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Perspectives and Initiatives on Integrated River Basin Management in Malaysia: A Review

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Abstract: The management of river and water resources in Malaysia remains fragile and inherited with many problems of a river basin. Rivers in Malaysia play an important role in conservation, agriculture and potable water supply but they are facing threat from rapid development in the industry sectors and urbanization. This study attempts to focus on the current situation of water issues in Malaysia in particular on perspectives and initiatives pertaining to Integrated River Basin Management (IRBM) within the more encompassing context of Integrated Water Resource Management (IWRM). The complex process of decision making for sustainable management of water and river basins needs an integrated and holistic approach involving many stakeholders and disciplines. In Malaysia, several government agencies and local authorities are involved in managing the rivers. The management of the water resources in an integrated and holistic manner for a river basin will lead to solutions to the several major problems encountered with water management in river basins. Water resources development, river and flood plain management and projects on policy analysis needs a multidisciplinary approach. This study also looks at several initiatives in Malaysia and few other countries in implementation of IRBM concepts.

Key words: Water resources, IWRM, river basin, water issues, authorities, Malaysia

INTRODUCTION

Increase in population leads to an increase in demand for water supply and safe water. This valuable resource needs to be managed in a sustainable manner in order to ascertain a sustainable development of human population in an environment with finite amount of resources. In many developing countries, water resources management is a problem due to lack of integration and holistic approach usually with little participation of the general public and other stakeholders apart from the government. In addition, not only are systems poorly designed and underfinanced but also regulatory and management aspects remain weak. Collaborative Decision Making (CDM) mechanism has been promoted as one of best management approaches in managing water resources in a river basin including the suggestion to use indicators in performance measurements (Mokhtar *et al*. 2004a, b).

The concepts of IWRM and IRBM treat water as a finite and vulnerable resource, water as an economic good and water governance should be based on a participatory approach involving all levels of stakeholders. The integration means integration within and between natural and human systems. Water resources management has often focused on satisfying increasing demands for water without adequately accounting for the need to protect water quality and preserve ecosystems and biodiversity. The changing in government policy plays an important role in increasing the complexity in managing water resources. Change in focus on economic development involves a change on emphasis on different sectors such as transformations from an agriculture-intensive to industry-intensive activity which resulted in changes in land use activities. Changes in land use such as deforestation, agriculture and industrial and residential development have large impacts on water quality in many river systems. Rapidly growing cities and industries, expansion of the mining industry and the increasing use of chemicals in agriculture have undermined the quality of many rivers. Rapid changes in land activities may increase the sources of pollution loads in the river systems. Maintaining good water quality is a growing concern in water resources management around the world. IWRM and IRBM when applied to water systems involved integration between freshwater and coastal zones; land and water; surface water and groundwater; quantity

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and quality and upstream and downstream. The principles to be adopted are economic efficiency, equity and environmental sustainability. There is also a need to develop a structural framework comprising management instruments, enabling environment and institutional establishment. IRBM which deals with issues of water allocation, pollution control, flood control is a subset of IWRM which addresses the broader issues of food self sufficiency, tariffs, cross subsidies, institutional roles, etc.

The role of the Global Water Partnership of which the Malaysian Water Partnership (MyWP) is a chapter, promotes and facilitates IWRM/IRBM. The global mission messages are involvement of all stakeholders moving towards full-cost pricing of water services, increasing public funding for research and innovation, promoting cooperation in management of international basins and increasing the investments in water projects (Hiew, 2001). Water as an important resource in the coastal zone should also be managed sustainably within the context of Integrated Coastal Zone Management (ICZM) as being discussed in a study by Mazlin and Sarah.

Concepts of IWRM and IRBM: The concept of Integrated Water Resources Management (IWRM) was already recognized in Agenda 21 of the United Nations Earth Summit on Environment and Development that was held in Rio de Janeiro in 1992. At the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, the international community has also took an important step towards more sustainable patterns of water management by developing IWRM and water efficiency plans with support to developing countries.

