

Strengthening Integrated Lake Basin Management Implementation in Malaysia through Research Framework

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1. Introduction

Management of lakes, reservoirs and ponds remains as one of the agendas of Malaysia to ensure these waterbodies continue to provide ecosystem services and water security. The Integrated Lake Basin Management (ILBM) approach has been adopted by Malaysia during the preparation of the strategic plan for lakes to address critical issues such as eutrophication. This management approach was embraced in the Malaysian National Water Resources Policy which was approved in 2012. Since then, ILBM implementation in Malaysia has evolved in three phases spanning over 15 years (Yusoff *et al.*, 2018). As illustrated in Figure 1, the first phase (2005 – 2010) involved development of the strategic plan for sustainable lake basin management in the country while the second phase (2011 – 2015) involved the development of more detailed action plans and governance instruments (Yusoff *et al.*, 2018). The third phase (2016 – 2020) which is currently in progress targets implementing the strategic plan.

Historically, the strategic plan for sustainable lakes and reservoir management and development, developed by the Academy of Sciences Malaysia (ASM) and the National Hydraulic Research Institute of Malaysia, was one of the policy documents that outlined the national policy framework on lakes for Malaysia namely “*Lakes and reservoirs will be sustained, restored and protected through the adoption of an Integrated Lake Basin Management (ILBM) approach*” (ASM & NAHRIM, 2009; Abdullah *et al.*, 2016). To support the strategic plan, a more detailed action plan was completed by Ministry of Water, Land and Natural Resources (KATS), which was previously known as the Ministry of Environment and Natural Resources (NRE), in 2013. One of the important strategies in the strategic plan was the setting up of a National Lake Research and Resources Centre for Malaysia, an idea approved by the National Water Resource Council in 2012 to be led by the National Hydraulic Research Institute of Malaysia (NAHRIM). To ensure this national role, NAHRIM established a Research Committee on Lakes, Reservoirs and their Catchments in 2014 to assemble various expertise. The research committee was tasked among others to develop a research blueprint to support lake management and governance in the country.

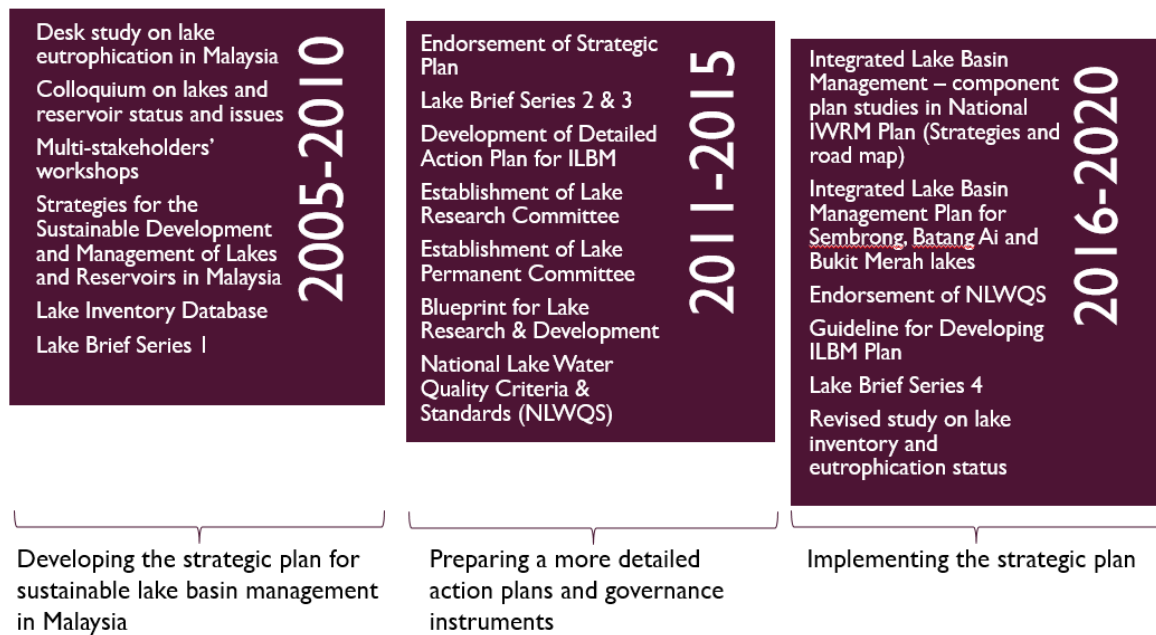


Figure 1. Historical evolution of ILBM implementation in Malaysia in three phases

2. The need for integrated research and blueprint development

Limited research and development (R&D) have been identified as one of the key challenges in supporting sustainable lake management in Malaysia (Sharip and Zakaria 2008; Sharip and Yusop 2007). As public funding and expertise are limited to address this issue, a blueprint that can prepare a common research framework and identify areas including disciplines and location to focus R&D effort is necessary for Malaysia. The idea for blueprint was mooted during the preparation workshop for the development of a detailed action plan by the Ministry of Natural Resources and Environment (NRE/KATS) in 2013. Following adoption of the Strategic plan, a research committee was set up and was tasked to develop the blueprint.

