LAND USE CONFLICT: A CASE STUDY FOR TAPAH AREA, SIBURAN SUB-DISTRICT, SARAWAK.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF PLATES

ABSTRACT

The goal of the study was to identify the impacts of land use conflicts on the water quality of Sungai Tapah sub-catchment, Siburan Sub-district, Kuching, Sarawak. Data were collected by visiting various Government departments, private agencies, informal interviews, literature search, and field visits to the study area.

At present, 15 water catchment areas have been gazetted under the provision of the Water Ordinance, 1994. The Natural Resources and Environment Board (NREB) have approved another 17 water catchment areas for gazettement, which is also devising a policy for introducing guidelines on permitted activities within water catchment areas. Although no agriculture is allowed in water catchment areas, encroachment by small-scale farming and shifting cultivation occurs in the study area, thus creating land use conflicts. Many concur that shifting cultivation is one of the main causes of siltation and river sedimentation in the State, particularly when appropriate fallow periods are not practiced.

Results from the water quality analysis indicated a higher level of suspended solids and turbidity during the first sampling (high tide and after rainfall), as compared to the second sampling conducted during low tide and no rainfall prior

to the sampling. This is indicative of surface runoff and the lack of groundcover to prevent it from reaching the waterways. In general, the water samples taken from Sungai Tapah are acceptable. However, this is not the case for the discharge water from the water treatment plant (sample WS3). The level of suspended solids and turbidity are considered Class V of the Interim National Water Quality Standards for Malaysia (INWQSM).

Therefore, the protection of our water supply should be of highest priority. Currently, shifting cultivation is not under any form of regulation, thus has the potential to cause adverse environmental impacts due to the vastness of these areas in the State. An integrated approach, whereby social, economic and environmental dimensions are taken into consideration, is used to formulate effective strategies and management frameworks for water resources management in order to tackle this problem.

ABSTRAK

Sasaran kajian ini adalah untuk mengenalpasti impak daripada konflik guna tanah ke atas kualiti tadahan kecil Sungai Tapah, di daerah kecil Siburan, Kuching, Sarawak. Data dikumpul daripada lawatan ke jabatan-jabatan kerajaan, agensi-agensi swasta, melalui temuramah tidak formal, hasil kajian bahan bacaan dan lawatan lapangan ke kawasan kajian.

Sehingga kini, terdapat 15 kawasan tadahan air yang telah digazet dan termaktub di bawah Ordinan Air 1994. Lembaga Sumber Asli dan Persekitaran (NREB) telah meluluskan 17 kawasan tadahan air bagi tujuan penggazetan, yang juga dalam perancangan polisi untuk memperkenalkan panduan bagi aktiviti-aktiviti yang dibenarkan dalam lingkungan kawasan tersebut. Walaupun pertanian adalah tidak dibenarkan di kawasan tadahan air, namun pertanian berskala kecil dan pertanian pindah wujud di kawasan kajian, oleh yang demikian, mengakibatkan konflik guna tanah. Ramai yang berpendapat bahawa pertanian pindah merupakan salah satu punca utama pemendakan dan pengkeladakan sungai di negeri ini, terutamanya apabila tempoh tanah terbiar tidak dipraktikkan dengan betul.

Keputusan analisis kualiti air daripada persampelan pertama iaitu pada ketika air pasang dan selepas hujan menunjukkan paras bahan terampai dan kekeruhan yang tinggi berbanding persampelan kedua iaitu pada ketika air surut dan tiada hujan berlaku sebelum persampelan. Ini menandakan terdapatnya hakisan tanah dan kurangnya tanaman tutup bumi yang mencegah hakisan daripada sampai ke laluan air. Secara umumnya, sampel air Sungai Tapah yang diambil boleh diterima. Walau bagaimanapun, ini tidak termasuk air buangan daripada loji perawatan air (sample WS3). Paras bahan keladak dan kekeruhan adalah dalam Kelas V bagi Piawaian Sementara Kualiti Air Nasional Malaysia (INWQSM).

Oleh itu, perlindungan ke atas bekalan air kita haruslah diberi keutamaan yang tinggi. Pada masa kini, pertanian pindah tidak dinyatakan dalam mana-mana peraturan dan oleh yang demikian, pertanian pindah yang berleluasa di negeri ini berpotensi untuk mengakibatkan impak buruk kepada persekitaran. Untuk menyelesaikan masalah ini, pendekatan integrasi yang mengambil kira dimensi sosial, ekonomi dan persekitaran adalah perlu untuk merangka strategi dan rangka kerja pengurusan yang efektif.