The World Summit on sustainable development has identified several key issues and challenges and proposed many actions to meet the challenges with increasing focus on water supply and sanitation as well as the need for improved frameworks for IWRM and water governance at all levels (WEHAB, 2002).

IWRM may be defined as a process that promotes the co-ordinated development and management of water, land and related resources in order to maximise the resultant economic value and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP-TEC, 2004). IWRM is a comprehensive approach to the development and management of water, addressing its management both as a resources and the framework for provision of water services. IWRM includes social, economic and environmental factors in the planning, development, monitoring and protection of land and water resources. Hence, IWRM is not limited to addressing just physical relationships or water resources characteristics. It also includes water as an integral part of the ecosystem, a finite natural resource and a social and economic good (Davis and Hirji, 2003a, b). IWRM includes the planning and management of water resources both conventional and unconventional and land. This takes account of social, economic and environmental factors and integrates surface water, ground water and the ecosystems through which they flow. It also depends on collaboration and partnerships at all levels from individual citizens to international organizations, based on a political commitment to and wider societal awareness of the need for water security and the sustainable management of water resources (Shahrizaila, 2000). IWRM approach in Malaysia has also been discussed by Mazlin and Ghani (2003). IRBM as a sub-set of IWRM deals with management at the basin level involving aspects like water allocation, pollution control, flood control, etc. (Clausen, 2000).

IRBM defined as the coordinated management of resources in natural environment (air, water, land, flora and fauna) based on river basin as a geographical unit/area with the objective of balancing man's needs with necessity of conserving resources to ensure their sustainability (Keizrul, 2000).

It means that river basins need to be managed in an integrated and holistic manner (IRBM). The river basin approach not only focuses on water itself and the services it provided to society but also to water related ecosystems, terrestrial and aquatic. Hence, IRBM would invariably address the integration of natural limitations, social and economic demands, legal, political and administrative processes.

IRBM is geared towards integrating and effectively coordinating policies, programs and practices addressing the water and river related issues to balance the needs of socio-economic development with the needs of conservation and protection of the environment (Keizrul, 2002). The water related issues include the efficiency of water use, long term resource protection and the economics that affect deterioration in water quality while the river related issues include river basin-based management of water resources and waste water, data collection and dissemination and model development. This process will require improved professional capability and increased financial, legislative, managerial and political capacity.

The concept of IRBM is recognized as highly desirable but is very far from being applied universally. Administering a river basin through a single organization may appear to have advantages over establishing various bodies. However, even where one organization has overall responsibility for a basin, the same compromises have to be reached internally which may be easier but does not have the advantages of transparency resulting from more open debate through public scrutiny (Brown, 1994).

IRBM in Malaysia: Malaysia has recently adopted IWRM as an innovative approach to managing its water resources. Clear pronouncements to the effect are found in the 3rd Outline Perspective Plan (OPP3) and the 8th Malaysia Plan (MP8) documents. The adoption provides the necessary impetus to break away from traditional practices characterised by multiple individualist sector-centred approaches. In line with the current international trend, the new approach promises to overcome deficiencies in cross-sector co-ordination, reduce conflicts and inefficiency and engenders equity.

Countrywide adoption and implementation of IWRM principles and practices has been hampered by the absence of an enabling environment which is contributed by factors including the following:

- General lack of awareness of IWRM-countrywide
- Lack of capacity in implementing agencies (public, private and NGO's)
- Absence of Best Management Practices (BMPs) in IWRM that is appropriate to the Malaysian context

Under the Malaysian constitution, water is a state matter. Nevertheless when it comes to water resources development, utilization and management both the federal and state governments are involved. This is because the responsibility for water resource administration is fragmented and is shared among a number of federal and state agencies each of them have their own specific involvement in water related issues (Welch and Keat, 1987). Their interest in water related matters could be viewed from any one or more of the following 3 aspects:

- The planning, development and management of water resources aspect
- The protection and conservation of water aspect
- The land-use control and watershed management aspect

