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Planning for Wise-Use of Bung Boraphet Wetland's Water Resources

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Abstract

Bung Boraphet is the largest freshwater wetland in Thailand. It is an important economic asset to the provincial economy as well as a significant national and international biodiversity resource. Pressure on traditional uses of this water resource, such as for fishing and rice agriculture, is intensifying, as more people settle on the floodplain. In addition, new uses like eco-tourism are competing with the traditional activities. Despite interventions, such as creating non-hunting zones, biodiversity conservation areas and a minimum drawdown level, there is mounting evidence of resource over-exploitation and significant ecosystem change. Different stakeholders are now applying political pressure to maintain or exploit the uses of the Wetland, which they value most. These challenges require new and more effective approaches to the management of Bung Boraphet, to satisfy the expectations of all stakeholders.

This paper describes a process now underway, to develop a Plan of Management (POM) for Bung Boraphet, based on principles of 'wise-use' and Ecologically Sustainable Development. The ultimate aim is to develop a management framework that balances the conflicting stakeholder demands for water, provides for multi-agency participation and implementation, and achieves sustainable use, for the benefit of current and future generations. The work is supported jointly by a RAMSAR Small Grant and a Kasetsart University Research & Development Institute grant.

We identified the issues of most concern through a review of literature and consultations with stakeholders. We also assessed the changes over time in Bung Boraphet's biophysical environment and catchment, in terms of hydrology, landuse, ecosystem biodiversity and stresses. Scientific tools are necessary to provide managers a quantitative and rational basis for balancing the competing needs of the local communities dependent on the Wetland for their livelihood, and environmental needs to maintain functional and diverse wetland ecosystems. Hydrological modeling is one such tool for evaluating the costs and benefits of different water use proposals. Our hydrologic budget for Bung Boraphet shows that evaporation and water extraction for irrigation are dominant terms. Scenario modelling of changes in weir height and extraction patterns suggest that while rice farmers might expect raising the weir height will provide more water for irrigation, much of the increased storage volume would be lost in evaporation. An analysis of land use change over time, using Landsat images of the catchment and the wetland show that the area of irrigated rice in the catchment rose 150% between 1993 and 2003, whilst the area of aquatic plants and wetland vegetation within the Wetland declined by 50%.

Consultations with stakeholders have identified the Wetland Values, which need to be protected, and a set of Economic, Environmental and Social Goals, which need to be met. Outcomes from the modeled scenarios are being provided to stakeholders in an attempt to influence their future plans for Bung Boraphet's water resources. Future work will include; establishment of the minimum levels for a sustainable drawdown regime for the Wetland; costs and benefits of sediment extraction; and a consideration of alternative farming practices that could optimise water use.

Keywords: Bung Boraphet Wetland, Water Budget, RAMSAR

Introduction

Bung Boraphet is Thailand's largest freshwater wetland. It is located in Nakhon Sawan Province (**Figure 1**), near the confluence of the Ping and Nan Rivers. The catchment area of the lake is ≈ 4288 km^2, in the districts of Muang, Chumsang and Tatago. Klong Tatako and Klong Bon are the lake's two main tributaries, and these have catchment areas of 3,141 and 1,124 km^2, respectively.