CHAPTER ONE

1 INTRODUCTION

1.1 Background and Rational of Study

Sarawak is the largest of the 13 states in Malaysia and covers a large area of approximately 12.3 million hectares, with a lengthy scenic coastline of 720 kilometers. The advantage of having large tracts of land means that Sarawak is able to cater for agricultural needs while maintaining a large forest resource base. Currently, some 390,000 ha of land is cultivated with perennial crops such as coconut, cocoa, rubber, oil palm and sago; whereas another 104,000 ha are cultivated with non-tree crops particularly pepper and wet and hill paddy or rice (Forest Department Sarawak, undated).

Besides large tracts of land, Sarawak is blessed with a large number of rivers, thus, referred by some as a 'land of rivers'. There are 23 major river basins in the State, a majority of which originates from the mountains of the Indonesian border (Memon and Murtedza, 1999). However, the problem arises when encroachments by small-scale farming occurs within watershed areas. For example, the recent trend is that small-scale crop cultivation continues to encroach into marginally suitable lands or land designated as water catchment areas, thus resulting in serious soil erosion, which is also due to the inconsistencies between actual land use and land capability of the area (Natural Resources and Environment Board, 2002a).

In general, a watershed is defined by the stream that drains it. It is simply the area that collects and discharges runoff through a given point on a stream. The term is often used synonymously with *drainage basin* or *catchment* (Satterlund and Adams, 1992). Land development within catchment areas has had an adverse impact on the quantity, quality and distribution of water resources in Sarawak (Memon and Murtedza, 1999).

As the need to protect and conserve water catchment areas in the State increases, 15 water catchments have been gazetted, which consists a total area of approximately 3,700,000 hectares under the provision of the Water Ordinance, 1994. The Natural Resources and Environment Board (NREB) have approved another 17 water catchment areas (an estimated 1,100,000 hectares) for gazettement, which is also devising a policy for introducing guidelines on permitted activities within water catchment areas (Memon and Murtedza, 1999). Although no agriculture is allowed in water catchment areas, some include villages around which shifting agriculture is carried out, thus creating land use conflicts. According to Memon and Murtedza (1999), siltation, a non-point source of pollution, is a major cause of river pollution in Sarawak, of which, shifting agriculture has been identified as one of the main causes. The problem escalates when shifting cultivators claim to have cleared the lands prior to 1959, whereby their lands are classified as Native Customary Rights (NCR) Lands (Natural Resources and Environment Board, 2002a).

This case study intends to discuss the nature of land use conflicts in the study area and present several recommendations on ways to minimize the impacts of these conflicts. For this case study, land use conflicts are indicated by the deterioration of water quality in the study area.

1.2 Study Area

The main focus is on the Sungai Tapah sub-catchment area, located within the Siburan Sub-District, Kuching Division (Figure 1.1). It is located approximately between latitudes 1°16' N - 1°18' N and longitudes 110°20' E - 110°24' E (Figure 1.2). Sungai Tapah (Plate 1) is also the main intake point for the Tapah Water Treatment Plant (Plate 2), which supplies treated water to the surrounding settlements.

The study area is easily accessible, whereby its main town, Tapah Bazaar, with a population of 2,518 people (Department of Statistics, 2002) is located at Mile 20 of the Kuching-Serian Road (Plate 3). Further access into the study area is via Jalan Padawan (Plate 4).

Figure 1.1: Locality Map

Almost all of lands within the study area are classified Interior Area Land. However, small areas of Mixed Zone Land exist, particularly along the Kuching-Serian road.

Sungai Tapah is actually part of the Batang Samarahan basin. This river basin has a total area of 1,088 km^2 and consists of two catchments, both of which are primarily drained by the Batang Samarahan. The upper catchment includes Pasar Pang Kut, Siburan, Beratok, Tapah and Kota Samarahan, whereas, the lower catchment is relatively narrow and runs from Kota Samarahan to the sea. Flash flooding occurs frequently in this area, mainly due to poor drainage and outlet systems (State Government of Sarawak, unpublished).

Generally, in the upstream of Sungai Tapah, extensive smallholding agricultural development has taken place. In particular, the study area is where the production of vegetables for Kuching occurs. Sadly, Sungai Tapah is overgrown with vegetation and siltation is a problem that needs to be addressed in order to ensure continuity of river flow and capacity.

There is only one settlement within the study area, namely, Kampung Mundai (Plate 5). This settlement consists of 120 households, with a total population of 624 people, of which all are Land Dayaks / Bidayuh (Mr. Colif, Siburan Health Clinik, personal communication).

