

## Proposed Integrated Land and Water Resources Management System (ILWRMS) for the Bang Pakong river basin: lessons from a user needs assessment

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### ABSTRACT

The institutional setting in Thailand is very complex, with various agencies dealing with a single resource, often competing for budgetary allocations. This is most evident in water resources, where the lack of co-ordinated river basin management has led to degradation of water quality and resource depletion. This paper, based on work conducted for the Royal Irrigation Department of Thailand and with financial support from the Canadian International Development Agency, discusses the user needs assessment of an Integrated Land and Water Resources Management System (ILWRMS) for the Bang Pakong river basin. The Bang Pakong is a tidal river in the eastern region of Thailand, with a total catchment area of 18,500 km<sup>2</sup>. Co-ordinated management of the basin may be achieved by improving the quality of land and water resources information, and by developing the means for information sharing. A system is needed in which the main parties have a sense of ownership while allowing access to land and water information to all stakeholders. The paper reviews the lessons learned during the user needs assessment regarding the interaction of technology and policy in water resources, and discusses the implications for institutional strengthening of river basin management in Thailand.

**Key words** | integrated, management, real-time, river basin

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### INTRODUCTION

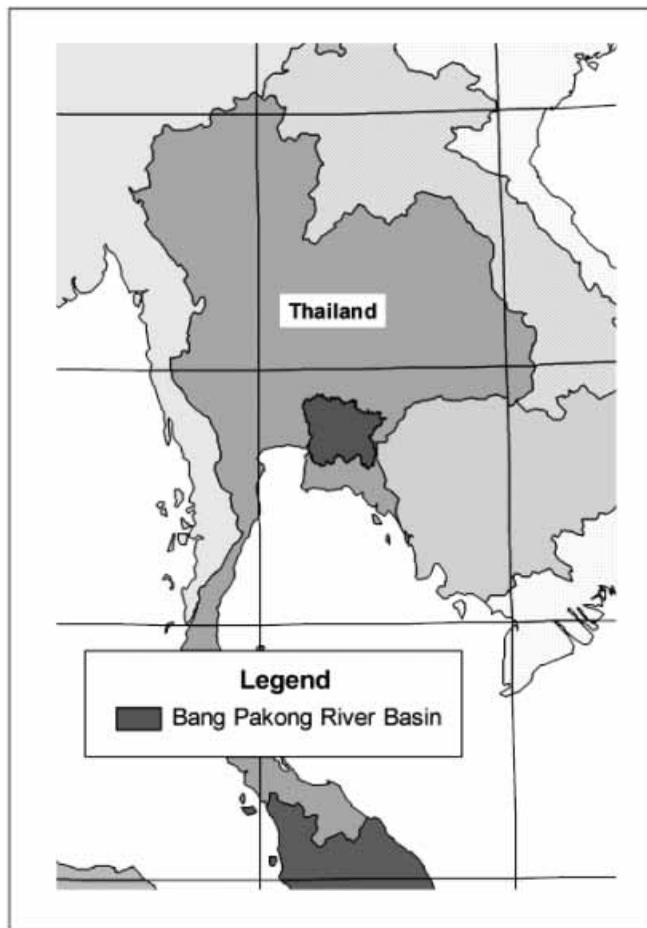
In February 2000 Thailand's Royal Irrigation Department (RID) undertook, with the financial support of the Government of Canada provided through the Canadian International Development Agency (CIDA), a feasibility study for an Integrated Land and Water Resources Management System (ILWRMS) for the Bang Pakong river basin.

One of the initial tasks of the study was a user needs assessment to answer important questions that would guide the study. What problems must be addressed? Who are the key stakeholders and what would they like ILWRMS to do? Which technologies will ILWRMS need to support or use? Detailed answers to those questions helped RID and its consultants with the development of a conceptual design for the system, preliminary specifications, and a costing and financial plan. On its own, the user needs assessment would raise

issues and communicate them to the various decision-makers.