3. Methods for the development the blueprint

3.1 Desk review of the major issues and challenges

In order to develop a common research framework, findings from past studies were collated to re-assess the major issues and challenges. Review of literature included published scientific works as well as unpublished materials by agencies. Eutrophication and sedimentation are some of the main issues facing lakes worldwide. Several reservoirs and lakes in Malaysia were found to be severely eutrophic such as Sembrong reservoir and Intan Baiduri pond. Few other reservoirs faced sedimentation issues such as Ringlet lake. Eutrophication and sedimentation related to development activity transported excess nutrient and sediment loads into waterbodies. Sharip *et al.* (2014) showed that biological productivity increased while water transparency decreased with percentage of developed area in the catchment. Inadequate biodiversity information and invasive species threats are other challenges faced by Malaysian waterbodies. Proliferation of non-native species was reported in many water bodies such as Chini Lake (Sharip *et al.*, 2014). Other biological invasions by

introduced fish species such as tilapia and arapaima affect fish resources and diversity (NAHRIM, 2016). There is also lack of information on the long-term impact of aquaculture activities on lake carrying capacity as well as the impacts of alien species unknowingly introduced in lake habitats such as for religious purposes.

The existing dam design is also an issue as it represents barriers to fish migration (NAHRIM 2016). Large and deep reservoirs, such as Kenyir, Temenggor and Bakun, create permanent stratification; making only the top 10 -15 m of water usable to support aquatic life while the bottom discharge from these dams is toxic with heavy metals leached from sediments as a result of anoxic conditions (Sharip 2017). Large dead water volumes also represent a significant loss of a strategically crucial asset for water resources (NAHRIM 2016).

Fragmentation of governance mechanisms attributed to state/federal jurisdictions and institutional mandates have been the biggest challenge in ILBM implementation (NAHRIM 2016; Yusof *et al.*, 2018). Currently, too many agencies exist with different institutional mandates and no single management authority can coordinate ILBM activities. The implementation of any national or federal plan also depends on State acceptance or adoption as management of land and water resources falls under State purview. Only a few States, such as Selangor and Kedah, have a dedicated institution to manage water resources at basin levels including lakes. Many agencies have limited capabilities to sustainably manage lakes at basin scale due to their different functions. Transboundary challenges also remain a challenge if the drainage basin transcends over two countries or states or districts. For example, transboundary challenge is faced by Putrajaya Lake between the State of Selangor and the Federal Territory of Putrajaya. Both Sembrong and Bukit Merah reservoirs face transboundary challenges between districts.

3.2 Stakeholder engagement using consultation and collaboration for identifying research clusters and interdisciplinary research and focus lakes

3.2.1 Stakeholder consultation findings

Collaborative consultation among experts and government agencies in the research committee identified seven research themes or clusters needed for integrated research. A research matrix was drafted for discussion. Based on this theme, expert leaders were selected to lead the cluster groups for a workshop. Breakout groups were organised along seven thematic lines identified. The discussion groups were structured with workshop guides that identified the main focus for discussion. A moderator was elected among group members to lead the discussion while rapporteurs recorded the discussion during break out groups and presentations. The output of discussion is given in Table 1.

Based on the discussions that spanned two days covering the different themes, and the broad spectrum of participants and institutions represented, broad consensus on what needs to be done concerning lake R&D was summarised in NAHRIM (2016) as follows:

- 1) The need for greater understanding of the country's lake resources, including:
 - a) Their type, locations and volume
 - b) The environmental services they perform
 - c) Their historical and heritage values
- 2) The need to look at lake management strategies in relation to:
 - a) Optimising lake use by various management agencies without compromising the environmental services
 - b) Catchment management, spatial planning and land use.