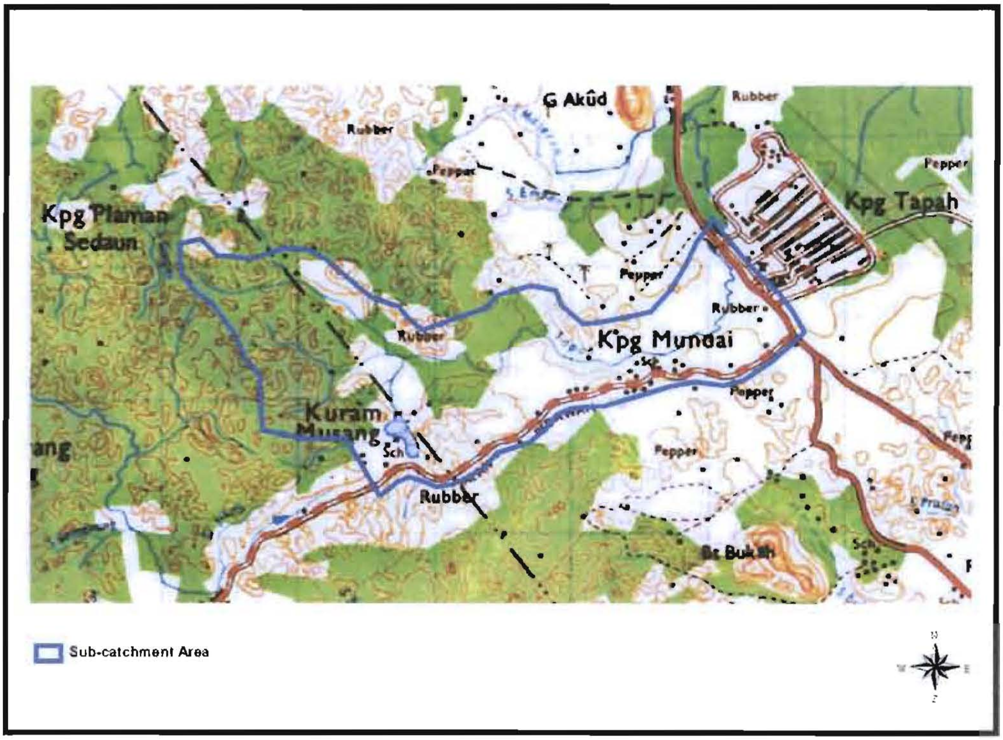


Figure 1.2: Study Area

1.3 Study Objectives

1.3.1 General Objective

The general objective of the study is to identify the land use conflicts and it's impacts on water quality in the study area.

1.3.2 Specific Objectives

The specific objectives are as follow:

(a) To **map existing land capability and land use patterns** in the study area;

(b) To **identify land use conflict indicators**;

(c) To **identify the impacts of land use conflicts towards the water quality** of Sungai Tapah;

(d) To **explore major factors that contribute to land use conflicts** in the study area; and

(e) To **make recommendations** on how land use conflicts can be minimized.

1.4 Significance of the Study

The protection of the water supply to the settlements within the study area is a matter of highest priority. However, it must be understood that water catchments do not pose an absolute constraint on all development, but rather, development and activities must be carefully controlled and monitored.

Thus, the significances of this study are as follows:

(a) The study will give us an overall picture of the land use conflicts in the study area;

(b) The study will provide indicators for land use conflicts and the resulting ecological and social problems, particularly with regards to water quality issues; and

(c) The study will provide recommended planning tools towards minimizing land use conflicts and hence, improve the quality of water supply in the area.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Global Population Increase and its Pressures Towards Our Environment

In 1992, the human population of the Earth as a whole passed a significant milestone: 5.4 billion individuals. The difference between birth and death rates during this year amounts to an annual worldwide increase in human population of approximately 1.7 percent. In 2000, the world's population reached approximately 6.2 billion and is expected to increase another 2 billion during the following 20 years. All these people consume a lot of food and water, use a great deal of energy and raw materials, and produce much waste. As a group, they also have the potential to solve many, perhaps most, of the problems that arise in an increasingly crowded world (Raven et al., 1993).

The need for consumables will increase exponentially in the foreseeable future in response to an increase in population. Human numbers have the potential for doubling once again well before the middle of the next century. We shall be drawing upon the resources and services of a finite, impoverished landscape for meeting those needs, as well as the need for a stable and secure environment (World Commission on Forests and Sustainable Development, 1999).

2.2 Global Water Consumption and Supply

Worldwide, we are using increasingly more water, in part because our population is increasing and in part because, on average, each person is using more water. The World Resource Institute estimates that water use has increased 4 to 8 percent each year since 1950 (Raven et al., 1993). The rate of increase is now slowing because water use has stabilized in developed nations, although it is still increasing in developing countries.

