

ABSTRACT

Appropriate Technologies and Systems to respond to Climate Change, Improved Water Resources Management, Waste Management and Sanitation

A Review of Water Information Systems in the English-Speaking Caribbean – challenges and lessons learnt

By

L.M. Fletcher-Paul,

*Food and Agriculture Organization of the United Nations
P.O. Box 631-C, Bridgetown, Barbados*

C. A. Madramootoo

*McGill University
Montreal, Canada*

H. Thomas

*Water Resources Authority
Hope Road, Kingston 6, Jamaica*

As Caribbean countries grapple with issues such as increasing food prices, declining agricultural sectors, a growing tourism sector, increased population pressures and climate change; water has emerged as a critical resource which must be sustainably managed to ensure food security, competitiveness, proper health and sanitation. In order to adequately manage the resource and institute measures to equitably allocate water among the various competing sectors, it is imperative that the countries have accurate and up-to-date data and information on water availability, quality, use and demand. In this regard, Water Information Systems play a key role in the management of the resource. This paper examines the water information systems of St. Lucia, Jamaica and Trinidad and Tobago, with a view to understanding the institutional arrangements within which they are housed, their structure, operation and use in decision-making. Moreover, it will discuss the lessons learnt and challenges of establishing, operating and maintaining such systems in the respective countries and propose measures to improve their performance and utility.

INTRODUCTION

Caribbean countries are presently confronting a number of issues which are likely to impact on their respective water sectors. These issues include: growing populations; a renewed thrust in agriculture in the wake of soaring food prices, which is likely to increase the demand for water by that sector; increased demand for water from the other sectors of the economy such as manufacturing and tourism; reduced water availability due to climate change, and reduced water quality due to pollution of from industrial, municipal, and agricultural wastes. Consequently, water resources managers and decision makers need to have a better idea of the available supply as well as present and future water demands in order to plan for its sustainable use.

In most Caribbean countries, there is a multiplicity of institutions and jurisdictions dealing with various aspects of water management. The meteorological services collect hydrometeorological data at a number of sites throughout the islands, some Ministries of Agriculture also collect similar data, the Water and Sewage Authorities may collect some stream flow data and the Ministry of Health may be responsible for data on water quality. In some countries Environmental agencies such as the National Environment and Planning Agency (NEPA) of Jamaica, monitor the natural resource assets (which include water) and environment. The NEPA also prescribes water quality standards for treated effluent. In Trinidad, the Environment Management Agency (EMA) provides information on water pollution rules. The Institute of Marine Affairs (IMA) also monitors water quality in coastal areas. Information on water-related legislation is scattered in a number of Ministries such as the Ministries of Environment, Agriculture or Public Utilities and even Foreign Affairs, depending on which Ministry is responsible for the particular aspect of the legislation. Water related socio economic data, if collected at all, are similarly housed in a number of agencies. The data are often stored in various formats by the respective agencies without a standard mode of storage and dissemination. This lack of appropriate facility for collating, analysis and dissemination of water data and information encourages a compartmentalized and isolated approach to the management of the water resource. Two notable exceptions are the Water Resources Authority in Jamaica and the Water Resources Agency of Trinidad and Tobago which collect, compile and analyze hydrological data.

A national Water Resources Information System (WRIS) is therefore, a valuable tool to assist countries in organizing their water data so that it is more easily accessible and for assessing the countries' water resources. There is now a move towards the integrated management of water, covering all the technical, environmental, socio-economic, legal and institutional aspects related to the sustainable use of the resource. This is rooted in the concept of integrated water resources management (IWRM). These multiple stakeholder needs and interests dictate the importance of having water data compiled and accessed in such a manner to make appropriate decisions about the wise use of water when the prevailing environmental and socio-economic conditions might be limiting. It is also important to note that data does not only refer to the physical attributes of water quantity and quality, but may also include other legal, socio-economic, institutional and environmental components.

In view of the importance of WRIS in the region, this paper describes the case studies of systems which have been established in three Caribbean countries: Trinidad and Tobago, Jamaica, and St Lucia. The aim of the paper is to describe the systems, their institutional setting and the challenges faced in establishing and operating the systems in the three countries. It is hoped that Caribbean countries considering establishing similar systems would

learn from the experiences in these countries and so develop more efficient systems, based on the lessons learned. .