- c) The totality of ecosystem services and their values - direct use values (i.e. water supply) and indirect use values (fisheries)
- 3) The needs to address governance issues especially the following:
 - a) Establishing a Federal coordination mechanism that brings all lake managers together under a single umbrella
 - b) Incorporating lake management prerogatives as part of statutory plans
 - c) Addressing current deficiencies in the legal regime
- 4) The need to emphasise on awareness and public perceptions of lakes and their management such as:
 - a) Awareness among the general public on the value and importance of lakes
 - b) Awareness among lake managers of the threats to lake environments and technological means for overcoming them
 - c) Awareness among senior planners of the economic values of lakes
 - d) Awareness among politicians of the strategic value and importance of lakes

The workshop articulated for a new lake R&D regime that can lead to a tangible outcome as basis for sustainable lake management. As such, the blueprint proposed a collaborative, interdisciplinary approach involving joint research and information sharing as the way forward.

Table 1. Summary of workshop discussion (Adapted from NAHRIM 2016)

<i>Physical Limnology and Hydraulic Modelling</i> Primarily focused on the need for watershed-based modeling on lake budgets that look at the net export of energy of the lake, after considering inputs from its water source and catchment as well as the internal processes for sustainable lake management. Modeling scope should encompass a wide range of issues such as: - Water quality due to anthropogenic activities. - Pollution of lakes by aquaculture, non-point sources such as from catchments clearing and point sources from sewage and industrial discharge from lakeside developments. - Land use planning, particularly in relation to catchment management. - Invasive species and their impact to ecology. - Ecosystem costing: The need to employ appropriate models that would provide an insight into lake economics.
<i>Pollution and Water Quality Management</i> Primarily focused on the following: - ILBM must form the basis of water quality management in lakes - Use of appropriate technologies in monitoring: The need for contemporary technologies, but suitably modified for local conditions, to be employed in monitoring regimes. For example, a parameter such as Biochemical Oxygen Demand, which is measured at 20°C, when the ambient water temperature for most part in the country is 28-30°C. - Control of Alien Invasive Species (AIS): Alien invasive species can be a major threat to the lake environment due to difficulty for complete eradication.
<i>Policy and Regulations</i> Primarily focused on governance issues and the legal environment enabling an integrated approach to lake management. - Definition of lakes: The need to refine the definition of lakes and reconcile the different definitions of different agencies. Currently, the absence of a standardised definition translates into a governance issue with agencies managing different water bodies separately according to their separate administrative mandates. - Lakes in spatial planning: The exigencies of lake management are currently not embedded in statutory plans such as the State Structure Plans or the Local Plans leading to conflicts in land use, especially where catchment development is concerned. - Legal fragmentation: The legal regime governing lakes is very fragmented among Federal and State agencies. Research should be directed toward establishing mechanisms that can integrate these disparate agencies to working collectively in relation to sustainable lake management. - R&D fragmentation: R&D into lake research is fragmented between different institutes and agencies, having different priorities and agendas. A consortium of all research institutes involved in lake R&D should be formed so that a more cohesive approach can be taken. - Lake security: Lack of control over lake areas where there has been abuse and intrusion by the public particularly for recreational use without jurisdiction to do so, and this may give rise to security issues.
<i>Socio-Economic and Ecosystem Services</i> The workshop discussion concludes on poverty of information on the economic values of lakes to ensure that priorities are addressed properly including: - Ecosystem Services: The need to inventories the various environmental services provided by lakes. The evaluation of environmental services is currently slanted toward the main user or operator of the lake/reservoir. This may give rise to conflict of interest due to multiple users of the lake. Also, the lack of information on the totality of environmental services makes it very difficult to do costing of lake resources. - History and Heritage: Many lakes are linked with a rich history and mythology which need to be captured as one of the natural assets of the lake and should be part of the evaluation of ecosystem services. - Lake Communities: Discussion on lake communities revealed that there is a dearth of information on lake communities. Since the proposed research matrix is slanted more toward scientific issues, community studies should stand as a separate domain in the matrix. - Ecosystem Costing: The inability to accurately gauge the economic value of lake resources. There is a need to employ appropriate models that would provide a detailed insight into lake resource economics.
<i>Technology</i> The workshop discussion concluded that green technologies have been poorly applied to water resources in general and sustainable lake management in particular. Also, lake managers and the general public need awareness of the availability and potential green technologies and technological approaches for lake

management. Currently, the lack of awareness represents a major impediment in their widespread use. The need to investigate technologies, preferably green, for:

- i. Monitoring and surveillance including catchment planning and control, and remote monitoring system.
- ii. Pollution abatement and amelioration of lake eutrophication.
- iii. Control of alien invasive species.
- iv. Production of renewable energy and monitoring system.

