INNOVATIVE APPROACHES TO MONITORING FOR TRANSBOUNDARY WATER GOVERNANCE

Haseen Khan[1],
Paula Dawe[1],
A. Ali Khan[1],
Thomas Puestow[2]

[1] Water Resources Management Division, Department of Environment and Conservation, Government of Newfoundland and Labrador, St. John's, Canada
[2] Centre for Cold Ocean Research (CCORE), St. John's, Canada

hkhan@gov.nl.ca

There are over 260 international or transboundary water basins shared by two or more countries worldwide. These transboundary watersheds comprise over 50 percent of the Earth's surface, contain 40 percent of the global population, and include no less than 145 different nations (Grover, 2007). Rarely does the convenience of having hydrologic boundaries match up with political ones exist, making management of transboundary water resources one of the greatest challenges currently facing our world today. In the last 20 years there has been a concerted movement toward integrated water resources management (IWRM), promoted heavily at the international level, even for transboundary basins. This approach arose in response to the fragmented regimes where water was managed as part of sectoral use, but never under a common, holistic policy framework. IWRM attempts to integrate social, economic and environmental factors and facilitates a more-complete understanding of the political, cultural, and social aspects of water.

The principles and elements of trans-boundary water governance have their foundation in international water law and include, but are not limited to, cooperation, equitable and reasonable use, obligation not to cause harm, obligation to exchange data and information, and emergency notification. Organizations that control transboundary water resources come in many forms, and much has changed since the first inter-state water agreements were created. Treaties and agreements in international river basins vary according to the parties involved (bilateral, multilateral), the subject matter (data collection, allocation, planning, construction), territorial extent (entire basin, sub-basin), and the intensity of cooperation (duty to inform, implementation of joint programs) (Tortajada et al., 2006). Transboundary governance structures can include: authorities, commissions, compacts, conventions, initiatives, agreements, treaties, councils and partnerships.

The fact of transboundary water governance in and of itself can be considered a success and has resulted in the evolution of robust institutions that can survive even through the worst of times. The management of transboundary rivers basins is a sufficiently focused issue area in which to drive international relations and cooperation. It is also a unique arena in which to test new intergovernmental policies and methods, a forum for engendering 'social learning', and is a field in which nations can show global leadership. Creating working transboundary water governance structures requires an adaptive approach, learning from member groups, and the development of trust between stakeholders. At the transboundary level, the concept of integrated watershed management has seen some improvements in water quality, greater equity in water allocation, and increased coordination between relevant stakeholders. Institutions for managing transboundary waterbodies are also useful channels for communication and discussion, and for the exchange of data and information.

The management of watersheds whether they cross international boarders or not is a difficult prospect in the face of hydrological extremes, deteriorating watersheds and water quality, rapid human population growth, increasing urbanization, climate change, and man-made disasters. The weaknesses of transboundary water governance are manifold in part due to the sheer scale of issues and the frequent gaps between policies, plans and practices. The various agencies and organizations involved in transboundary water governance in any given region make decision-making and consensus building very difficult to achieve. Agencies directly responsible for water resources are often overextended, with insufficient technical capacity and support. If planning in jurisdictions is not done in parallel, collaboration can be hindered. Scientific and political approaches can differ between countries as can ambition levels. Funding is also a major issue as this allows long term planning and institutional stability. In many transboundary governance organizations too much time is spent on administration and other irrelevancies, time which would be better spent working on watershed issues. Some water agreements are simply too narrow in focus and are vulnerable to climate change. Water quality is often overlooked in the context of international water management which focuses more on water quantity and allocation. Joint development of international rivers is difficult to achieve because of questions of sovereignty, ownership and jurisdiction. Lack of authority and enforcement power plagues all transboundary water governance organizations. Success also relies on having an impartial basin coordinator and avoiding institutional, sectoral, and jurisdictional bias. Transboundary governance organizations do little to raise awareness within the general public as to their activities and achievements. Information production also tends to lag behind information needs in water management (Nilsson, 2003).