### THE BANG PAKONG RIVER BASIN

The Bang Pakong is a tidal river, with brackish water reaching 120 km upstream during the dry season when freshwater runoff is minimal. The Bang Pakong river basin is an important basin in the eastern region of Thailand, with a total catchment area of 18,500 km<sup>2</sup>. As shown in Figure 1, it is part of the country's eastern seaboard which, given its proximity to the Bangkok metropolitan area, has been the target of considerable economic development and, due to its location along the border with Cambodia, represents an area of strategic national importance.



**Figure 1** | Location of the Bang Pakong river basin in Thailand.

The population living along the Bang Pakong and its tributaries was 1,972,372 in 1997, which represents about 60% of the total population in the six provinces that share the river basin. Mean monthly rainfall ranges from 5 mm in December to 278 mm in September. The region has a flat topography in lower-lying areas, which is ideal for rice and other farming activities, but makes it prone to flooding. Although irrigation projects have improved the year-round supply of water, droughts remain a significant problem for farmers and industries alike. The watershed supports a diverse economy, including farming (rice, cassava, maize and other annual crops; trees such as mango, coconut and rubber; and livestock such as chickens and pigs) as well as a developing industrial

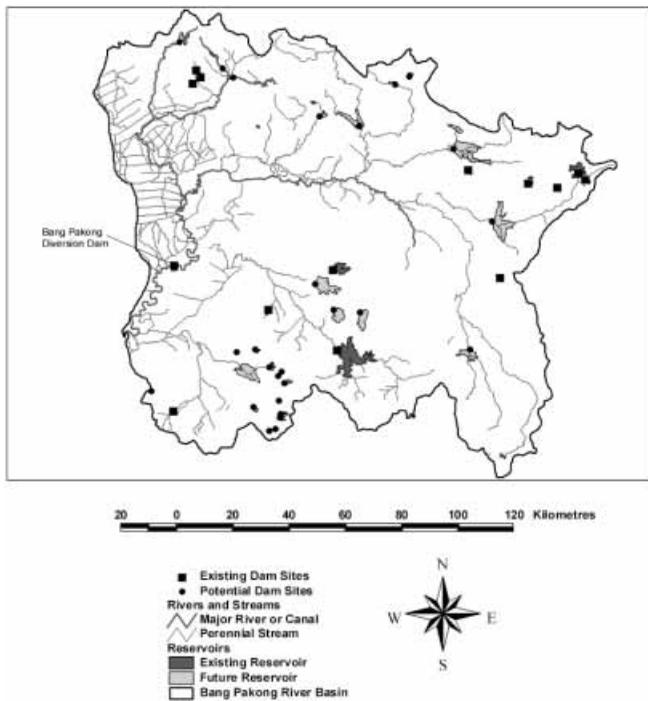
sector. Approximately 50% of the area is legally designated as forest, although roughly half of that amount is considered ‘encroached’, which means that it may be populated or supporting agricultural activities. Water demand for the region has been estimated at over 2,300 million m<sup>3</sup>/year in 1997, growing to over 3,200 million m<sup>3</sup>/year by 2017 (Kasetsart University, 2000).

Several water development projects have been planned and implemented to address increasing water needs in the basin, including the Bang Pakong diversion dam, the Klong Rabom reservoir and the Si Yat dam in Chachoengsao province, and the Klong Ta dam in Nakhon Nayok province (JICA, 1990; Panya, 2000). Further projects are under study or undergoing detailed design.

In January 2000, RID first operated the gates on the Bang Pakong diversion dam. The dam’s objective was to divert and store freshwater for different uses, mainly urban, and to prevent saltwater intrusion into irrigation areas. It operated only briefly before severe environmental problems, both downstream and upstream of the dam, forced RID to cease operations and evaluate how to proceed.

