THE IMPACT OF LAND USE IN THE CATCHMENT OF BATANG AI AND RESERVOIR FISHERIES ON BATANG AI HYDRO-ELECTRIC POWER (HEP) LAKE

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A thesis submitted
in fulfillment of the requirements for the degree of
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Specially dedicated to:

my beloved children;

Vanessa Elna, Bernstein Nanang, Zeiger Lang, and Michellia Elma.

"Enti kitai nadai pemandai,
kitai disema ka baka ai dalam dulang,
kulu enda nyegang kili enda langkang."

The late Tun Jugah.
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*Mancha anak Bagat*

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ABSTRACT

The lack of farm land at Batang Ai Resettlement Scheme had lead to an increased in the number of resettled communities to come back to utilize their former NCR lands which were not submerged by the construction of the hydro-electric power dam. Increased in population of the area resulted in the increased for land use and water resources utilization. Therefore the objectives of this study were to: (i) record the water quality of the lake in accordance to the INWQS, (ii) examine the existing agriculture and reservoir fishery practices at the lake, and (iii) evaluate changes in fish species at the lake and its tributaries. The water quality of the lake, Batang Engkari, and Batang Ai all falls under Class II of DOE WQI which was categorized as good. Under INWQS classification, it falls into Class I to Class III of INWQS which is good to moderate. The result shows that the water of Batang Ai HEP Lake, Batang Engkari and Batang Ai is still viable to support economic activities at that area. The lake has been utilized to cater for the large scale cage culture activities managed by the some community groups, individuals, and government agencies. This study also found that there were changes in the population of fish species of Batang Ai before and after the construction of the dam. A number of fish species of the former river had disappeared and were being replaced by the introduced species in the lake.
ABSTRAK

Chapter 1

INTRODUCTION

1.1 Background of Batang Ai, Lubok Antu

Batang Ai and Batang Lupar are parts of the same river system. Batang Ai is the upper part of Batang Lupar, beginning right at the mouth of Batang Skrang, another tributary of Batang Ai, up to the source of the river. Batang Lupar implies only to the lower part of the river from Sri Aman down stream to the mouth that meet South China Sea near Lingga. Batang Lupar is famously associated with Sri Aman town together with the tidal bore phenomenon. On the other hand, Batang Ai is best known to be associated with Engkilili town at the lower part and Lubok Antu town at the upper end.

Lubok Antu town is located near the Sarawak-Kalimantan border, about 82 km from Sri Aman town and 300 km from Kuching (Figure 1.1). Administratively, Lubok Antu is a district under Sri Aman Division, which is further divided into two sub-districts of Lubok Antu and Engkilili. It covers an area of 2,338.4 km² and with a population of 30,377 (Table 1.1) which comprises almost entirely the Iban community that are found living in longhouses along the Batang Ai and the main roads. The Chinese and Malays communities live in the towns of Lubok Antu and Engkilili and the nearby area.
Figure 1.1: Lubok Antu District which is divided into Engkilili and Lubok Antu Sub-districts.
Table 1.1: Population of Lubok Antu District, 2002.

<table>
<thead>
<tr>
<th>No.</th>
<th>District/Sub-district</th>
<th>Iban</th>
<th>Chinese</th>
<th>Malay</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lubok Antu</td>
<td>9,048</td>
<td>498</td>
<td>149</td>
<td>87</td>
<td>9,782</td>
</tr>
<tr>
<td>2</td>
<td>Engkilili</td>
<td>17,387</td>
<td>2,858</td>
<td>220</td>
<td>130</td>
<td>20,595</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>26,435</td>
<td>3,356</td>
<td>369</td>
<td>217</td>
<td>30,377</td>
</tr>
<tr>
<td></td>
<td><strong>Percentage</strong></td>
<td>87.3</td>
<td>11</td>
<td>1.2</td>
<td>0.58</td>
<td>100</td>
</tr>
</tbody>
</table>

(Others: Bidayuh, Melanau and other Bumiputra working in the district)

The main economic activity is subsistence agriculture where the main crop is hill padi, pepper and rubber. Commercial agriculture also covers a large area of land where few oil palm plantations which was developed by SALCRA are expanding. Like any other places in Sarawak, the Iban are farmers, managed both subsistent and cash crops like hill padi, rubber, and pepper. The Chinese and Malays are involved in some commercial activities in town and also as farmers and administrators in various government offices.