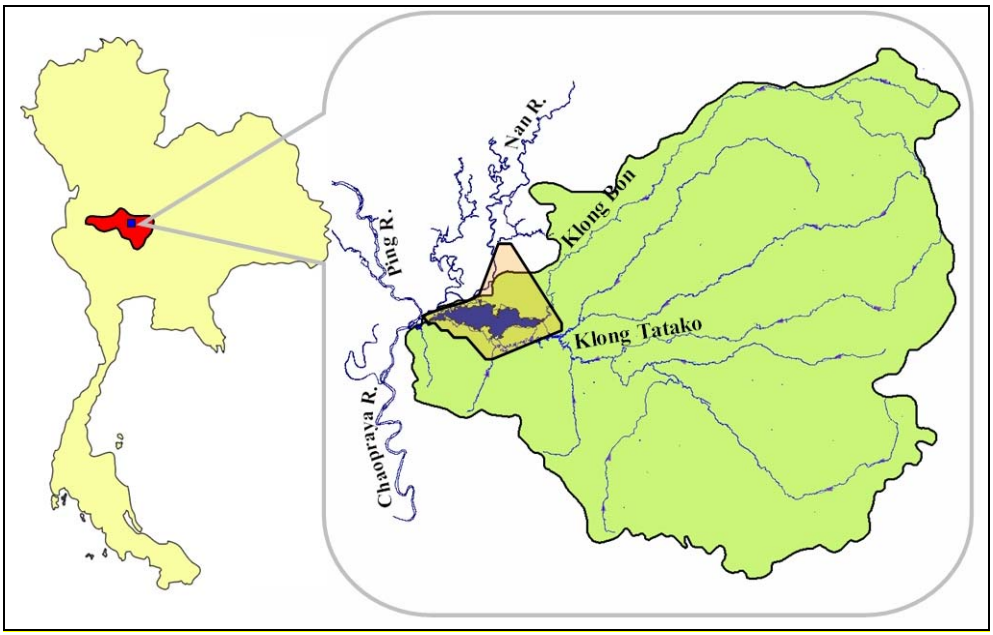

Figure 1. Bung Boraphet Wetland in Nakhon Sawan Province, Thailand

Notes: Nakhon Sawan Province in red on left; Bung Boraphet watershed on right within black line, the Conservation (restricted use) Area shaded in orange; Bung Boraphet in solid blue.

Fishing, aquaculture and irrigated rice farming are the main income sources for more than 15,000 people living around Bung Boraphet. The wetland is a habitat for 54 fish species, 252 bird species, and other significant flora and fauna (National Parks, Wildlife, and Plants Conservation Department 2005; Office of Natural Resources and Environmental Policy and Planning, 2002).

In the 1970s, a small weir was constructed by the Fisheries Department to store water. The weir crest was raised to +24.0 m (MSL) in 1993. At full storage, the lake now has a surface area of 148 km^2 and a storage volume of 178 million m^3 (Royal Irrigation Department, 2003). The Fisheries Department is responsible for managing the lake as a fishery resource, and recommends the water level should not fall below +23.0 m (MSL) to sustain the Wetland's fauna and flora. However, in recent years, abstraction of water from the lake to irrigate dry season rice has drawn the lake level below this recommended minimum. Historical records show that between 1993 and 2001 the average annual low water level was +22.35 m (44 million m^3), but between 2002 and 2006 the annual average water level fell to +21.44 m (17 million m^3). Over extraction of water is thought to be an important factor contributing to diminishing fish yields and reduced biodiversity of the system.

This paper describes how scientific decision support tools can be used to assist in evaluating the costs and benefits of a range of water use options for Bung Boraphet. We also discuss the process, now underway, to develop a Plan of Management for the Wetland, which aims to manage the conflicting demands for the lake's water supply, and promote the 'wise-use' of its water resources.

Methodology

The process for developing the POM is listed in **Table 1**. The methods used were:

- Review of available literature and plans;
- Interviews with stakeholders (governmental agencies, local government, local community) to better understand the uses and demands on the wetland system;
- Field work to identify significant environmental issues affecting the lake system, particularly landuse practices, which may be causing ecosystem change;
- Written Consultations seeking views of stakeholders/community representatives;
- Development of a Decision Support Tool (i.e. a hydrological model) to predict the lake's water budget; and extensive field data collection, to test the model;
- Scenario testing using the Model, to predict outcomes of different management interventions and water levels;
- Evaluation of remote sensed data to determine catchment landuse changes; and
- Workshopping with stakeholders to identify and reach agreement on 'values' and 'goals' for developing a Plan of Management.

Table 1. *Process followed in planning for 'wise-use' of Bung Boraphet

Task	Activities
1. Background Information	1. Meetings with Stakeholders; Field inspections; Review of background reports and plans; data collection
2. Decision Support Tools	2. Identify key environmental management issues, including ecosystem condition; Develop scientific tools for data analysis; verify applicability; Test future scenarios using tools
3. 'Draft' Plan of Management (POM)	3. Meetings with Stakeholders; Establish Wetland Values, Goals & specific management Objectives; 4. Develop Action Plan to deliver outcomes; assign resposibilities and timeframe; 5. Wider Consultations with Stakeholders, including Community
4. Implement POM	6. Adoption of POM; Set up 'Management Steering Committee'; 7. Establish framework for implementing major Actions
5. Review	8. Annual review of actions against goals and objectives; 9. Adjustments to POM after review (if required)