To meet the growing need for water, we try to augment our supply by building dams to create reservoirs and by diverting river water. In many areas, the quantity of water is not as critical as its quality, and steps must be taken to ensure a supply of clean water. All of these efforts to obtain and maintain a steady supply of clean water involve considerable expense.

Data on global water availability and use indicate that, overall, the amount of fresh water on the planet is adequate to meet human needs, even taking population growth into account. These data do not, however, consider the distribution of water resources in relation to human populations (Raven et al., 1993).

2.3 Global Water Shortages

Many developing countries have insufficient water to meet the most basic drinking and household needs of their people. The World Health Organization (WHO) estimates that one billion people lack access to safe drinking water and almost 2 billion are without access to satisfactory means of domestic wastewater and fecal waste disposal (Raven et al., 1993).

Continuing forest decline exacerbates water shortages in many parts of the world, reducing the amount of water available for agriculture, fishing, industrial and domestic purposes. Deforestation, including intensive forest cutting without changes in land use, disrupts water supplies. The increased run-off from upland areas leads to increased sedimentation of dams and reservoirs. In addition, water quality issues have taken on renewed urgency. Inadequate water supply and sanitation services cause ill health and human suffering. Pollution of water resources is reducing usable supplies and aggravating the scarcity problem. Thus, quantity and quality issues have merged in a way that reinforces the need for a more integrated approach to water policy. Solutions will need to focus first on managing water as an economic good that is a product of the landscape where forest exert a major control on water flows and water quality (World Commission on Forests and Sustainable Development, 1999).

2.4 Importance of Forests Worldwide

In their natural state, not disrupted by human incursions, forests stabilize the landscape. The binding action of tree roots slows erosion, reducing sedimentation, protecting rivers, coastlines and fisheries. They control the chemistry of water in groundwater and in streams and lakes; thereby protecting fish and fisheries. Forests make rain locally and keep landscapes moist in periods of drought. They prevent desertification and natural disasters caused by flooding and landslides. All forests play a central role in the nutrient cycles of elements including nitrogen, phosphorus, and potassium as well as calcium, magnesium, and iron and the trace elements. Trees absorb and store the nutrients, preventing them from being leached away to cause pollution of waterways a well as impoverishment of the land.

Forests regulate water supplies. They collect, store, filter, and re-circulate the water so essential for all life. On a global level, forests contribute to the integrity and stability of the hydrological cycle and ensure the proper stability of the circulation of water from land to atmosphere and through precipitation, back to the land. The latent heal of evaporation is the major source of energy driving climates globally and forests have a major influence or that part of the global hydrologic cycle, as shown in Figure 2.1 (World Commission on Forests and Sustainable Development, 1999).

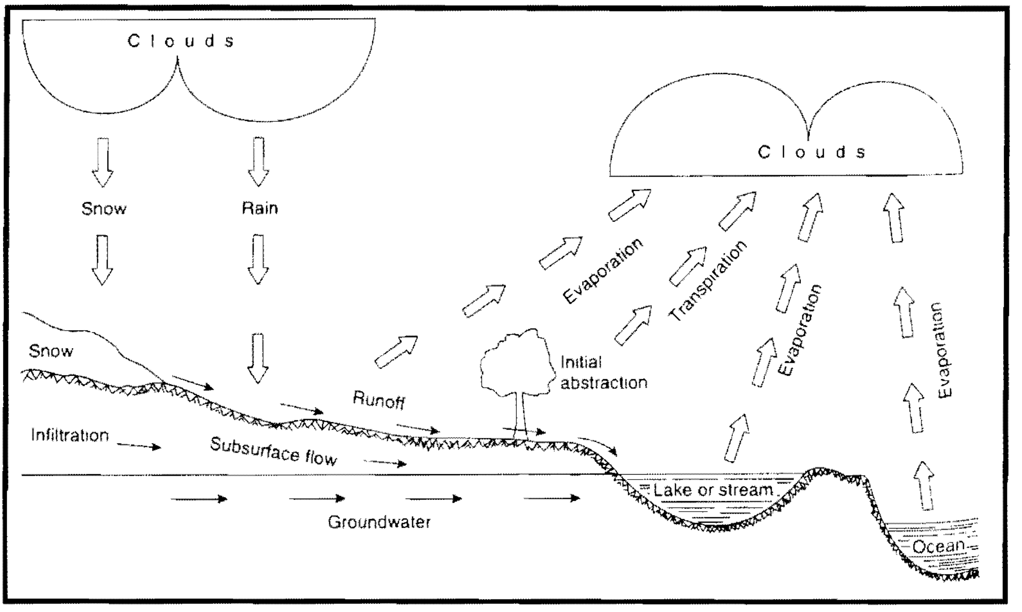


Figure 2.1: Hydrologic Cycle (World Commission on Forests and Sustainable Development, 1999)

The quantity and quality of water delivered to cities and rural villages depend on conditions within the entire hydrological system, and thus in part on upstream forests. Therefore, forests, by providing steady flows of good quality water, are a line of defense against the spread of these maladies, followed by sewage facilities, water treatment plants, and public health programs, many of which are lacking in developing countries (Latin American and Caribbean Commission on Development and Environment, 1990).