Downstream, the dam’s operation interfered with tidal fluctuations that had not been properly assessed during project planning studies: the river rose to a level that caused severe bank erosion (OEPP, 2001). Upstream, the dam prevented tidal flushing of the river laden with municipal sewage and the considerable effluent from pig farms and prawn culture ponds. Also, the dam prevented tidal flows from reaching upstream saltwater fishery operations.

The Bang Pakong diversion dam was intended to be part of a series of development projects for the basin, including several upper watershed reservoirs to provide freshwater for flushing and other demands, as shown in Figure 2. Unfortunately, the diversion dam project secured financing and government approval before the (upstream) projects that should have been constructed earlier. The delay of the upstream projects was prolonged by new regulatory requirements for environmental impact assessments which came into effect after approval to proceed with construction of the Bang Pakong diversion dam.



**Figure 2** | Bang Pakong river basin dams and reservoirs (existing and proposed).

The user needs assessment concluded that a lack of appropriate information for basin-wide planning was a significant underlying problem. If the proposed ILWRMS is to be successful, it must support modelling of water management functions such as dam operation in a comprehensive and detailed manner, well in advance of actual construction.

## INSTITUTIONAL SETTING

The institutional setting in Thailand is very complex, with various agencies dealing with a single given resource, often competing for budgetary allocations. As in many developing countries, overlaps and conflicts in administrative jurisdiction occur at the central level among government agencies, as well as between central and provincial authorities. The success of the ILWRMS project will depend as much on its ability to fit into the basin's

water-related institutional framework as on its technical merits.

Thailand has 34 different agencies with budgets for managing water resources for their own purposes, while 23 agencies deal with diverse aspects of land use and management. The Thai government has attempted to address the resulting conflicts by introducing co-ordination committees or boards with representatives from multiple interests. Examples include the National Water Resources Committee, the National Environment Board and the Pollution Control Committee.

Thailand's Eighth National Plan (1996–2001) introduced a scheme for the development and conservation of surface and groundwater resources, using a river basin approach integrating economic, social and environmental factors. The Office of the National Water Resources Committee (ONWRC) was established in 1996 to work as a national apex body for the integrated management of water resources (Pattanee, 2001). At present, ONWRC is constrained by the lack of comprehensive water resources legislation, and the fact that existing regulations are implemented by various agencies sometimes in contradictory fashion. Among the many concerns that could be broached by clear legislation is the definition of water rights in a country where water is regarded as a common good (and therefore everyone feels entitled to all the water they want or need).

Despite the lack of actual legislative backing, ONWRC has proceeded with important institutional development activities designed to put into operation an eventual water law at the basin level (Kasetsat University, 2001; TEAM *et al.*, 2001). With funding from the Asian Development Bank (ADB) and AusAID, ONWRC has overseen the creation of river basin committees for three sub-basins selected as pilot areas. In early 2001 ONWRC conducted meetings with stakeholders in the Bang Pakong region. In July 2001 the Bang Pakong river basin committee was established with the inclusion of representatives from water agencies, NGOs, academics, water users, farmers and local governments. Eventually, ONWRC expects to set up committees for all 25 designated river basins in the country, and to equip each of them with a water resources development master plan addressing allocation, conservation, water quality and flood mitigation.

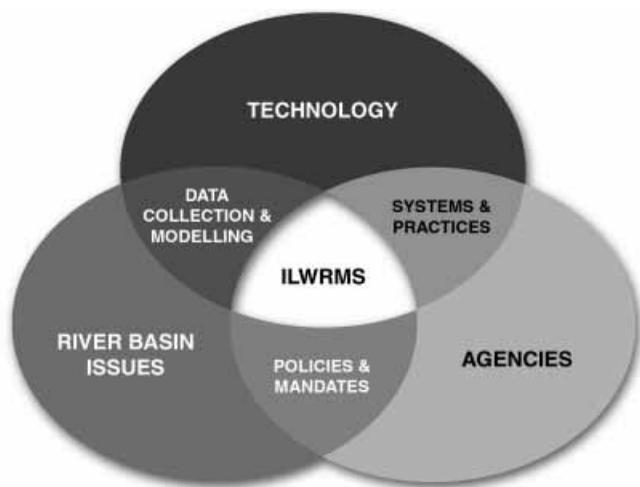


Figure 3 | River basin interactions.