* Steps 1-2 have been completed; Step 3 is currently in progress

A Water Budget for Bung Boraphet

A daily water budget for Bung Boraphet was developed from primary and secondary data collected between December 2002 and March 2006. Details of data collection and model calibration methodology are in Sriwongsitanon *et al* (in prep). A balanced water budget was developed based on daily changes in lake volume in wet and dry seasons using the following equation:

$$\frac{\Delta S}{\Delta t} = \sum I(t) - \sum O(t) + (I_r - ET - SL)A_S$$

where, ΔS is the difference in the lake volume for any time period (Δt); $\sum I(t)$ is the total nett daily inflow; $\sum O(t)$ is the total nett daily outflow; I_r is the daily increase in lake level due to rainfall on the lake surface; ET is daily fall in lake level due to evaporation from the lake surface; SL is the daily variation of the level due to seepage, and A_S is the lake surface area at a specific water level.

The two principal sources of water to the lake are rain falling on its surface and runoff from the watershed. Water losses are mainly through evaporation and regulated outflows for agriculture (**Figure 2, Table 2**). In the dry season, the water level is drawn down by extraction from tributaries and irrigation canals upstream of the lake for rice irrigation, within the 212 km^2 conservation zone (**Figure 1**), where farming is actually prohibited. There are minor diversions of water to supply domestic users in Tatako District and aquaculture ponds. During the wet season, inflows mainly enter the Wetland via its tributaries and the regulator connecting the lake to the Nan River. This flood mitigation system was rarely used in the dry years between 2002-06.

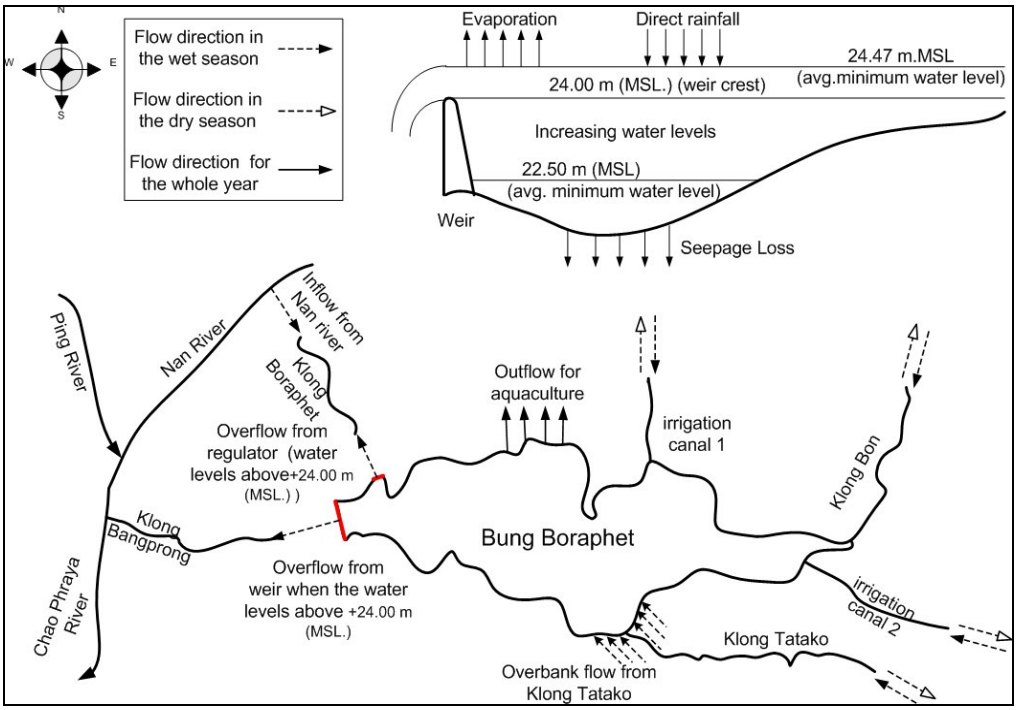

Figure 2. Conceptual model of Bung Boraphet water budget

Results and Discussion

The lake level usually decreases continuously from early December to the annual minimum (ca. +22.5 m MSL) in late June (**Figure 3**). The lowest water level in the past 15 years was in 2005 when the level fell to +21.44 m (MSL).