IWRM plans include actions necessary to develop an effective framework of policies, legislation, financing structures, capable institutions with clearly defined roles and a set of management instruments (GWP-ToolBox, 2003). The purpose of such framework is to effectively regulate the use conservation and protection of the water resources, balancing requirements for broad economic development and the need to sustain ecosystems. The emphasis here is on the process of establishing priorities and actions for integrated management of water resources Priorities include ecosystem protection and conservation in the basin. Although, modest progress has been made in creating public awareness in IWRM, its realisation is still minimal. IRBM concept was taken into consideration in the study by Mokhtar *et al.* (2004 a, b) titled Ecosystem Health of The Langat Basin. This study was started at the end of year 2000 and completed on December 2003 under the IRPA Grant mechanism. The objectives of the study were:

- To understand inter and multi-disciplinary approaches to monitoring and assessing the health of the Langat basin ecosystem and suggest framework for integration
- To identify strategies and tools that allow integration of conservation and development, maintenance of ecological integrity, protection of ecosystem resilience and satisfaction of basic human needs
- To gather scientists and technical experts to monitor, analyze, evaluate and make recommendations on the sustainable management of ecosystem health at the national level based on the Langat basin a case study
- To suggest a list of environmental health indicators which will assist planners, policy and decision makers in planning and environmental management
- To develop information directory related to Langat basin ecosystems to facilitate finding of information and references
- To develop a decision support system inclusive of data bases, good management systems, modeling and friendly user interface

This study advocates the concept and scope of IWRM-IRBM and introduces a general framework for structuring IWRM-IRBM planning and implementation. It also involved the development of a simulation model using Artificial Neural Network (ANN).

Widening application of the concept of IRBM in the world: This study looks at two examples of the application of IRBM in others countries, i.e., the Mekong river basin and the Murray-Darling basin.

Mekong river basin: The Mekong river is the longest river in South-East Asia. The mainstream of the Mekong river flowing through six countries namely China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam to the sea via My Thuan and My Tho in Vietnam. The four downstream countries (Cambodia, Lao PDR, Thailand and

Vietnam) are members of the Mekong River Commission (MRC) for sustainable development to build regional cooperation on water resources management. Water resources management issues and priorities differ in each of these countries as do the level of economic development and size of population (WWF, 2003a). The Mekong river commission's work in the sector areas feeds into core programmes. The core programmes facilitate joint planning and development between the 4 member countries of the Lower Mekong basin in a way that looks at the river basin as an ecological whole.

Basin development plan: The Basin Development Plan (BDP) is a planning process to identify and prioritise development projects that will bring the best, most equitable benefits to the people of the Lower Mekong basin.

The BDP institutionalises a planning process necessary for the responsible management and sustainable development of the Mekong river basin's resources. The BDP will achieve a balance between socio-economic development and environmental concerns and ultimately create a framework for development based on technical knowledge as well as public, stakeholder and political views. Through, the development of scenarios, strategies and planning guidelines the BDP will foster co-operation between stakeholders throughout the Lower Mekong basin.

Water utilisation programme: The water utilisation programme is developing rules for water use that are agreed upon by the four governments of the Lower Mekong basin.

Environment programme: The environment programme strengthens the framework for transboundary environmental management by the four Lower Mekong countries.

Flood management programme: The Flood management and mitigation programme have been recently developed, focusing on three areas: providing technical products and services, addressing differences and facilitating solutions and capacity building and technology transfer.

Capacity-building programme: This programme has provided support to the Secretariat and National Mekong Committees in each country for improved systems of administration, management and communications.

Agriculture, irrigation and forestry programme: The programme focuses on water-use efficiency, catchment management and capacity building. In 2002, watersheds in the Lower Mekong basin will be inventoried and key areas of transboundary significance will be selected for activities.

Fisheries programme: The fisheries programme aims to manage the productive Mekong fisheries so as to sustain their high yield and economic output well into the future. The programme does research into capture fisheries, trains fisheries managers, promotes aquaculture of indigenous Mekong fish species and disseminates information to policy makers and planners in the four Lower Mekong countries.

Water resources and hydrology: A network of river monitoring stations along the Mekong transmits real-time information on water levels for flood forecasting and other uses. The MRC runs training of gauge readers and other water resources staff of the four Lower Mekong governments.