2.5 Effects of Deforestation and Land Degradation in Asia

Between 1990 and 1995, Asia suffered high rates of deforestation, concentrated in tropical areas. During this period, tropical Asian forest suffered from deforestation rates averaging 1.1% per year. Forest decline in Asia (Figure 2.2) has occurred mainly through clearing for agriculture (both shifting cultivation and commercial farming) and timber harvesting (World Commission on Forests and Sustainable Development, 1999). Other activities implicated in the decline include mining, irrigation, hydroelectric projects and urban expansion (FAO, 1997).

In Asia, much of the blame is laid on shifting cultivators. Fernando (1989) described shifting cultivation as the 'single greatest threat to the conservation and the biological diversity of the tropical forests of Asia'.

Throughout Asia, there are many signs of land degradation associated with forest decline. They are, reductions in agricultural productivity over large areas of land that was once productive forest, and high rates of soil erosion and sedimentation of dams, reservoirs and irrigation systems (World Commission on Forests and Sustainable Development, 1999).

Forest decline also leads to loss of biological resources and their diversity, which threatens humanity's food and wood supplies, and the availability of medicinal elements. It leads to loss of economic and recreational opportunity. It disrupts essential ecological functions such as the regulation of water run-off, the control of erosion, the assimilation of wastes and purification of water, cycling of carbon and nutrients, and climate stability (Heywood, 1995).

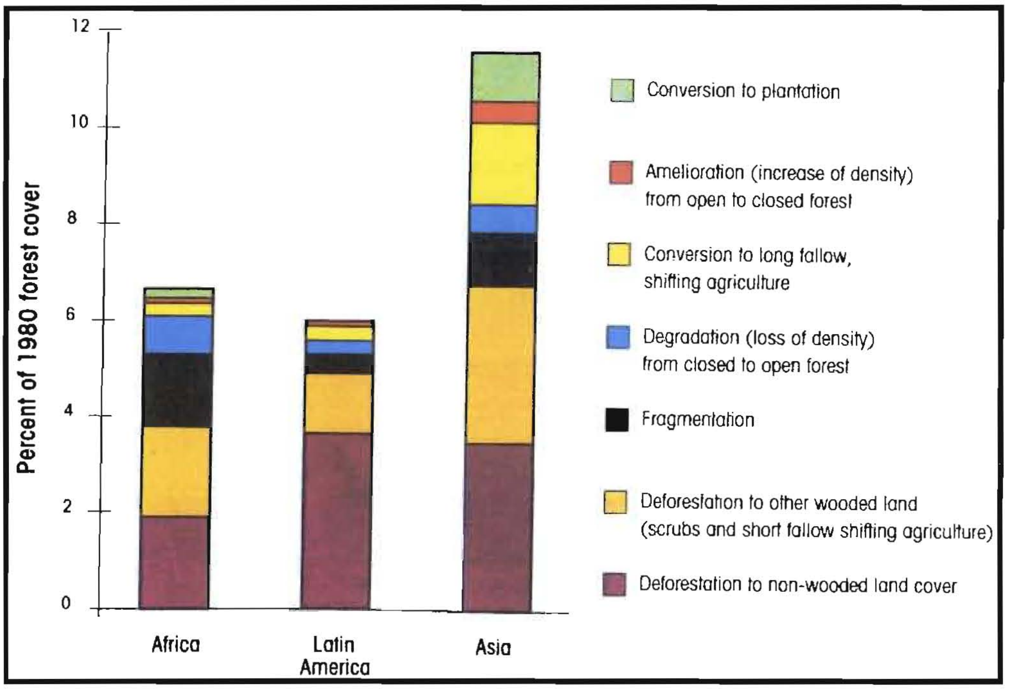


Figure 2.2: Changes in forestland cover in tropical regions, 1980-1990 (World Commission on Forests and Sustainable Development, 1999).

In developing countries alone, approximately US$45 billion are lost each year because of poor forest management (Chandrasekharan, 1996). The losses are recorded in terms of extinction of species, loss of topsoil, the sedimentation of reservoirs, and the loss of productive fisheries (MacNeill, 1996).