Table 2. Water Budget components for Bung Boraphet for years 2002-2006

	Losses (m^3 x 10^6)					Inflows (m^3 x 10^6)				
	Evap.	Seep.	Irrig[C]	Disch.[A]	Total Out.	Direct Rain	Kl. Bon	Kl. Tatako	Irrig. Canals	Total In
Ann. average inflow (%)	35 (92)	0.1 (0.2)	0 (0)	3 (6)	39 (100)	60 (27)	42 [B] (20)	106 [B] (51)	4 [B] (2)	212 (100)
Ann. average outflow (%)	61 (41)	0.1 (0.1)	81 (56)	4 (3)	147 (100)	9 (100)	-	-	-	9 (100)
Cumulative Ann. average	96	0.2	81	7	184	69	42	106	4	221

Notes: A – Discharges downstream over weir, through the regulator; **B** – This is the net inflow as wet season extractions cannot be measured; **C** – This irrigation term only represents water extracted from the lake. In the wet season, farmers also abstract water from canals before it reaches the lake. This term is not calculated, but can be estimated from our farmer surveys.

Scenario analysis

We used the water budget model to analyze the changes in the lake water level for five scenarios in which the volume of water stored or extracted was changed (Figure 3). One proposal is to raise the weir crest by 0.5 m to +24.5 m (MSL), to increase the stored volume water for dry season irrigation. In three scenarios (Cases 3, 4 and 5), we also varied the water volume abstracted each day for irrigation as a fixed percentage of volume abstracted between 2002-2006, which was set to 100%.

The current situation (Figure 3, **Case 0**) has the weir crest at +24 m (MSL) and abstraction is 100%. In **Case 1** the weir crest is raised to +24.5 m (MSL) and water usage remains at 100%. The model predicts the minimum water level would then fall to +22.46 m (MSL), which is about 0.5 m below the level recommended for sustainable fisheries. On the other hand (**Case 2)**, the model predicts that if the weir height is raised to +24.5 m (MSL), water abstraction has to be reduced by 35%, to achieve the recommended minimum water level (+23 m (MSL).

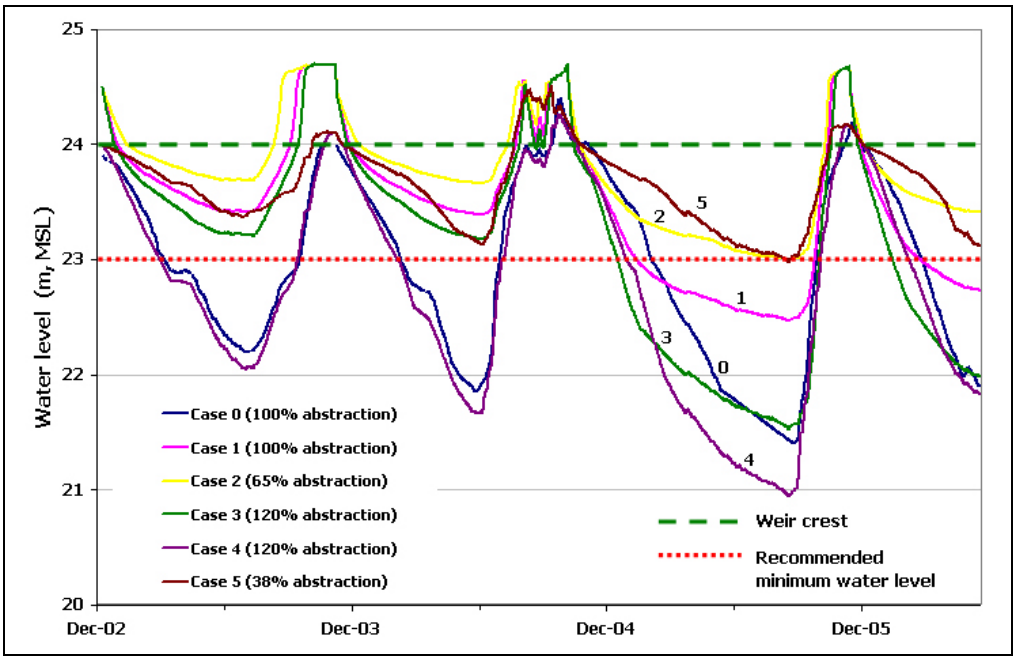

Figure 3. Modelled water level scenarios in Bung Boraphet for different management responses

A likely scenario (**Case 3)** is that if the weir crest is increased to +24.5 m (MSL), farmers will also increase their abstraction. Assuming water abstraction increased to 120% of Case 0, the model predicts a minimum lake level of +21.55 m (MSL) – similar to the current condition. **Case 4**, assumes no change to the weir crest, but an increase in extraction by 20%. That would draw the water level down to +20.96 m (MSL), which is below the current minimum and more than 2 m below the recommended level for maintaining biodiversity. This scenario shows the minimum lake level is very sensitive to any increase in abstraction for dry season irrigation. **Case 5** shows that if the weir height is not raised, water abstraction from the lake has to be reduced by 62% to achieve the recommended minimum level of +23 m (MSL).