Many transboundary basin organizations are at the point now where stagnation has set in; they have achieved all they can in their current form and must decide whether to evolve with the times and make use of emerging technology to improve effective management of watersheds. The doctrine "you can't manage what you can't measure" applies to the governance of transboundary waters. In order not to become redundant, such organizations must have data, and a wide spectrum is required to support informed decision-making and to evaluate the effects of decisions. Science-based assessment of key transboundary problems and their root causes creates a factual process that can assist countries and different stakeholders to become aware of the top priority transboundary concerns and to focus politically on key issues. Having a solid scientific footing for multi-country collaboration has proven to be effective in reducing tensions between conflicting resource interests, and transitioning from water conflict to cooperation. The next steps in the transboundary governance process therefore must involve more comprehensive monitoring programs. Emerging technologies that can be used in transboundary water governance to produce necessary data include:

- In-situ, real-time water monitoring technologies
- Earth Observation (EO) remote sensing technologies
- Communication and network technologies
- Water related indices

Emerging water management technology has seen only limited use worldwide, and even less use in the context of transboundary water governance. One location where the integrated use of different emerging water monitoring technologies has been piloted is in the Nile Basin in Egypt in two recent state of the art environmental monitoring and sensing programs:

- "An Environmental Security and Water Resources Management System Using Real Time Water Quality Warning and Communication" implemented in 2007 under the Science for Peace initiative of NATO
- "Satellite Monitoring of Lake Water Quality in Egypt" implemented in 2005 and funded under the TIGER initiative of the European Space Agency (ESA)

The Nile is the longest river in the world at 6,695 km, with a drainage basin covering an area of 2.9 million km^2, or about 10 percent of the African continent. The Nile and its tributaries flow though ten countries: Uganda, Sudan, and Egypt, Ethiopia, Kenya, Tanzanian, Democratic Republic of Congo (DRC), Rwanda, and Burundi. On average 85% of Nile water is utilised for agricultural purposes. The Nile River is also an important source of hydroelectric power. Today, Nile Basin countries face the challenges of poverty, instability, rapid population growth, and severe environmental degradation. However, joint regional development of the Nile offers significant opportunities for cooperative management and development that can catalyze greater regional integration for socioeconomic development. With assistance from the UNDP and the World Bank, in 2001, the ten Nile basin countries cooperated in launching the International Consortium for Cooperation on the Nile known as the Nile Basin Initiative (NBI) (Raadgever et al., 2005).

In recent years, Egypt has become increasingly vulnerable to the loss of Nile waters through a combination of withdrawals by upper riparian countries, water pollution, climate change, and increasing water demand in Egypt and throughout the Nile basin. Egypt has a population of 76 million (in 2007), 99 percent of which lives within the Nile Valley and Delta. Egypt depends on the Nile River for 97% of its surface water, has 3.2 million hectares of cropland totally dependent on irrigation, and at current water demand is very near the limits of water supply (Khan et al., 2006). The economic and social importance of ensuring the security of the Nile River against any natural or anthropogenic threats cannot be overemphasized and would have far reaching economic, social and political implications.

Real time water monitoring involves continuous measurement of water related parameters in-situ with results provided in real time or near real time. The water monitoring system implemented under the NATO Science for Peace initiative comprised of four real-time water monitoring stations (quantity and quality), one automated weather station, and set-up of a data collection and reporting command centre (Khan et al., 2006). The new integrated water monitoring, warning and reporting system will allow the management of Egypt's water resources using a real-time pro-active approach, providing decision makers with information about the present status of water quality. It will allow senior water managers to protect the integrity of Egypt's vital water resources against any natural or anthropogenic threats, take immediate corrective and mitigation measures, and report the suitability of water for designated beneficial water uses. Such a real time water monitoring network will lay the foundation for greater environmental security and water resources management in the country.