2.6 Watershed Management in Malaysia

A river is but one part of a complex life support system defined by the river itself, its riparian wetlands, its floodplain and catchment area (the area of land that drains into the river) and, of course, its human inhabitants. In total, this is the river basin (sometimes called the catchment or the watershed).

Effective management has been the exception rather than the rule in river basins. The problem lies not just in the large areas involved or the huge demands human populations make upon their wetlands, but most significantly through the sectoral approach to management.

All too often hydrological management – for water supply (for industrial, agriculture including irrigation, and domestic use), flood control, navigation – is controlled by national agencies that are quite separate from those responsible for ecological / habitat management – the management of forests, wetlands, and other habitats that play a role in the water regime of the river basin. Such a fragmented approach naturally leads to conflicting policies, laws and practice.

The solution – Integrated River Basin Management (RBM or IRBM), whereby the basin is managed, as an integrated unit that must balance economic, social and ecological needs in a sustainable manner. A mighty challenge within any country but an even more daunting task when you realize just how many rivers span one or more political boundaries. (Malaysian Nature Society, 2004)

2.7 National Agricultural Policy

The National Agricultural Policy (NAP) that guided the activities of the agriculture sector during the 6MP had been reviewed in the light of the rapid transformations taking place both within the Malaysian and the international economy. The 7MP, covering the period 1996-2000, sets out the broad objectives that aim to achieve productivity improvements through more efficient and greater utilization of agricultural resources particularly through:

- encouraging private sector participation;
- re-orientating production methods to improve competitiveness;
- consolidating the planted areas of rubber, oil palm and cocoa; and
- accelerating the adoption of labor-saving techniques, mechanization and automation.

In general, the Government has been pursuing a market-oriented policy of liberalized price regimes, low tariff thresholds and dismantling of government intervention in production and marketing. The Government will, by providing the required support services, encourage private sector participation in agriculture on a large-scale basis, particularly in the production of food and high-value produce. Production methods will be reoriented to improve competitiveness in response to the more liberal market environment. Consolidation of holdings of rubber, oil palm and cocoa will be pursued to reorient production to meet the needs of local agro-based industries.

2.8 State Agricultural Policy

Within the State of Sarawak, one of the principle means for achieving this objective, particularly with reference to oil palm, is to be the new concept of development on Native Customary Rights (NCR) land. The latest directions and policy thrusts spelt out for the State agricultural sector include:

- The sectoral policies, plans, programs and project must reflect a modern, commercial and global approach;
- The development of land holdings, particularly those involving smallholders and Native Customary Land (NCL), must be consolidated for commercial agriculture under a centralized management (covering production, processing and marketing), and/or through joint-venture arrangements;
- There must be an increase in uptake of research finding by the agriculture smallholders;

- Accessibility of agricultural production areas and transportation of agricultural inputs and produce need not only depend on road transport, but also on available waterways or river systems;
- Planning and implementation of agricultural projects must take full account of economies of scale;
- Vegetables and fruit farms should be established on a commercial basis near the urban areas and as such, suitable lands (State Land/alienated land/NCL) should be identified and made known to the private sector; and
- Food industry should be given emphasis and it should incorporate the integration of production, processing and marketing.

Therefore, the new State agricultural policies are focused on the development of a modern and commercial agriculture sector, with particular emphasis on food production. Food commodities include rice, fruits, vegetables, and also animal feed for livestock and aquaculture. For Sarawak in particular, the current State Government policy is to intensify the production of food crops, with emphasis on rice in order to increase the State's level of self-sufficiency from the current level of 35% to a target of 75% by the year 2005. In order to facilitate commercial agriculture, small land holdings should be consolidated; management should be centralized, incorporating a whole spectrum of production, processing and marketing; uptake of research findings should be maximized; and economies of scale should be fully considered during project implementation (State Planning Unit, unpublished).

2.9 Land Classification in Sarawak

Under the 1957 Sarawak Land Code, all lands in the State are classified under the following categories. There is a need to look briefly into how each and everyone of this category works to better understand and appreciate the overall nature of the land tenure system in the State. This will give us a better insight on the development of such land.

Mixed Zone Land. This category of land may be held under title. Anyone can hold title to this category of land that can also be occupied by indigenous people under customary tenure. This is the only category of land which the non – natives can own or occupy.

Native Area Land. This land may be held by natives under title. A non–native can also acquire rights over Native Area Land in the following manner. Firstly, if he is prospecting for minerals or taking forest produces. Secondly, when he becomes a 'native' by identifying with and subjecting to any native system of personal law. Thirdly, the Yang di-Pertua Negeri can issue a permit or an order under the Land Rules that will allow him to occupy the land. Fourthly, when a registered native proprietor executes a deal in favour of such a person. In such a case the person shall be deemed to be a native for the purpose relating to the dealing.