JAMAICA

Primary data collection systems and central database

The WRA of Jamaica routinely monitors river flows at 117 gauging stations and groundwater at 283 wells throughout the island. It has a database of quality checked data, stored in computerized format dating back to the 1950s. It also monitors 9 rainfall intensity gauges for flood assessment and warnings. The Meteorological Service of Jamaica has overall rainfall monitoring responsibilities. Table 1 below summarizes the number and type of recording stations.

Table 1: Number and type of water recording stations in Jamaica

| Type | Stream flow | Rain gauge | Groundwater |
|----------------|--------------------|-------------------|--------------------|
| Recording | 34 | 0 | 0 |
| DCP loggers | 17 | 20 | 0 |
| With telemetry | 1 | 4 | 0 |
| Manually read | 65 | 327 | 283 |
| TOTAL | 117 | 351 | 283 |

The central database of the St Lucian and Jamaican WRIS are similar in structure, having been developed by the same consultant. The system comprises two components – the database and the web based database interface. The Database allows the Data Administrator of the WRA to enter the data and provide quality control over the inputs. The interface is used by the clients who access and use the data and it does not require any kind of administration intervention.

Data entry into the system is accomplished via e-mail. Because the system is web-based, selected variables can be extracted from the existing database of the contributing institution, and sent in electronic format via e-mail or by uploading the data using a customized user interface for data providers to the WRA. There is, therefore, a reduced chance of errors from transcribing.

The data are accessed via a map of the country. This map is a geographical representation of the objects in the database. Users of the Information System can browse through the different objects such as maps, variables and files which are stored in the database, without having access to the actual data. These data may be presented as tables, reports, charts, files or basic statistics. The tabular data include monthly and yearly minima, maxima and averages. Reports are in the form of tables which print ready in Microsoft Word format. Charts are presented as line or bar charts which may be zoomed, copied and printed. Values on the charts may even be accessed by moving the mouse over the point of interest on the chart. Files are in ASCII, Excel file or comma delimited format data for the selected period. The statistics include basic statistics about the selected time series, maximum and minimum with date of first occurrence and averages.

Through the use of GIS technology, digital images such as vegetation, roads and soil types, may also be included on the map to provide additional information for decision making.

Institutional Setting

The Water Resources Authority is the premiere organization for water resources management in the country. It is part of an inter-agency system of permits, checks and counterbalances to ensure proper utilization of the resource, equitable distribution, efficient delivery, environmental stewardship and fair customer practices. The other agencies include the National Irrigation Commission, the Irrigation Unit of the Rural Agricultural Development Authority, the National Water Commission, the Office of Utilities and Regulation and the National Environment and Planning Agency.

The WRA was instituted with the enactment into law of the Water Resources Act 1995, in April 1, 1996. The Water Resources Act repealed the Underground Water Control Act (1959) and added the responsibility for surface water and water quality in streams and the change of name from Underground Water Authority to Water Resources Authority. The Authority is responsible for the management, protection and controlled allocation and use of Jamaica's water resources. Its mission is to ensure the sustainability ... through continual assessment and proper management, promotion of conservation and protection and optimal development of these resources; to ensure rational and equitable allocation of the nation's water resources; and to reduce conflicts among water users." The major activities of the WRA include hydrologic data collection, compilation and analysis; water resources investigation, assessment and planning; water resources allocation; and environmental monitoring and impact assessment.

Jamaica's Water Resources Authority Web-based Hydrological Database System was first introduced to the Jamaican water sector stakeholders on March 22, 2007 as one of the main activities of World Water Day. It was made accessible on the internet in August 2007. The system was established to fulfill the mandate under Section 4.3a of the Water Resources Act, to "obtain, compile, store and disseminate data concerning the water resources of Jamaica". It therefore offers on-line access to water resources and other related data and information. Furthermore, it reduces the time and effort of the WRA staff in responding to numerous requests from its clients.

Operation

Currently, 6 institutions contribute data to the system. These are the National Water Commission, Forestry Division, National Land Agency, Land Information Council of Jamaica, National Environment and Planning Agency and the Environmental Health Unit of the Ministry of Health.

Several agencies use the data. These range from the Fire Service, National Irrigation Commission, Ministry of Agriculture, NGOs, educational institutions, local and foreign consultants and private developers.