Modeling is clearly a powerful tool for analysing different water use scenarios objectively and with scientific rigour. Management plans for BB should use this tool to assess the costs and benefits of proposed schemes for increasing the lake storage volume by water diversion (from Nan River) or by raising the weir height.

Analysis of catchment land use changes by Satellite Imagery

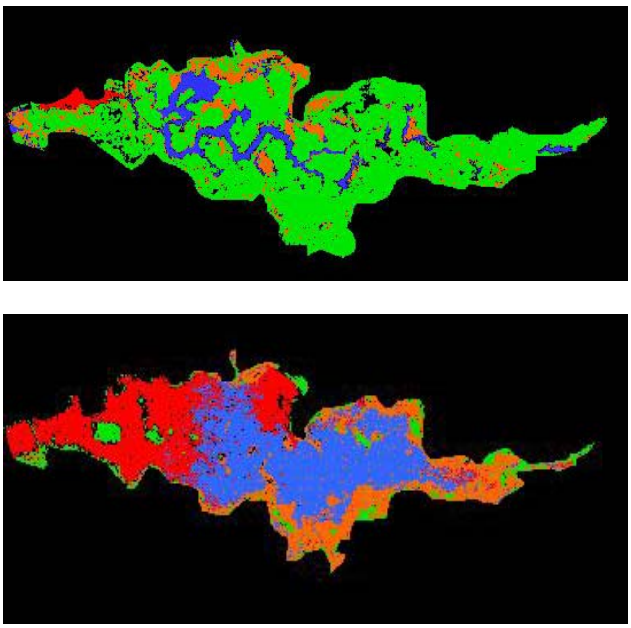

Figure 4. Landsat images of Bung Boraphet, showing various changes between 1993 and 2003.

Note: green and brown areas denote emergent and submerged plant cover; blue- clear water; red - turbid water.

Land use change is also important to consider, and we analysed this in a series of Landsat images of the Bung Boraphet watershed (**Figure 4**). The Lake level was at +23 m (MSL) on date of each Landsat Image, so areas are directly comparable.

Our results show that the area of irrigated land in the catchment rose 150% between 1993 and 2003 (data not presented). At the same time, the area of plant cover in the Wetland (both submerged and emergent vegetation) declined by about 50%, and the amount turbid water in the lake increased significantly due to dredging (**Figure 5**).

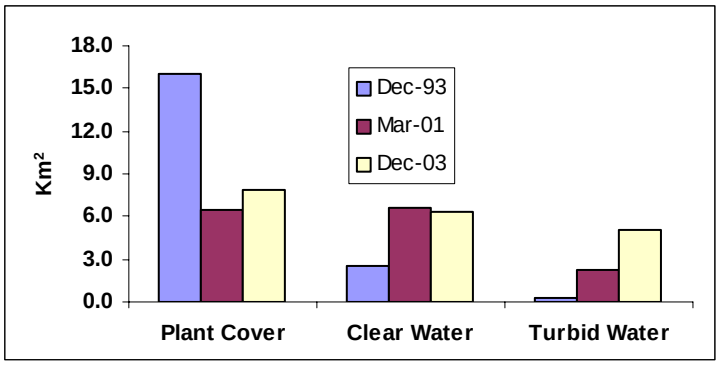

Figure 5. Change in characteristics of Bung Boraphet over 10 years, as determined by Landsat imagery.

Significant Environmental Issues

The information gathered from literature, field work and interviews provided insights into the 'condition' of the Bung Boraphet ecosystem, as well as the 'stressors', which are causing significant environmental change. These are summarised in **Table 3**.

Stakeholder Workshop

Outcomes from the modeled scenarios were provided to multiple stakeholders in a facilitated Workshop Forum, stimulating discussion on the likely impacts of changing water level in the lake. The Workshop Forum reached agreement on the 'Wetland Values', which need to be protected (**Table 4**), and established a set of Economic, Environmental and Social Goals, which need to be met in the future (**Table 5**).