Navigation programme: The Navigation programme promotes freedom of navigation on the Mekong and works to increase social development and international trade opportunities using the natural navigation potential of the river system. Although, all parts of the system will be addressed 2 critical areas will receive special attention (Davis and Hirji, 2003a). These are the delta in Vietnam and the Tonle Sap lake in Cambodia. The delta covers about 12% of Vietnam's land area, supports about 17 million people and produces half of the country's rice. With catchment and other changes, the river's flow is increasing subject to floods with excessive floods occurring about every 30 years instead of every 200 years and consequent lower flow in the dry season. As a result, there is increasing saltwater intrusion into the delta which adversely affects delta residents, domestic water supplies and up to 2 million ha of agricultural land.

The Great lake or Tonle Sap is of exceptional ecological, economic and cultural importance. Situated in Cambodia, it is linked to the Mekong river by the Tonle Sap river. In the dry season, The Great lake drains into the Mekong. In the wet season, The Mekong reverses the flow of the Tonle Sap river which expands the lake from about 3,000-16,000 km^2. Gradual drainage of the lake in the dry season significantly contributes to dry season low flows in the delta.

Murray-darling basin: Located in the South-East of Australia, the Murray-Darling basin covers over 1 million km^2 of the country's total area. East-West, the basin extends for 1,250 km while from the source of the Warrego river in the North to the headwaters of the Goulburn river in the South, the distance is some 1,365 km. The basin covers four states (New South Wales, Victoria, South Australia and Queensland) and the entire Australian Capital Territory (ACT) and contains about half the irrigated agriculture in Australia. Some 2 million people live in the basin, another 1 million outside it are dependent on its water. It contains some of the country's best farmland and use of its waters has allowed expansion of irrigated agriculture into the drier inland areas.

The rivers of the Murray-Darling basin in Australia are seriously degraded as a result of over-abstraction of water and increasing nutrient and salinity levels (Davis and Hirji, 2003a). It suffers from drought and increasing levels of salt in soils and water. To address the challenges faced, the Murray-Darling basin commission has implemented a comprehensive planning framework for the river basin and its natural resources (WWF, 2003b). As part of its approach, the commission placed a cap on total water withdrawals at the river basin level and set up a process to negotiate environmental flows for each tributary and the main river.

Past management practices which have led to unsustainable land and water use and current practices which focus on achieving sustainability, provide an essential context for determining priority crops. The biophysical characteristics of the basin reveal the inherent difficulty of applying European-style water use practices in a very different geological and hydrological setting. The attempt to harness water resources in Australia has led to a particular type of agricultural use and this in turn has led to a wide range of environmental problems (WWF, 2003a). In many parts of the basin, water trading systems are in place enabling farmers to buy and sell their water allocations, enabling producers of low value crops or on leaky land to sell their water to producers of higher value crops or who are located on better soil types (WWF, 2003b). Further, government charges for water are being increased towards the real cost of supply, removing a perverse subsidy and providing an incentive for more efficient use. While, there is significant room for improving the emerging systems, the net result is that water is increasingly used for high value purposes and minimum water levels are guaranteed in the river to support other functions, including nature that supports agriculture in the first place.

The IRBM-modelling approach: Mathematical model provides a basin wide representation of the water availability and use of water offers a strong, transparent and easily understandable framework for analysis and discussions of resource sharing and development option. The application of modeling in river basin management was widely used among scientists and engineers. It can be seen in exponentially increase in publications recently. One of the challenges of today's river basin management is to reduce the cost and develop more intelligent computer aided tools in evaluating river basin management. This study proposes to investigate the ability of Intelligent Predictive Tools (IPT) to estimate the WQI at Langat river basin.

Approaches based on IPT are highly desirable in estimating the non-linear behaviour of urban water quality under historical and future scenarios. The most popular predictive model usually applied to model non-linear environmental relationship is the Artificial Neural Network (ANN) (Zhang and Stanley, 1997; Jain and Indurthy, 2003). The use of ANN in this study was justified from the availability of abundant historical data for the Langat river basin. Successful application of ANN as a water quality forecaster at the Langat river basin can be seen in several recent publications.