The system is currently managed by 2 WRA's Computer Unit Staff; an Information Systems Engineer, a Systems Analyst with assistance upon request by the consultant software developer. The area leader in each of the 3 units of the Data section, is responsible for the

preparation of the data for uploading, including quality assurance checks. Primary data are collected on a daily and monthly basis.

Challenges

The main difficulties encountered in operating the system to date are:

- Browser limitations due to the version – it only works on Microsoft Internet Explorer 6.0 and above
- The data entry system is cumbersome – data have to be uploaded and cannot be entered directly from the screen
- Limitations in printing map sections
- Access to the database depends on network speed and is sometimes slow
- Programme enhancement is restrictive in that required changes have to be done by the software developer
- The help menu screen is too wordy and technical

Suggestions for improvement

In Jamaica, the developer is currently upgrading the system with a data entry screen for time series data. A demo tutorial will also assist in making the system more user friendly. The WRA also needs to invest some time in training stakeholders and potential users of the system so that it can be effectively used both in-house and by external stakeholders.

For the future, it is foreseen that the databases of other agencies will be included in the Water Resources Information System and the facilitating agencies would control their respective components.

ST LUCIA

Primary data collection systems and central database

The water monitoring network in St Lucia was established in 1980 to assess the water resources potential of rivers to satisfy irrigation requirements in the agricultural sector. During the 1980s eighteen stream gauging stations were operated in 10 of the island's 37 watersheds. Of the total stations, 11 were recording and 7 were non-recording. Spot measurements were routinely carried out at 10 sites. All stations were discontinued for reasons such as shifting of the channel away from gauges, washing away of some gauges by Tropical Storm Debbie in 1995 and subsequently the challenge of the engineering department of the Ministry of Agriculture, Fisheries and Forestry to find suitable sites and also the lack of an adequate cadre of trained hydrological technicians to ensure the continued operation of the stations.

With the revised Water and Sewerage Act (2004), the role of the network was expanded to provide information to decision makers for water resources planning and allocation, trends of the country's water resource and information about droughts and floods.

Table 2 below is a summary of the water data collection networks of the country

Table 2: Number and type of water recording stations in St. Lucia

| Type | Stream flow and water quality | Rainfall |
|------------------|-------------------------------|----------|
| Recording | 2 | 25 |
| Non-recording | 0 | |
| Manual | | 6 |
| Spot measurement | 12 | |
| Telemetric | | 13 |
| TOTAL | 14 | 44 |

In addition, there were 7 agricultural and 30 domestic abstraction sites as well as 14 sites which record water quality on a monthly basis and 8 which record solid waste data.

The central database for St. Lucia's Water Information System is identical to that described for Jamaica.

Institutional Setting

In 2001, the Government of St Lucia established the Water Resources Management Unit (WRMU) as part of the Water Resource Management Project financed by the European Development Fund (EDF) and the Government of Saint Lucia. The objective of that project was to create the capacity within the Ministry of Agriculture, Forestry and Fisheries, to effectively manage water use for agriculture. Project activities included the training of staff in the use of Geographic Information Systems; Rationalization of the Regulatory and Legislative Framework; installation of hydrometric monitoring systems; public/farmer sensitization programme and watershed rehabilitation and assessment.

Under the institutional framework for implementing the policy and legislation, the WRMU became the Water Resources Agency (WRA), which is a semi-autonomous body affiliated with the Planning Division of the Ministry of Finance. Its roles and management function are enshrined in the Water and Sewerage Act of 2004.

In 2005, the Government of St Lucia sought technical assistance from the FAO to strengthen the role of the WRMU. The aim of the assistance was to transform the WRMU (and eventually the WRA), from a being merely a data collecting service for stream flow and water level data, into a true information service serving all stakeholders and providing them with data on water quality, availability, demand and supply, in a format required by the user to allow decision-making. The St. Lucia WRIS was therefore established in 2005.

The system is currently not operational, even though some preliminary data were entered into the system.

Challenges

The WRIS is currently not functioning. This is because the Water Resources Authority is still not operational. Although funds have been allocated in the national budget for its establishment and operation, additional staff have not been recruited neither has the database administrator/manager been appointed. Moreover, the change in government at the end of

2006 has set back the project even further as a new government has identified different priorities. A new Permanent Secretary was only appointed in December 2007 and that new person now has to be apprised of the project and the Information System and encouraged to allocate resources towards its operation and appoint the necessary staff to ensure its sustainability.