Native Customary Land. This is defined as, "Land in which native customary rights whether communal or otherwise have lawfully been created prior to the 1st of January 1958". Anyone practicing native customary rights over any land after this date will be committing an offence for unlawful occupation of State land.

Interior Area Land. This land is defined as all land not falling within any of the other classifications. Much of this land lies in the deep interior, is under primary forest and cannot be held under title. In addition, it comprises unsurveyed State land, which maybe subject to native customary right claims. The government may alienate unencumbered Interior Area Land and it has to be classified into Mixed Zone Land or Native Area Land.

Reserved Land. This includes State Land that is used by and reserved for the Government for various purposes. It includes forest reserves, protected forests, national parks, wildlife sanctuaries, nature monuments etc.

2.10 Land Status and Availability of Land in Sarawak

The land status of the steepland in the State comprises Forest Reserve, Protected Forest Land, Native Customary Rights Land, Native Area Land and

Interior Area Land as well as land that are subjected to Native Customary Rights (NCR) claim. The land status in the steepland can be so diverse that it restricts preferential selection of contiguous blocks of land for the plantation development. The present land cover information indicates that a large proportion of the relatively accessible steepland (outside the Forest Reserves and Protected Forests) has been used at one time or another for smallholder farming by rural farming household nearby. Inevitably, this land is subjected to some kind of NCR claim. However, such land by inclusion of potential NCR claimants as stakeholders in project proponent is considered a desirable opportunity to facilitate and accelerate the development of some of the steepland into commercial plantations in the State (Teng, 2000).

2.11 Land Use in Sarawak

There has been a steady decline in the area of forested areas in Sarawak (Table 2.1). This decline is attributed to the increase in population, thus an increase in demand for settlements, and the establishment of vast areas of oil palm plantations in-line with the State Government's efforts in developing NCR lands.

Table 2.1: Land Use in Sarawak (Department of Statistics Malaysia Sarawak, 2002).

Land Use classes	*1976*		*1991*	
	Area (km²)	*%*	*Area (km²)*	*%*
1. Settlements and associated non-agricultural lands	**151.8**	**0.12**	**359.6**	**0.29**
2. Horticultural lands (misc. cultivation, small areas of fruit trees)	**83.7**	**0.07**	**468.2**	**0.38**
3. Tree, palm and other permanent crops	**3 026.1**	**2.45**	**2 476.7**	**2.01**
Rubber	2 033.9	1.65	1 448.0	1.18
Oil Palm	189.3	0.15	309.2	0.25
Coconut	408.7	0.33	433.7	0.35
Pepper	236.5	0.19	114.4	0.09
Sago	157.7	0.13	171.4	0.14
4. Crop land	**28 945.6**	**23.49**	**37 075.9**	**30.08**
Wet Padi	417.0	0.34	558.6	0.45
Shifting Cultivation	28 528.6	23.15	36 517.3	29.63
5. Unused land (secondary growth)	**724.2**	**0.59**	**633.7**	**0.51**
6. Swamp forests	**13 837.1**	**11.22**	**12 622.4**	**10.24**
Mixed swamp forest	10 839.7	8.79	9 714.0	7.88
Alan	2 409.0	1.95	2 334.4	1.89
Padang paya	588.4	0.48	574.0	0.47
7. Dry forest land	**74 801.9**	**60.69**	**68 225.9**	**55.36**
Hill forest	71 529.8	58.04	65 089.5	52.81
Kerangas forest	2 973.8	2.41	2 869.4	2.33
Riverine forest	289.8	0.23	259.0	0.21
Beach forest	8.5	0.01	8.0	0.01
8. Swamp (including fresh and salt water and mangrove and nipah)	**1 682.5**	**1.37**	**1 389.8**	**1.13**
Total:	*123 252.9*	*100.0*	*123 252.2*	*100.0*

2.12 Long-term Sustainable Development in Sarawak

It is vital in the interests of long-term sustainable development to protect all valuable environmental resources. Under this principle, it is intended that certain types of land should be subject to very strict controls on the type and scale of development, ranging from almost no development in the National

Parks to limited village expansion and agriculture related development in areas with soils and topography suitable for major agriculture development. Other protected environments include forest reserves, water catchment areas and special landscapes with potential for tourism and recreation (State Government of Sarawak, unpublished).

In Sarawak, it is reported that the Dayaks have collectively not fewer than one million acres of Native Customary Rights (NCR) land that are at present poorly utilized, under–utilized or not utilized at all. If these lands could be developed commercially, it could generate tremendous wealth to the rural Dayaks. On their own, the rural Dayaks do not have the means to develop these lands commercially as most of them are small time farmers who cultivate their land mostly on subsistence basis. (SLUSE-M, 2003.)