Among the studys that have been published are Juahir *et al*. (2003) showed that the ANN model gives a better performance compared to the autoregressive integrated moving average (ARIMA) model in forecasting DO; the use of ANN for river regulation (Mohd and Hafizan, 2003) and the application of second order backpropagation method (Juahir *et al*., 2004). The IRBM in Malaysia was applied in the case study of ecosystem health of the Langat basin. In this study, we try to develop the decision support system or river management tools (Fig. 1).

The application of ANN covers:

- Multi-disciplinary expertise coupled with the state of the art information technology and capacity to develop and transfer tailor-made mathematical models to assist water managers
- Expertise involving transformation of knowledge, training and institutional support to make operational innovative new approaches to the task of balancing water management tasks with economic and ecological sustainable development
- New information technology and mathematical modeling which has been proved be a cost-effective method for water managers in developing and optimizing the rational and environmentally sound use of the natural resources

The Langat river basin: The Langat basin is an area drained by the Langat river in the state of Selangor, Malaysia. The basin is currently the fastest developing area in the country. A number of large scale social-economic projects have either currently taking

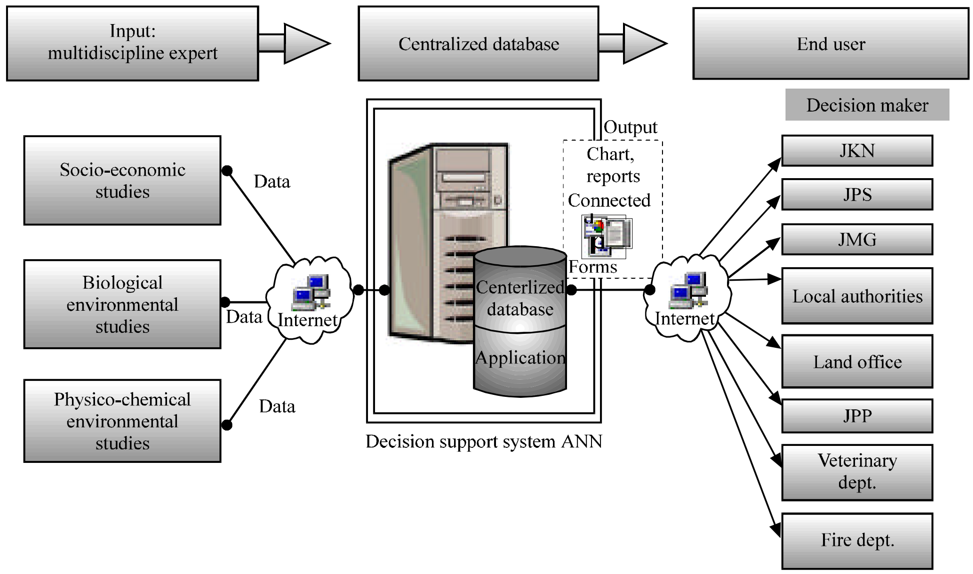

Fig. 1: Ecosystem health of the Langat basin database

shape or are already completed in the basin. This include the new township of Putrajaya (new Federal Government Administration Center), Multi-Super Corridor (MSC) for information technology industry, the BioValley for biotechnology research/industry, the Kuala Lumpur International airport and several other institution of higher learning including universities. The rapid urbanisation in the basin has led to a large influx of people into the region.

The sudden increase in population has exerted a number of stresses on the Langat river. One of the main problems is river pollution from sewage and suspended solids resulted from land clearing and discharge of untreated or incompletely treated sewage. The problem is a concern of many including government, non-governmental organisations and the public as the Langat river is the main potable water resource for the whole Langat basin and the Klang Valley (Kuala Lumpur) nearby where almost a million people depend on the Langat for drinking water. Many activities have been carried out to arrest the deterioration of the Langat river water quality but few have achieved success. The root to the problem is the absent of a truly integrated management system of water resources in the basin (Rahmah *et al*., 2004).