Additionally, the network of agencies responsible for data collection to contribute to the WRIS was never fully established because there was no Database Administrator appointed at the WRA. The Administrator is responsible for coordinating the inputs of the other contributing agencies.

Suggestions for improvement

The Government of St Lucia needs to commit resources to make the Water Resources Agency fully functional. Competent staff has to be hired and additional equipment needs to be purchased so that there is better coverage of the country at the primary data collection sites.

TRINIDAD AND TOBAGO

Primary data collection systems and central database

The Water Resources Authority of Trinidad and Tobago commenced the collection of stream flow data in 1968. Primary stream gauging stations have been established on sites at major rivers and their tributaries. Rainfall data are collected via an elaborate network of recording and non recording rain gauges established throughout the twin-island state. The recording network has been developed by the WRA throughout the years. The non-recording network was originally established by the Drainage Division of the Ministry of Works and Infrastructure and was eventually taken over by the WRA in the early 1990s.

The number and type of recording station is shown in Table 3 below.

Table 3: Number and type of water recording stations in Trinidad and Tobago

| Type | Stream flow level and water quality | Rain gauge | Groundwater level and water quality |
|-------------------|--|---------------------------------------|--|
| Recording | 32* | 45 | 0 |
| Non-recording | | 133 | 0 |
| With telemetry | 35 4 reservoir level | 35 10 hydrometeorological stations | 10 |
| Production wells | | | 168 (9**) |
| Observation wells | | | 110 (9**) |
| TOTAL | 67 | 233 | 288 (18**) |

* only 15 of the stream flow meters are currently operational

** located in Tobago

The telemetry system can immediately deliver flood warnings at the catchment level, early warnings to advise of possible risks of contamination of the natural water systems and

reliable, up-to-date information to facilitate decision-making for Integrated Water Resources Management.

The central database in Trinidad comprises Excel spreadsheets into which the recorded data are entered, collated, analyzed and processed into charts or tables, depending on the needs of the user of the system. Reports are prepared in Microsoft Word format and are tailored to meet the demand of the users.

Institutional setting

The system was established in 1965. It was not founded by an act of Parliament, but rather it arose out of the need by the Government of Trinidad and Tobago for data on surface flows of water because they wanted to construct a dam. Since the information was not readily available and there was no central unit which collected the requisite information at the time, a Cabinet Note was prepared which resulted in the formation of the Water Resources Survey Unit. The Water Resources Agency subsequently evolved from that Unit.

The WRIS was established to provide hydrological information for domestic, agricultural use as well as use by consultants. It is currently housed in the Water Resources Agency which is within the Ministry of Public Utilities under the statutory body of the Water and Sewerage Authority, which is the institution which was originally charged with the responsibility for all issues dealing with water in the country.

More recently, the WRA has been given the mandate to change from a hydrological data collection agency to an agency which manages the water resources of the country. The Water Resources Management Policy for Trinidad and Tobago was approved in 2005 and the Ministry of Public Utilities has established a management committee to examine the movement from the WRA to a WRMU.

Operation

Currently data are collected by the Meteorological Office, the Drainage Division and the Water Resources Agency, itself. Prior to the closure of the sugar industry, Caroni 1975 Ltd maintained climatological and rainfall data at its agricultural stations but since the demise of Caroni, those data are no longer collected.

The Water Resources Agency has a staff of 79 persons comprising 11 professional and 68 administrative support staff. There are also 15 field technicians, 4 instrument technicians, 8 craftsmen who maintain the surroundings of the gauges. Eighteen technicians monitor and oversee the network.

Data from the database are used by water sector institutions, the Ministry of Agriculture, oil companies, industries e.g. when building industrial plants they have to get a Certificate of Environmental Clearance, educational institutions, schools and consulting firms. These consulting firms have subsequently built up their own databases based on the information they obtained from the WRA and now have more comprehensive and up-to-date data than the Agency.

There is a fee charge system for accessing and using the data. Initially users of the data were charged an initial fee to cover the cost of photocopying, Now, the cost covers all transactions

from the time the request is made to the time the data are delivered – i.e. the cost to extract the data. The total cost depends on the amount of data requested and the amount of work required to access and gather the data and prepare the report.