Biodiversity and Natural Products

Primarily focused on:

- i. Lake fisheries: The need to further study fish populations within lake systems.
- ii. Aquaculture: The need to investigate the impact of aquaculture, that is actively being promoted by the government, on the lake environment so that there is no conflict with the overall environmental values of lakes concerned or the services they provide.
- iii. Natural products: The commercial application of lake biodiversity has not been adequately pursued.

Lake Ecology and Basin Management

Investigations in lake ecology and basin management should be given priority since such studies would be fundamental to our understanding of the environmental services they provide, their valuation and sustainable management. Lake basins need to be studied, especially how they impact on their hydro-ecology. The absence of such investigations prevents basins from being managed consistent with needs of the natural lake ecology. Aspects to be looked into include how basins contribute runoff, nutrients and sediments to lakes and the impact these have on their prevailing natural ecology. The need to adopt community-based management; involving community for water quality monitoring.

3.2.2 Research direction and focus

The workshop outcomes were deliberated in the various research committee meetings. The research matrix, cluster and projects were prioritised based on importance. The blueprint proposed subjects in need of research, examples of much needed projects and their research outcomes. According to Sharip et al. (2018), the research cluster and matrix can be categorised into four research aspects or philosophies, namely:

- 1) Demand-driven research for sustainable governance and management:
 - a) Ecosystem services and socio-economy
 - b) Governance
- 2) Application of basic research for determining carrying capacity
 - a) Water quality and pollution
 - b) Physical limnology and hydrodynamic
- 3) Sustainable lake resources management based on ecosystem approaches
 - a) Biodiversity and natural products
 - b) Eco-hydrology and basin management
- 4) Innovation and sustainable rehabilitation and Management
 - a) Sustainable technology

The first philosophy of the research framework is based on demand-driven type of research towards sustainable governance and management. This philosophy was ranked as first to ensure that future R&D is targeted towards research solution to problem and needs of society (Sharip *et al.*, 2016). Two research themes fall within this research philosophy namely addressing understanding on lake ecosystem services and governance. The next important research philosophy is to apply basic research to understand the lake water quality condition and carrying capacity through physical hydrodynamic studies. The third philosophy focuses on ecohydrology and basin management approaches; based on the ecosystem approach by weaving the underlying hydrology and biota in the waterbodies and the catchment. Innovation and technology development provided the tools for ensuring the demand driven research as well as rehabilitation or management activities.

The overarching goal outlined in the blueprint would be to intensify the coverage and

depth of knowledge of Malaysian inland waterbodies so as to enable them to be managed sustainably towards conservation and development goals and their benefits optimized in the interests of the nation (NAHRIM 2016). This framework spells out the need for future lake R&D to be carried out with the following characteristics:

- 1) Should have both spatial reach and strategic depth in its approach,
- 2) Promote sustainable management,
- 3) Anchor on both conservation and development, and
- 4) Optimizing the benefits from lakes.

The blueprint formulates five primary research thrusts, and five secondary cross cutting thrusts (Figure 2). The primary thrust is generally defined as major scientific disciplines while the cross-cutting thrusts are approaches that resonate through all the primary thrust (NAHRIM, 2016).