The basic concepts of ANN applied in Langat basin: In general, ANN models are specified by network topology, node characteristics and training or learning rules. It is an interconnected set of weights that contain the knowledge generated by the model. An ANN is composed of a large number of simple processing units each interacting with others via excitatory or inhibitory connections (Fig. 2).

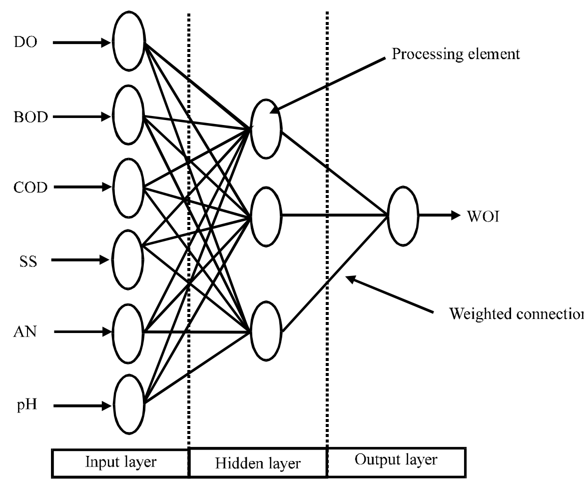

Fig. 2: Example of ANN configuration

Distributed representation over a large number of units together with interconnectedness among processing units, provides a fault tolerance. Three different layers can be distinguished as follows:

- An input layer, connecting the input information to the network. In this study 2-6 input nodes were applied which are DO, BOD, COD, SS, AN and pH
- Hidden layer (one or more hidden layer) acting as the intermediate
- Computational layer, multi-layer feed forward networks formed by only one hidden layer
- Output layer producing the desired output. In this study WQI is the desired output

During training, the error in the model's response to input examples is measured and the internal configuration is adjusted accordingly (weightings of connections between processing elements are changed) to reduce the error in the overall response (Sudheer *et al*., 2003). Training is analogous to model calibration (Rojas, 1996). Levenberg-Marquardt back propagation algorithm was chosen as the training algorithm. The ANNs are trained starting from two inputs and 20 different initial networks, randomly initialized from which the best performing network on the training data is chosen as the trained network. The training considered an early stopping approach and only training set was used for determining weights and biases. About 2 activation functions were applied in these networks which are log-sigmoidal (logsig) and linear transfer function (purelin).

CONCLUSION

Proper management of river basins are important in reducing water pollution which not only causes degradation in the upstream areas but also downstream; as well as coastal and estuarine areas. River basin management should take into consideration the integration of the roles played by various agencies (both government and private sectors and NGO's and the citizens), land use development activities and protection of vital ecosystems. Strong coordinated national actions are required to integrate legislation and also all the related agencies that are related to river and water resources management.

The integration will take into account the coordination in decision making among different levels of government and among various sectoral departments and agencies within government, private sectors, NGO's, communities and also universities or research institutes. It is also the integration in terms of holistic approach management that looking at overall development in the river basin to avoid conflict among users.

The task of the integrated approach will include the setting up of water quality standards, regulation and control of pollution. Coordination among various agencies could help to prevent conflict and duplication of functions and roles. In order to achieve the objectives of IWRM and IRBM to obtain effective river basin management, appropriate decision support systems and management tools are indispensable. A suite of flexible of models allowing for extrapolation, interpolation and detail evaluation of data and refinements in description is advantageous to simple rigid models. Without flexibility of models, experience shows that application and maintenance of models becomes too tedious and laborious and benefit compared to cost is significantly reduced when compatibility is not achievable. One example of a flexible and loose model was developed with the user's input data and requirement for increasingly advanced approaches in modeling is Artificial Neural Network model.

In numerous cases around the world, these models have demonstrated their usefulness providing water managers a powerful decision support system. Water managers need to develop an understanding of the concept of IWRM, its potential benefits and how best to put it into practice. In addition, water professionals need to acquire skills to apply specific (often sectoral) management tools to make regulations to set up financing systems, etc. Specialist training courses in such topics as social assessment, designing and running participatory and gender sensitivity processes, dispute management and consensus building, institutional design, policy profiling and working with the media can be valuable.

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