## METHODS

User needs assessments are based on a combination of descriptive and analytical techniques. The user needs assessment for the Bang Pakong river basin was carried out on three aspects of the feasibility of the ILWRMS:

- River basin issues
- Agencies
- Technology

The interaction of these aspects is illustrated in Figure 3.

### River basin issues

The user needs assessment identified 23 subjects pertinent to water and land resources in the Bang Pakong basin. Subjects ranged from topography and hydrology, though natural and human-induced hazards, to socioeconomic and environmental considerations. The assessment of each subject was focused on addressing the following questions:

- What information is available?
- What are the main government policies and regulations?
- What entities are responsible or interested parties?
- How is the subject perceived and handled?

### Agencies

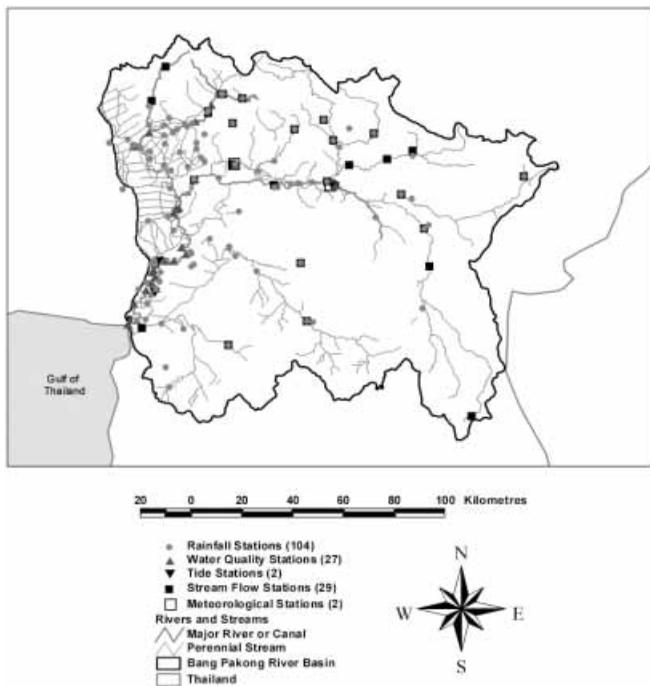
The river basin committee for the Bang Pakong is still at its initial stage. There is as yet no clear structure for water decision-making in the basin. Planning and implementation decisions are currently made on a project-by-project basis without much consideration of the basin as an ecosystem unit.

Twenty-two groups or agencies were identified in the user needs assessment as having a stake in the performance of the river basin. The participation of 14 stakeholder agencies from that list can be considered either essential or very important to the success of ILWRMS. The identified stakeholders were evaluated in terms of their potential contribution (primarily of data) to ILWRMS, and on the basis of the results they may expect from their participation.

### Technology

Data collection technology, models, geographic information systems and computer systems, currently maintained by Thai agencies, were assessed in terms of their implications for ILWRMS. As shown in Figure 4, a sizeable network of climate, stream flow and meteorological measurement stations is already in place. However, much of the data are collected manually and infrequently, making it impossible to provide a real-time picture of the river basin. Automation of data collection sites and adoption of new technologies to extract data from satellite images need to be seriously considered for their benefits in terms of better planning and management.

Despite the need for some upgrades, it was determined that ILWRMS could capitalize on software and hardware that already exist and are proven to be within the capabilities of stakeholder agencies' staff. Many of the basin's stakeholder agencies have made significant progress in digitizing data into geographic information systems. Also, hydrological models from the US Army Corps of Engineers' HEC series, and/or the Danish Hydrology Institute's MIKE series could become standard for ILWRMS, since Thai agencies are already familiar with their use.