Table 3. Significant environmental issues to be managed at Bung Boraphet

Issue	Comment
Water quantity	High evaporation losses and increasing extraction for farming in the dry season are reducing the stored volume.
Water quality	Poor water quality, attributable to human activities in the watershed and in the lake.
Sediment loads	Increased sediment loads to the lake from human activities in the floodplain (farming etc). Resuspension of sediment in mid lake by dredging that produces a permanent turbid water plume.
Loss of connectivity between river, lake and floodplain	No discharge from the weir means no connectivity between lake and Chao Phraya River system. Activities to reclaim land and minimise flooding reduces connectivity between lake and floodplain. This limits fish passage and reduces other net exchanges through the system.
Losses of biodiversity	There is mounting evidence of habitat loss, habitat fragmentation and reduced biodiversity (i.e. fish, birds).

Table 4. Bung Boraphet Wetland's Values

Economic Values	Social Values	Environmental Values
o Livelihoods o Eco-tourism o Flood mitigation	o Scientific o Recreational o Educational	o Biodiversity/Genetic resources o Productivity/Range of habitats o Water quality improvement o Water quantity

Draft Plan of Management

A 'draft' Plan of Management for Bung Boraphet is being developed, based on the scientific information gathered so far, attempting to balance the economic, social and environmental needs identified by the stakeholders. This POM addresses key management issues, including multiple user groups and stakeholders and inter-agency cooperation. We see this draft POM as a document that would generate further discussion on a 'best management practice' framework for the Wetland.

Discussion and Conclusions

The limited water resources of Bung Boraphet are under increasing pressure. Water abstraction by rice farmers is increasing and is difficult to control. Further falls in the minimum water level may cause irreparable damage to ecosystems and biodiversity. Consultations reveal that some lake management decisions lack a rigorous scientific basis. The quantitative water budget we have developed is a crucial tool for understanding the importance of different hydrologic components, and for managing the lake's water in a sustainable way. Evaporation is an important loss factor in the water budget; so, increasing the stored volume by raising the height of the weir is an 'inefficient' way of storing water.

In our opinion, over-extraction of water for dry season rice, sediment dredging in the lake, and loss of connectivity between lake and floodplain during much of the year, are causes of significant environmental impacts on the Wetland's natural ecosystems. Given that the system requires practical management, our POM, which is being developed, attempts to provide a framework for multi-agency participation in implementing management actions to achieve sustainable use of Bung Boraphet, for the benefit of both the current and future generations.

Future work will need to: (a) establish minimum levels and a sustainable drawdown regime for the lake, (b) consider costs and benefits of sediment extraction, (c) farmer education in alternative cropping practices, to optimise water use, and (d) promote changes in land ownership in the floodplain, especially in the conservation zone.

Table 5. Targeted initial Goals* for 'Wise-use' of Bung Boraphet's Water Resources

Goals	Task
Goal 1	**To manage BB wisely following best practice standards with integrated catchment management approach** o Co-ordinate management actions by appointing a 'Steering Committee' o Follow an integrated catchment management approach
Goal 2	**To manage BB's economic values wisely for sustainable use** o Maintain non-hunting zone and no-fishing zone by appointing a "Wetland Keeper" (i.e local committee) o Change land use pattern in the floodplain and ownership of land (leases ?) and future settlement o Educate farmers (irrigation practices, demonstration school) and encourage efficient water-use (i.e. change to less water consuming crops)
Goal 3	**To manage BB's water wisely for conservation and enhancement of its environmental values** o Maintain appropriate water level (between +23 and +24 m MSL) to preserve fish habitat, stock, breeding; reduce over extraction for farming o Improve water quality to promote growth of water plants; discontinue sediment dredging and creation of islands o Maintain hydraulic connectivity between river-lake-floodplain, through regulator and fish ladder, and to the floodplain (floods) o Maintain flood mitigation capacity; reduce land reclamation on floodplain o Enhance bird habitat (Manage invasive species (weeds); Enhance diversity of wetland vegetation (reintroduce species that have been lost)
Goal 4	**To manage BB Wetlands' social values** o Maintain education values- Enhance information and education centre o Promote recreational values- Promote BB as a tourism destination o Promote use as a scientific resource- Study site for natural processes

*These are the initial Goals arrived at in a stakeholder workshop

Acknowledgements

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