

Understanding Pressure-State-Response in Governance Assessment—A Case of Two Tropical Reservoirs



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Abstract Lentic ecosystems such as reservoirs contribute invaluable ecosystem services to support human livelihoods and economic development. Reservoirs are increasingly built for specific provisioning and regulatory purposes such as water supply, energy and flood regulations. This study aims to identify the pressure-state-response in two reservoirs in Malaysia based on Ecosystem Services Shared Value Assessment (ESSVA), Integrated Lake Basin Management (ILBM) indicators questionnaires and stakeholder consultations. ESSVA showed that agriculture development was the main pressure contributing stress to Bukit Merah and Chenderoh lake basin and their ecosystem services. ILBM indicators assessments showed that current management practices of the two reservoirs remain economically focused and singular. Scoring on policies indicates that Chenderoh Lake Basin is moving towards long-term outcomes. Institutions were the strongest pillars in place to support conservation efforts, however, adequate financing needs to be enhanced to support basin management including participation from various stakeholders. The governance assessment suggested a few responses to be undertaken by various agencies to address the pressure influencing the ecosystem state of the lakes.

Keywords Ecosystem services · Governance · Lake management

1 Introduction

Lentic ecosystems comprising lakes, reservoirs, swamps and ponds are providing provision and regulatory services that would affect not only the livelihoods of the surrounding local communities, but also the economic development of the country. These reservoirs also have cultural and supporting services such as aesthetic and nutrient cycling that need to be preserved to ensure food and water security. In

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fact, the sustainable management of these ecosystems, including their related lotic ecosystems is central to the ecological, economical and social interests to ensure food and water security [1]. Impacts from climatological and hydrological changes, as well as anthropogenic activities within the lake basin result in ecological imbalances that require sound management plans and operational procedures to ensure sustainable and positive interactions between the lake and its catchment area. The ability of the lake ecosystem to continue providing the resources and services depends on the sustainable practices in its basin including its watershed [1, 2]. Such environmental response, however, requires an understanding of the ecosystem services and the pressure that alters ecosystem state and services. Such a Pressure-state-response framework was introduced by the OECD in 1994 to assess the pressures of human activities on environmental states and to provide policy responses that can form decisions and actions to alter the changing state and pressure [3]. A similar framework has been further expanded into driver-pressure-state-impact-response (DPSIR) by the European Environmental Agency in 2003 and demonstrated a great potential to guide community programmes, policy development, planning, and decision-making in water resource management and conservation [4, 5]. The tool has also been used to improve soil management for agriculture development [6].

As a basin management plan is a document that entails the plan for managing sustainably a lake and its catchment or basin, evaluating the driver and pressure on the lake environment is necessary in order to propose the right management interventions [2]. Basin governance improvement is considered when the change in the reduction in stress to the lake basin environments, and the change in the state of the lake environment itself are met [2]. Currently, there are numerous DPSIR indicator and integrated lake basin management (ILBM)-based tools that have been introduced worldwide [7–10]. The use of such tools for ILBM application was recognised to be successful in a few lakes in Africa [10]. In these lakes, the application of Ecosystem Services Shared Value Assessment (ESSVA) framework in the ILBM process was suggested to enhance the participatory process [10]. Despite the ILBM concept having been adopted more than 10 years ago in the country, a past study showed that only 2% of the lakes in the country have a basin management plan in place [11]. National Water Research Institute of Malaysia (NAHRIM) undertake few researches related to development of ILBM plan for selected lake basin starting 2016. The lake basin was selected based on lake type and function, status, immediacy in facing development pressures and contribution to the nation requiring assessment for their governance improvement.

This paper documented the application of multiple governance assessment tools in order to propose improvement and management interventions as part of the ILBM plans for two reservoirs, namely hydropower and irrigation purposes. The main objective of this study is to assess and comprehend the pressure-state response of the studied lakes.

2 Materials and Methods

2.1 Study Area

This study was undertaken at two reservoirs, namely the Chenderoh Reservoir and Bukit Merah reservoir in Perak, Malaysia (Fig. 1). The reservoirs were located between a latitude of $4^{\circ} 55' 00''$ to $5^{\circ} 0' 56''$ and longitude $100^{\circ} 39' 00''$ to $100^{\circ} 59' 30''$. The Chenderoh Reservoir was impounded across the Perak River and fully operated in 1929 and has a total surface area of 21 km^2 at full supply level [12]. The lake is located about 31 km from the royal town of Kuala Kangsar. It is the oldest hydropower lake in Malaysia. The lake is also famous for its fermented fish or “ikan pekasam” and is widely used for tourism, aquaculture and sport fishing. The catchment area is about 6500 km^2 [12]. The main land uses are forest and agriculture.