**Figure 4** | Existing measurement stations in the Bang Pakong river basin.

## RESULTS AND DISCUSSION

Solutions for the Bang Pakong basin can be addressed from different angles:

- Market (e.g. water allocation that recognizes externalities).
- Institutional (e.g. multiple agencies sharing resources).
- Legal (e.g. appropriate water code).
- Infrastructure planning (e.g. effective operation of diversion dam).

The user needs assessment identified that consistent and appropriate information for decision-making is needed to support solutions in all these spheres of interest. In contrast, where agencies derive their own data to fulfil their own needs, data collection schemes are designed to serve a narrow range of uses.

The Bang Pakong watershed is perceived differently by the various agencies: the Royal Forestry Department

sees a watershed in which diminishing forests are reducing the capacity to retain and hold runoff; RID sees a Bang Pakong watershed that has untapped reservoir capacity; and the Ministry of Science, Technology and Environment sees a Bang Pakong watershed that is so threatened by pollution that it is being considered as an Environmental Protection Zone (Ministry of Science, Technology and Environment, 1997; OEPP, 1997). Although it is inevitable that multiple perceptions can coexist, they do not add up to a river basin as a whole.

For example, one of the tenets of river basin sustainability is that water quality should be considered along with water quantity when designing and operating water resources systems, because the physical and biological characteristics of the available water may limit its beneficial uses. Decisions bearing on water allocation or dam/reservoir operation would benefit from water quality information that is accurate, that is as close to real-time as possible, and that is validated by the participation of stakeholders with an environmental mandate. The ability to access and share information as a common resource provides the possibility of understanding the Bang Pakong basin's behaviour as an ecosystem.

From the perspective of an integrated data system, the participation of diverse agencies sets the stage for co-operation. But more than data sharing is needed: data must be fully integrated for the river basin. The emphasis therefore is on creating tools that (a) reflect the data collection and modelling needs to attend to river basin issues, including some that are presently not properly addressed; (b) utilize to the largest extent possible the existing systems within relevant agencies; (c) are responsive to the needs and constraints of individual key stakeholders in the basin; and (d) use geographical referencing to allow the integration of radically different data types within the same database.

The user needs assessment identified areas of operation where an ILWRMS could be of significant benefit in the Bang Pakong river basin. These areas of operation can be classified into three groups on the basis of the mode/objective of operation, as described below.

*Warning and monitoring components of ILWRMS* will use real-time geo-referenced data to identify current and pending situations. This mode of operation will be

used to generate warnings and to assist in daily decision-making. Applications will include:

- Water distribution monitoring/modelling to ensure match of supply to demand on a daily/weekly basis.
- Flood forecasting to provide timely warnings and prepare for evacuation.
- Monitoring streamflows to minimize damaging water release at the Bang Pakong diversion dam by understanding dam operation.
- Monitoring groundwater level and quality.
- Monitoring crop health as a function of irrigation water supply.

*Applications for improvements in operations* will provide a level of short- to medium-range forecasting to aid in decision making at the project level, including:

- Refining/optimizing dam operating procedures, with the potential for future automation.
- Water quality modelling to support pollution reduction initiatives (e.g. to limit salt water intrusion, identify trends in degrading quality).
- Forecasting crop yield as a function of irrigation water supply.

*Applications for planning purposes* will include long-range forecasts to enable the participating agencies to plan for the future, including:

- Planning for sustainable water supply to support increases in farming and industrial uses (for example, examining the opportunities for transferring water to an adjacent water basin such as the east coast river basin).
- Water distribution modelling to reduce or avoid flood/drought in the long term.
- Surface water distribution and quality modelling to support widespread potable water availability.