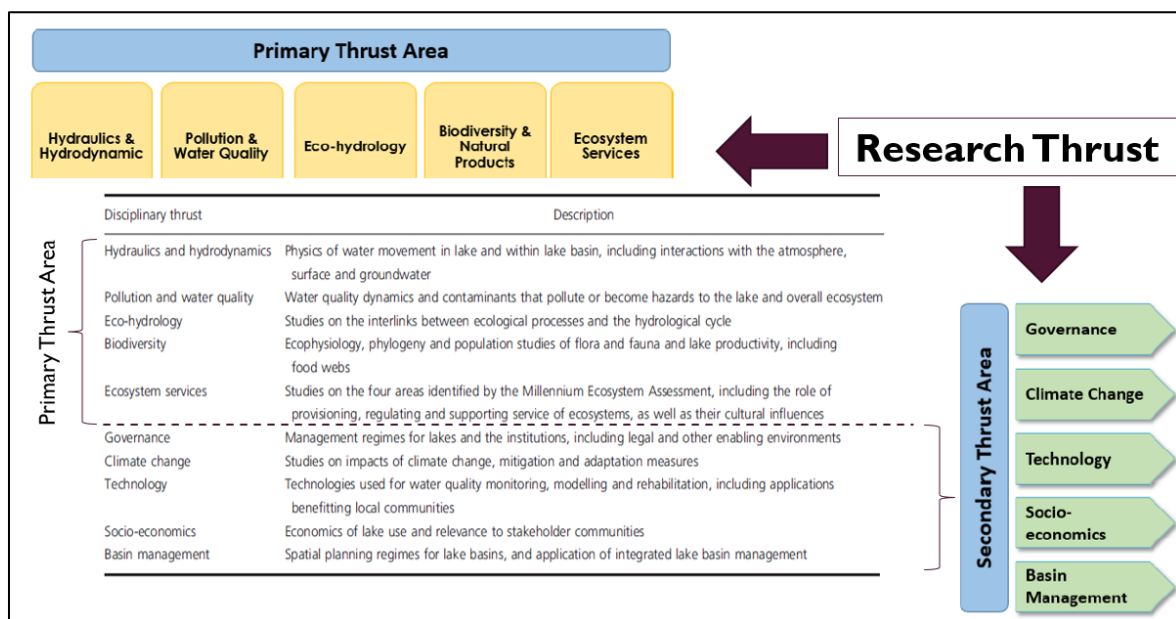


Figure 2. Matrix of lake research blueprint (adapted from NAHRIM, 2016).

4. Implementation of the lake research blueprint

A revision on the total inventory of lakes as part of the blueprint development indicated that there are about 98 major lakes and reservoirs in the country (NAHRIM 2016). Since funding and manpower are major constraints, it is not plausible to undertake full investigation of all lakes and reservoirs within the short term of 2 – 3 years. Further collaborative discussion suggested that a representative sample be the focus of research activity in the blueprint. The criteria for location selection are based on various factors such as lake type, status and size, their major contribution to socio-economic development, most problematic in particular for those lakes that have multiple functions and immediacy. A total of 30 lakes including reservoirs were identified for integrated research throughout the country. For successful implementation of the blueprint, sufficient funding in R&D is necessary to ensure that good science, technology and innovation in developing a management and rehabilitation plan as well as to addressing the multiplicity of issues faced in lake environment.

Two integrated studies were undertaken involving all research clusters namely the Sembrong and Batang Ai reservoirs. The selection of the reservoirs was based on (i) different geographic location; one in the west and one in the east of Malaysia, (ii) different depth; shallow versus deep and (iii) different characteristics trophic status; eutrophic-hyper eutrophic and mesotrophic. A guideline on preparing the integrated management plan was also developed subsequent to the management plan.

5. The need for monitoring and capacity building

Water quality monitoring programmes are essential to aid decision-making processes for management and research. According to Robarts et al., (2009), a properly designed water quality monitoring and supported with decision support system provides crucial information for the developing policies and management plans that protect and preserve lake ecosystems. Specific water quality standards for lakes known as the national lake water quality criteria and standards were established by NAHRIM in 2015 to support research and management activities. Standardized monitoring parameters have been introduced to support lake basin management plans. Adequate funding is needed for continuous monitoring of the waterbodies to achieve the goal and for successful rehabilitation and management of the water bodies.

Management plans are essential to aid lake managers. Based on the blueprint and standards, development of management plans that address the integration of various researches can support management and improve the governance framework. However, the management plan document remains as a tool to aid in decision making and in developing action plans for lake management (Yusoff *et al.*, 2018). It basically outlines a common goal in managing lakes. As highlighted by Yusoff and colleagues (2018), the success rate in implementing ILBM depends on the capacity of the targeted central authority to enhance their management role besides understanding the specific lake basin issues. Long term commitment from every stakeholder to achieve a common goal in managing lakes is the prerequisite. To ensure success, awareness and capacity building of ILBM principles are required at all levels of stakeholders to develop competent lake managers with multi-disciplinary skills. Sufficient funding mechanism and investment should be explored for research and management activities.

6. Conclusion

Since the lake management initiatives in 2005, a research blueprint on lakes was established in 2015 by the NAHRIM and ASM with collaboration from various agencies and experts to aid development of sound management plans in Malaysia. ILBM implementation has evolved from strategic planning into implementing phases beginning in Sembrong in Johor and Batang Ai in Sarawak (Yusoff et al., 2018). The success in ILBM implementation depends on the capacity of the targeted central authority to enhance their management role as well to understand the specific lake basin issues. Continuous monitoring, learning and capacity building in ILBM among all stakeholders as well as funding mechanisms for research and management are necessary to support ILBM implementation. Long-term commitment among stakeholders will enable success in achieving the common goals in managing lakes in Malaysia.

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