There is a two tier system – one system for consultants and another for educational institutions. Each datum of information costs TT \$ 5.00¹. One year of data could cost as much as TT \$ 2000. The Annual State of Water Resources Publication costs US \$ 200.

Challenges

With respect to primary data collection, many of the stream flow gauges have been destroyed or vandalized and are therefore, non functional. Some of the equipment is also obsolete. In the case of Caroni 1975 Ltd, the data are no longer collected since the company was closed. Moreover, financial restrictions and onerous bureaucratic procedures make it difficult to access funds to replace and upgrade the equipment.

The WRA has moved at least three times since its inception. With each move, data files have been lost since the system is not fully computerized and most of the information is stored on hard copy.

There is a high turn over of staff since the job of data entry and collection is considered mundane. There is also need for further staff training, more opportunities for knowledge sharing and networking with other similar organizations in the region and the rest of the world.

Suggestions for improvement

There needs to be an on-going programme of upgrading of measuring equipment as well as a centralized database for easy storage and retrieval of data. A Geographic Information System also needs to be added to the system to incorporate the spatial dimension to the dataset. Staff also need to be continually trained. A data policy with relevant protocols for data exchange needs to be established and a policy is needed on copywriting, privacy of information and charge rates.

LESSONS LEARNED AND RECOMMENDATIONS

The Information systems in each country are only as good as the primary data collected. Consequently, all stream flow, hydrometeorological and other equipment should be in good working condition and a system should be put in place to monitor and calibrate them at regular intervals.

Staff must also be adequately and continually trained in the various aspects of hydrology, as well as operation and maintenance of equipment so that they assist in recording reliable data and information and maintain the system in a sustainable manner. Particular attention should be paid to the placement of recording equipment so that the data collected give a good representation and coverage of the situation in the country.

¹ US \$ 1.00 = TT \$ 6.00

A central database for storing, collating and summarizing the data and information is an essential component of the water information system. In this regard, the model used by Jamaica and St Lucia provides a good example of best practice. The advantage of the system is that contributors of data to the system could simply create sub files with the relevant information from their respective agencies' databases and send them by e-mail to the data administrator to be uploaded. In this way, errors in transcribing are minimized. A data policy with relevant protocols for data exchange needs to be established and a policy is needed on copywriting, privacy of information and charge rates.

Water Resources Agencies are increasingly being mandated to assume the role of managers of the Integrated Water Resources. In this regard, the types of data collected should be expanded beyond the technical, to include socio-economic, legal, environmental and institutional so that all stakeholders could have ready access to information to assist in decision making in all aspects of the water sector.

The institutional setting of the information system is an important consideration. The Agency in which the Water Information System is placed must be mandated, by law, to carry out its role in data collection, analysis, collation and distribution to the relevant information users. Government, should, therefore, be committed to the maintenance of the information system and contribute adequate financial and human resources to ensure its sustained existence.

There must also be a demand for the data and information provided so that there is an incentive to collect the data. The agencies which provide the data must see the benefit of collecting the data and passing them on to the central agency, i.e. what is the "value added" provided by the agency which houses the system.

The charging of fees for use of the information is also a good practice as it contributes to the financial sustainability of the system and also is a good barometer of the information needs of the users. In this regard, data administrators should be in constant contact with the contributing agencies to ensure that they are satisfied with the products provided and to solicit their views on how the system could be improved to serve them better. A National Steering Committee on Water Information may be a useful vehicle for constant communication among users of the database.

REFERENCES

FAO. 2003. *Terminal Statement of the project entitled "Assistance to develop a National Agricultural Water Information System.* Bridgetown, Barbados.

FAO/CARICOM/CARIFORUM. 2007. *Best practices in Water Management in the Caribbean: Regional Review and Selected Case Studies.*, Food Security Project Water Management Case Studies. December 2007.

Fletcher-Paul, L.M and D. Lekic, 2005, *Development of a National Agricultural Water Information System – A Case Study of St Lucia.* Paper presented at the National Agricultural Conference, Bridgetown, Barbados

Thomas, H. 2005. *Assessment Study and Rationalization of the Existing Monitoring Program of the Water Resources Management Unit in St Lucia,* Consultant's report for project

“Assistance to Develop a National Agricultural Water Resources Information System” FAO and the Ministry of Agriculture, Forestry and Fisheries, St. Lucia.

Water Resources Agency. 2005. *State of the Water Resources*, Government of Trinidad and Tobago.