The findings from the user needs assessment were incorporated into a conceptual design report for the proposed system, as a part of the feasibility study. The implementation cost of the system was estimated at US\$6.7 million, including all hardware, software, fieldworks, monitoring equipment, consulting costs and training. A full discussion of the design would be outside the scope of this user needs

paper. Direct financial benefits of the system would include reductions in data collection costs for major and minor studies. Indirect financial benefits would come from the potential reduction in flood damage compensation payments that could be brought about through improved warning and, ultimately, through more effective dam operation. Economic benefits would include these financial benefits as well as reductions in uncompensated damages borne by farmers and other residents. Based on these potential savings, estimated financial and economic benefit/cost ratios for system implementation were both favourable.

System implementation would be planned so as to begin with a portion of the field installation, and with the most direct hardware and software elements. Phase I would include the foundation of the underlying GIS database structure, with software to support routine data collection as well as data conversion from other systems. The database alone will be of value, because it provides the consistent dataset upon which all agencies can undertake their analyses. Using software already owned and operated by RID, the data component of ILWRMS would be sufficient to enable RID to carry out most of the functions listed under '*warning and monitoring components*', above. The system would be designed to grow geographically as well as functionally, in keeping with the comfort level of the agencies involved, and available resources.

## CONCLUSIONS: IMPLICATIONS FOR INSTITUTIONAL DEVELOPMENT

The user needs assessment identified a complex institutional network of water resources responsibilities in the Bang Pakong basin, featuring the multiple and overlapping jurisdictions that are part and parcel of the Thai public sector.

A river basin committee for the Bang Pakong was created in July 2001 under the auspices of ONWRC. Such an entity would be the natural 'address' for ILWRMS. However, it is recommended that RID be the agency with prime responsibility for ILWRMS, at least until the river

basin committee is more firmly established. The ongoing co-operation and participation of a variety of other agencies will be pivotal to the system's ultimate success.

The foundation of ILWRMS will be a GIS database, representing a universally recognizable means of storing geo-referenced data for multiple purposes. This approach is not only the most suitable way of storing the data for this type of system, but it is a familiar approach to most of the agencies identified as ILWRMS participants.

The system should contain components to support warning and monitoring, applications for improvements in operations, and applications for planning purposes. It will be modular and open, and will draw upon the existing data, systems and expertise of the Thai government agencies that would form its contributors and users. This approach will take advantage of the considerable mass of existing information and expertise, while providing the highest probability of continued buy-in by participants from co-operating agencies. It will also provide the flexibility required so that ILWRMS can support future needs including third party application software developed in the future.

The successful implementation of the proposed ILWRMS project will lead to significant economic benefits to the Bang Pakong river basin, in addition to non-monetary benefits such as improved water quality and reductions in the human costs of floods and droughts.

Despite RID's role in the overall management of ILWRMS, many of the system's functions are either routinely or occasionally the responsibility of other agencies. Most notably, the Pollution Control Department routinely performs a water quality monitoring function, while the Thai Meteorological Department continuously monitors weather. The Department of Mineral Resources is charged with groundwater investigations while the Office of Environmental Planning and Programming has an institutional interest in documenting drought conditions. The implementation of ILWRMS will need to work within this framework of separate data responsibilities, while generating an integrated database for use by all participating agencies.

The philosophy behind the proposed system is to make full use of existing and ongoing functions of the interested participants in ILWRMS, while new functions

emerging from the conceptual design should be adopted and carried out by those agencies in the best position to perform them technically and cost-effectively.

Given the broad scope of ILWRMS and the number of discrete activities it entails, its implementation must be approached in a way that avoids 'over-innovation'. In other words, agencies involved in ILWRMS, including RID, have a greater chance of success at integrating their work with that of others if the elements of ILWRMS they adopt allow the agencies to continue what they are already doing.

As part of the ILWRMS feasibility study, two workshops were hosted by RID for stakeholders from interested parties to generate debate regarding the proposed system's technical and cost proposals. The integration of ILWRMS agencies into the selected organizational structure will follow the phasing of the project and proceed hand-in-hand with the required training.

Two important outcomes are expected from the implementation of ILWRMS: reliable information and dialogue among basin stakeholders. Together they should serve as incentives for more equitable resource allocation and improved decision-making in the river basin.

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