Bukit Merah Lake is one of the oldest reservoirs in Malaysia created in 1906 located about 28 km from Taiping town. The lake has a total surface area of about

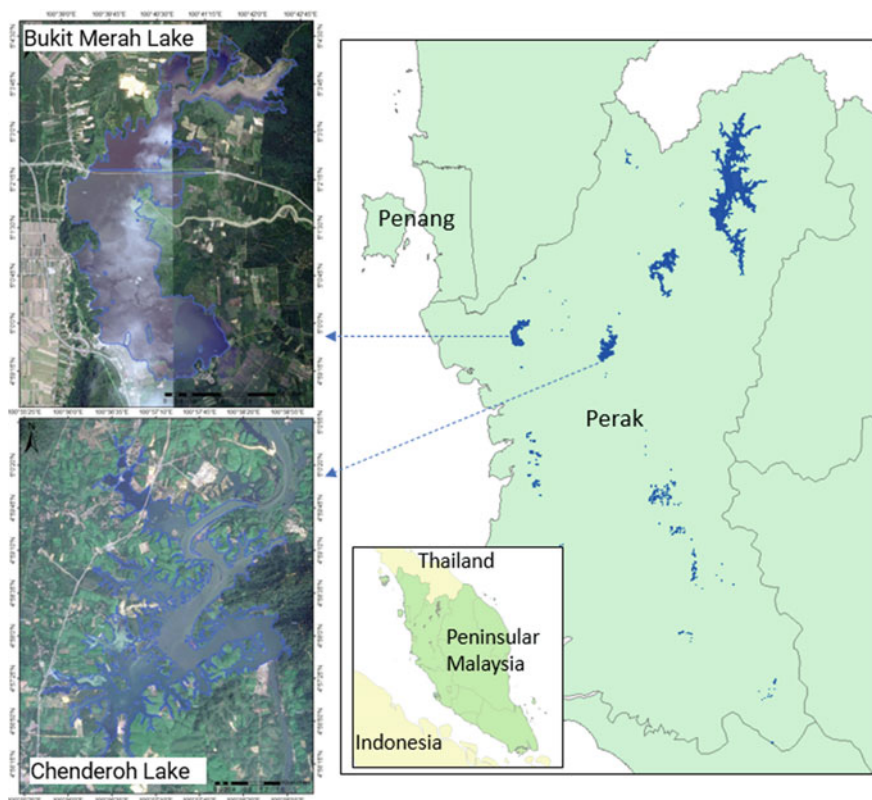


Fig. 1 Location of study lakes

33 km² and a catchment basin area of approximately 408 km² [13]. This man-made reservoir was originally designed for irrigation but has been used for flood mitigation and water supply. The land cover of the catchment has changed extensively with the expansion of agricultural activities namely oil palm plantation.

2.2 Data Collection and Analysis

The assessment was divided into two: (1) stakeholder consultations and (2) a questionnaire survey. Two stakeholder consultations were conducted for each lake. The first consultations occurred in July 2020 and gathered 18 stakeholders in Chenderoh Lake and 14 stakeholders in Bukit Merah Lake while the second consultation occurred in August 2020 and gathered 33 stakeholders. The assessment in stakeholders consultation workshops involved quadrant analysis of influence and interest [14] and sets of questionnaires related to Ecosystem Services Shared Value Assessment (ESSVA) and ILBM indicators developed following [6, 7, 15]. ESSVA has been recommended in the Malaysian Guidelines for Integrated Lake Basin Management Plan for governance assessment [16]. During the workshops, participants were divided into a few groups and asked to place stakeholders on a matrix according to their relative interest and influence. To avoid marginalisation of certain stakeholder groups, the matrices were then summarised and finalised during the second consultation. The method was adopted due to its advantage that enables prioritisation of stakeholders for inclusion and distinguishes their power dynamics [14]. Additionally, the stakeholders were asked to answer questionnaires related to current management practices as listed in Table 1.

Table 1 Examples of questionnaires during the workshop

Scope	Questionnaires
Ecosystem services	• What is the main use/function of the lake? • What is the benefit gained from the lake uses? • What are the main activities within the basin impacting the lake?
Policy	• List of agencies involved in the management of lake basin? • What are the existing policies and regulations available to support lake management? • What is the future management direction for the lake?
Institution and management	• What is the current and new institution to support/enhance lake basin management • What technology is needed to support lake basin management?
Finance	• Who should finance the management of the lake? • Through which agency financial aid should be channelled to support lake management?