An indicator is a means for reducing a volume of data without loosing significant information. Indicators are useful tools as they meet the information needs of policy and decision makers. One component of the water monitoring and reporting system implemented under the NATO Science for Peace initiative was the development and implementation of a water quality index to report the suitability of water for designated beneficial uses such as drinking, irrigation, livestock, fishing and recreational use. The Egyptian Water Quality Index (EWQI) was developed in parallel with the real time water monitoring network to create a more integrated approach to water monitoring, coupling the production of Egyptian water quality data with the ability to provide decision makers with information that can then be acted upon (Khan et al., 2008).

Earth Observation is the gathering of information about the Earth's physical, chemical and biological systems. It is used to monitor and assess the status of, and changes in, the natural and built environment. In the context of emerging technologies for transboundary water governance EO involves the use of photos and radar images taken from remote-sensing satellites. EO systems provide spatial observations at a large scale, and temporal information at increased monitoring frequency as compared with regular in-situ monitoring systems. EO has the ability to extend point measurements to estimates of water quality over larger areas and it more easily captures non point pollution sources over field methods. EO can be used to identify where pollution is coming from, what areas are affected by pollution, status and trends in water quality and surface cover over time, identify actions to mitigate problems, and measure the effectiveness of different mitigative actions. In 2005, the project "Satellite Monitoring of Lake Water Quality in Egypt" was funded under the TIGER initiative of the European Space Agency (ESA) with the objective to design, develop and implement an EO based capacity for the operational monitoring of water quality in Lake Manzalah, Egypt (C-CORE, 2007). When integrated with real time monitoring networks, the project produced a comprehensive set of water management products including both water quality (TDS, TSS, turbidity, chlorophyll) and surface cover (vegetative cover, land reclamation). Other value-added information that can be produced from EO water quality monitoring includes development of water quality management zones; monitoring of secondary parameters that cannot be observed directly via EO, but that could be mapped via existing relationships with primary parameters; evaluation of temporal variability in the absence of in-situ data; and evaluation of seasonal differences in water quality.

Figure 1: Lake Manzalah water quality management zones (C-CORE, 2007)

These projects provided a holistic approach that is inherently proactive and that encompasses different aspects of integrated water resources management including data collection, early warning, analysis, reporting, response, and mitigation. The networks established use existing technologies, but their integration into a single system involves development of protocols and procedures unique to the needs of water resources security and management in Egypt. The testing of such innovative water management technologies in Egypt has so far only been on an ad hoc basis. What is needed is a single project with integrated application of advanced communication technology, real time water monitoring, water related indices, and EO systems. This is an innovative approach to IWRM that could be expanded to other countries within the Nile basin under the direction of the Nile Basin Initiative. Other potential application and testing areas include anywhere there are international transboundary waters under pressure.

The use of innovative monitoring technologies in transboundary water governance is still, for the most part, in the pilot stage. New uses for the technology are continually being found as well as linkages in how the technologies can be used together, to support, reinforce and strengthen water resources management. The conventional approach to water monitoring essentially involves the running of different stand alone monitoring programs in parallel. The innovative approach using emerging technologies creates a network interlinking all aspects of the monitoring program. The use of innovative technologies in water management is inherently pro-active allowing for more immediate, comprehensive and integrated assessments and decision making. Monitoring data is available in real time and can be generated over the entire basin. For decision makers, the web of integrated information produced with emerging water monitoring technology can exponentially enhance their understanding of the drivers and pressures impacting the state of the watershed. This innovative approach makes the watershed come alive– its character, behaviour and responses.

The overarching goal of sharing international waters through transboundary water governance is built upon the foundation of integrated water resources management. At its core, IWRM provides a holistic and adaptive approach to resource management where the total land and water resource base is considered as a whole. The information needs implied by integrated water resources management should be met in a manner as integrated, comprehensive and adaptive as the concept itself. The use of innovative and emerging water monitoring technologies and methods brings us closer to achieving this. In the future, IWRM should also stand for Integrated Water Resources Monitoring.

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