The climate is classified as tropical equatorial and is generally warm and humid all year round. The average daily rainfall is at a maximum of about 85 mm with a total annual rainfall generally above 3,000 mm. The drier period is from February to August when the South-East Monsoon that blows across the mainland does not carry much moisture. From September to January, that is during the North-East Monsoon, the amount of rainfall and the corresponding number of rainy days increase where the maximum rainfall is normally exceeding 300 mm monthly. Mean relative humidity is in the range of 80% to 90% and temperature is relatively uniform between 23 °C to 30 °C.
The land of Lubok Antu District is categorized under the physiographic region of Central Lowlands which was made up of erosional and depositional landforms. Typical of the Central Lowland, low hills, dissected hills and terrace of subdued relief are dominant. The amplitude of the relief ranges from 30 to 300 m above mean sea level which is also broken up by a few mountains ranges with peaks up to 600 m. The slopes are gently rolling to moderate and steep ranging from 6 to 33 degrees. The soil resources and agriculture capability of Lubok Antu District is rated as marginally suitable (Class 4 land) to unsuitable (Class 5 land) for agriculture. Most of the land is largely used for agriculture at small-holder level only even though a few oil palm plantations had been established by SALCRA.

1.2 The Construction of Batang Ai Hydro-electric Power Station

The Sarawak Electricity Supply Corporation (SESCO) built a hydro electric power station at Wong Irup on the Batang Ai, about 19 km upstream of Lubok Antu town in the early 1980s. This power station involved a construction of a main dam with a height of 116 m. The dam created a reservoir with water level of 112 m and a surface area of about 90 km²/million m³. The catchment area is 1,200 km². This project have affected and necessitated the resettlement of 3,600 people involving 600 families from 26 longhouse communities along Batang Ai and Batang Engkari. The communities within that two main rivers were caught by surprise and although they were quite reluctant, they were relocated and resettled involuntarily by state government, between the years 1882 to 1984 (Cramb, 1979; SALCRA, 1989).
The relocation concept was that the people were regrouped in an area where they were provided with modern facilities such as treated water, electricity, roads, and schools. Their natural preference to retain the longhouse style of living with a measure of isolation from other longhouses can be accommodated to some extent by relocating the whole longhouse 'en bloc' with their farm lands acting as buffers between different longhouses.
Chapter 2

LITERATURE REVIEW

2.1 Water Quality

Water is one of the most important elements in the environment that plays a key role in the biological, physical and chemical processes and it is a unifying factor in most ecosystems (Ali & Murtedza, 1999). Like other natural resources, water resource is at constant risk of being further degraded and gradually become limited.

The availability of water resources for human consumption and agriculture is constrained by its quantity and quality. As such, the solution manifestly lies in the strategy of sustainable water resources management within the broad framework of sustainable development. The concept of sustainable development has energized as an important vehicle to integrate economic development and environmental conservation. Sustainable water resource management is defined as a set of cation securing the present function of water without jeopardizing the need of the future generation in that area (Golubeu 1993, as cited by Ali & Mutedza, 1999).

The degradation in water quality was mainly from land use due to fast growing human economic activities such as agriculture, timber extraction, infrastructure development like building of roads, mining, and even some sports and recreational activities. The
common and critical impact on water quality resulting from land use include: changes in suspended sediment load, organic matter and biological (and chemical) oxygen demand, bacteria and viruses, nutrient loads, temperature, acidification (pH), salinization, heavy metals, toxins such as pesticides and herbicides, and changes in the water flow itself (Perry & Venderklein, 1996).

Water quality is important to sustain both human and aquatic life of the water bodies. The critical water quality parameters used to determine water quality of the lake includes pH, dissolved oxygen, temperature, suspended solids, biological oxygen demand, ammonical-nitrogen, nitrate, silicate, and phosphorus.

2.2 Water Quality Parameters

2.2.1 Physical Variables

2.2.1.1 Temperature

Water temperature affects some of the important physical properties and characteristic of water quality such as density, specific weight, surface tension, thermal capacity, and some chemical properties.

Water temperature is the environmental parameter having the greatest effect on fish. Water temperature greatly influences physiological processes such as respiration rates, efficiency of feeding and assimilation, growth, behavior, and reproduction (Meade, 1989; Tucker and Robinson, 1990). Temperature also affects oxygen solubility and causes
interactions of several other water quality parameters (Lawson, 1995). A temperature increase of 10 °C will generally cause rates of chemical and biological reactions to double or triple. For example, fish will consume two to three times as much oxygen at 30 °C than they would at 20 °C, and their biochemical reactions will double or triple. Because of this, dissolved oxygen requirements are more critical in warm water than cold water. Temperature also indirectly affects those water quality variables besides regulating some biological activities (Boyd & Tucker, 1998). The relationship between temperature and water quality variables can be attributed to temperature-dependence of chemical reaction rates, equilibrium constants, solubility products, gas behaviors, and other physiochemical processes.

