundwater. Also there is a need to introduce a compatible modern database system for the storage and management of these data to enable the linking of those data to the archives maintained for other water data.

The nation's hydrological archive at the ID, comprising mostly hard copies, would require new hardware, software, and staff training to successfully undertake the building of the database in computer format and to upgrade the management capabilities. New instruments such as data loggers will be needed for improved data collection.

Regarding the climate data, access to appropriate digitizing software would enable the processing of continuous chart data, which currently does not take full advantage of, due to the manual processing. Otherwise, the MetD seems to be well equipped with computers and trained staff capable of completing the ongoing database management. The computerised data are in a suitable format for integrating into a water resources information system.

Groundwater Data

In the case of groundwater, there is however, no long-term monitoring of water levels on a seasonal or annual basis, which is important for assessment and sustainable management decisions. Currently, the NWS&DB and the WRB operate separate and independent data archives, which are similar in function and purpose.

Two actions are required in the area of groundwater. First, a nationwide groundwater-monitoring program of water level and water quality data needs to be implemented. Initially, this would involve designing the appropriate monitoring network and cross-referencing this with other monitoring programs that the ID, the MetD, and the CEA undertake. Second, the database systems of both the WRB and the NWS&DB should be integrated into a single system and linked to a central Water Resources Information System (WRIS).

Data Management

As part of the development of a WRIS, the option of including water usage data should be examined as it is important for determining the total water budget of the country's river basins, since this is a prime requirement for planning basin development projects. However, because usage data are presently not collected for smaller irrigation schemes, the water budget would be estimated only in part.

For a data management policy in Sri Lanka to be successful, it is essential that a clear understanding be established for the different roles of the organizations in the management process. To achieve this there needs to be a cooperating agreement spelling out the roles and responsibilities for the various groups involved in the collection, processing, and management of water resources data and information.

In conclusion, based on the survey results, the following are considered fundamental for improved management of water resources data and information in Sri Lanka.

- improved coordination between data collectors and data users in the areas of accessibility, quality, publication, and pricing
- a review of current data collection networks in terms of methodology, frequency, quality, etc., to meet future water resources planning needs
- The adoption of new technologies, which would include new hardware, software, and staff training for data collecting, processing, dissemination, and publication

The recommendations above have been developed after undertaking detailed surveys and interviews with water agencies and data user groups where information was acquired through discussion. In addition, the experiences and knowledge of data collection and management arrangements in other countries, such as Australia, New Zealand, and the USA were incorporated in the study (WRCNSW 1991; DISC 1989; WMO 1990; AWRC 1989; USGS 1982).

LITERATURE CITED

AWRC (Australian Water Resources Council). 1989. *Guidelines for the design and operation of surface water information systems.* Australia: Australian Water Resources Council, Water Management Series 18.

DISC (Department of Industrial and Scientific Research). 1989. *Policy on the management of the water resources archive in New Zealand.* Colombo, Sri Lanka.

GOSL (Government of Sri Lanka). 1994. *Comprehensive water resources management in Sri Lanka, Vols. I & II.* Report prepared under the project TA 1918-SRI with the Asian Development Bank and the USAID.

GOSL. 1998. *Information system analysis. Final report.* Report prepared by Water Resources Consultating Services (Australia) in association with DHV consultants (The Netherlands), Environment Management Lanka (Pvt) Ltd (Sri Lanka), Resources Development Consultants Ltd. (Sri Lanka), and Lanka Hydraulics Institute Ltd. (Sri Lanka) under the project TA 2422-SRI with the Asian Development Bank.

USGS (US Geological Survey). 1982. Water-data program of the US Geological Survey. *Geological Survey Circular* 863.

WMO (World Meteorological Organisation). n.d. *Guide to hydrological practices.* WMO no. 168. Geneva: World Meteorological Organisation.

WMO. 1990. *Progress in the implementation of the Mar del Plata Plan and strategy of the 1990s.* Geneva: WMO/UNESCO Water Resources Assessment Program.

WRCNSW (Water Resources Council of New South Wales). 1991. *Co-operating agency policy on water data management.* Australia: Water Resources Council of New South Wales.