2.2.1.2 Total Suspended Solids (TSS)

TSS is the total amount of tiny particles (normally tiny particles of eroded soil or small organic matters) held in water. Suspended solids in water can be described as the filterable components of solids present, in which fine particles are held in suspension for long periods, depending on the intensity of water turbulence. The suspended solids comprise the suspended soil particles and particulate organic matter resulting from degradation of dead branches and leaves, detritus and sewage. According to Ali and Murtedza (1999), the measurement of total suspended solids (TSS) is used to determine soil erosion of that area. All organic and non-organic materials which can be filtered by using filter paper are termed suspended solids (Cheremisinoff, 1993). The high TSS value shows that the area experience high rate of erosion. High TSS can block light from reaching submerged vegetation. The reduction of light passing through water will slow
down the photosynthesis process of some aquatic plants. This will lead to the decrease in release of oxygen by aquatic plants in the water. The cutting of vegetation of the riverine environment directly or indirectly contribute towards soil erosion. Sedimentation of the suspended solids result in siltation, changes in color of the water, the river become shallower, and these in turn influenced water use and valuation.

2.2.1.3 Conductivity

Electrical conductance is a measure of the dissolved mineral content of the water and changes in direct proportion to salinity (Lawson, 1995). The greater the proportion of ions in water, the higher the conductivity. Because water ionizes so slowly, it acts as an insulator and is a poor conductor of electricity. Chapman (1996) stated that conductivity is the ability of the water to produce electrical current. Liquid that contains more organic materials is a good conductor. On the other hand, some unrelated organic molecules in aqueous solution produce little electricity (APHA, 1998). The unit of conductivity is microsiemens per centimeter (μScm⁻¹) or micromho per centimeter (μmho/cm). Distilled water has a conductivity of about 1 μScm⁻¹ while natural freshwater have conductivities ranging from 20 – 1,500 μScm⁻¹ (Boyd, 1990). Conductance can be used to reliable estimates salinity or TSS. Conductivity can also be used to determine pollution zone especially in the area that receives high runoff (Chapman, 1996).
2.2.1.4 Turbidity

Turbidity is a measure of light penetration in water. It is produced by dissolved and suspended substances, such as clay particles, humic substances, silt, plankton, and colored compounds (Lawson, 1995). The cloudy or muddy appearance is mainly an indicative of the amount of solids suspended in the water and, to a lesser extent, the color of the water. The denser the substances, the higher will be the turbidity and the murkier the water. Turbidity may be the result of soil erosion, waste discharge, urban runoff, or the presence of excess nutrients that result in algal growth.

Turbidity caused by suspended clay and other colloidal particles is undesirable. Clay turbidity that restricts visibility to 30 cm or less can inhibit the development of good plankton blooms (Romaire, 1985). Excessive runoff from the surrounding watershed can often cause clay and silt loads to exceed 20,000 mg/l. This is a cause for alarm since these particles can clog the gills of small fish and invertebrates, settle onto and smother fish eggs, and shield food organisms. However, fish seem less affected at concentrations below 20,000 mg/l for short periods (Lawson, 1995).

Turbidity caused by suspended solids appears to affect aquatic life especially fish more than clay turbidity. Cold water fish have been killed as a result of exposure to 500 to 1,000 mg/l suspended solids for three to four days (Alabaster and Lloyd, 1982). Good to moderate fish production can result at suspended solids concentrations between 25 and 80 mg/l, but 80 mg/l is recommended as a maximum (Lawson, 1995). Tucker and Robinson (1990) found out that channel catfish seem to be more tolerant as both
fingerling and adults can survive long term exposure to 100,000 mg/l suspended solids. However, they had also noticed that some behavioral changes occurs at 20,000 mg/l.

2.2.1.5 Color

Color is the result of the interaction of incident light and impurities in the water. Pure water appears blue in white light since the blue colors of the spectrum travel further in water than others and is scattered more (Wheaton, 1977). The addition of humic substances in water imparts a tea-colored or reddish blue. Heavily manured ponds or ponds in wooded areas or swamp lands are often high in dissolved humic substances (Lawson, 1995). Iron associated with humic substances can impart a yellow color. Certain alga impart a color dependent upon the species (i.e., the presence of green alga makes water appear green in color).

Water color in highly productive waters like fish ponds is largely dependent on the color of the predominant species of phytoplankton. Unproductive waters generally have a bluish color and are very transparent since color is caused by light scattering as it hits dissolved particles in the water (Wheaton et al., 1979). Impending oxygen shortages in the water can often be detected by changes in color (Lawson, 1995).

2.2.1.6 Redox

This is the ability of oxygen potential. High redox reading shows high oxidation processes. The surface and ground water usually contains dissolved oxygen between the range of redox 100 mV – 500 mV (Chapman, 1996). This parameter is measured in-situ