Therefore, all parties involved in economic development and environmental protection must strike a balance between these two elements in order to ensure that our future generations can benefit from the policies spelt out today.

2.13 Effects of Deforestation on River Systems in East Malaysia

Significant portions of the natural vegetation in the lowland forests of East Malaysia have been extensively disturbed or completely removed either for extraction of timber, or for agriculture, mining or urbanization purposes. Data gathered during the last ten years show that these activities have resulted in extensive siltation of rivers draining these lowland areas. In Sabah, the sediment yields of major watersheds are in excess of 200 tons per square kilometer per year. Removal of tree canopies in the upstream regions over the ten years has led to increased storm flows, which in turn aggravated channel erosion. As with excessive sediment loading of rivers in any situation, a number of direct adverse implications are evident. They include power losses due to disruption of municipal and industrial water supplies, restriction of estuarine pliability, and flash floods due to reduced channel capacity. Apart from these direct physical effects, disturbance and fragmentation of forest habitats have also resulted in depletion of biological resources, particularly in terms of species diversity and density (Murtedza and Ti, 1991).

2.14 Agricultural Activities and their Contributory Effects on Soil Erosion in the Steepland of Sarawak

The State of Sarawak covers approximately 12.3 million hectares, of which, 1.78 million ha (or 14%) are suitable for agriculture. The remaining 10.7 million ha (or 86%) are marginally suitable to conditionally suitable for agriculture. Out of the 86% marginally suitable to conditionally suitable agricultural land, approximately 67% consists of hilly, steeply dissected land or commonly known as steepland in the State. The remainder areas are made of 14% of peat swamps and 5% of coastal plain respectively (Teng, 2000).

Many earlier workers reported that soil erosion under sedentary agriculture was potentially serious in the steepland (lands with slopes exceeding 25 degrees). Some reported that surface erosion and mass wasting were much in evidence on slopes exceeding 25 degrees. Other workers reported that planting on bench terraces with cover crops significantly reduced soil erosion. Many workers have expressed concern, as quite often the steepland is being mismanaged to such low levels that soil erosion and fertility depletion are perceptibly aggravated (Teng, 2000).

The present available information on agricultural activities and their contributory effects on soil erosion is scarce and incomplete. There is a need to generate updated information to validate the feasibility in adopting some of the previously prescribed slope safety limits for establishment of oil palm plantation, and of latex-timber rubber plantations in the steepland. Soil research on generation of soil erodibility indices and soil erosion risk is also to enhance and improve planned operation practices for agriculture in the steepland (Teng, 2000).

2.15 Water Resource Management in Sarawak

According to Memon and Murtedza (1999), water is one of the major development assets in Sarawak. Sadly, water has been utilized without much thought of sound management. Despite its relative abundance, there is evidence of growing strain on the accessibility to the supply of clean water. Therefore, all parties involved should adopt the concept of sustainable development, whereby the needs of the present as well as the future generations of Sarawak are protected.

The implementation of sustainable water resource management can only be achieved through integrated catchment management. This will require appropriate institutional arrangements that provide adequate legislative mandate and allocation of responsibilities, organizational arrangements and decision-making procedures for formulating plans and implementing these using a combination of different instruments.

2.16 Water Supply in Sarawak

Being a major natural asset of Sarawak, water is currently extracted at an estimated rate of 3,300 megalitres per year by various water authorities in the State. In addition, water is used for various purposes at a rate of 412,000 m^3 per day. This figure is expected to rapidly increase in the coming years.

Water supply is now regulated under the Water Ordinance, which took the place of the former Water Supply Ordinance in 1994. Under the Water Supply Ordinance, Jabatan Kerja Raya Sarawak (JKR) was vested with the responsibility of developing and administering water supplies throughout the whole of Sarawak, with the exception of Kuching and Sibu where water supply has been provided by the respective water boards. The Kuching Water Board and the Sibu Water Board were established as statutory bodies in 1959 under the Water Supply Ordinance, each headed by an Engineer and Manager, with the Director of JKR as the Chairman of the Water Boards. The boards have served the respective municipalities and their immediate environs. The water supply authorities came under the direct control of JKR (Memon and Murtedza, 1999).

2.17 Existing Laws Related To River Protection in Sarawak

The State Government has taken a holistic approach with the aim to protect and preserve the State's river system through the formulation of legal frameworks. In addition, the State Government has directed the Natural Resources and Environment Board (NREB) to ensure that the water quality in all rivers of Sarawak be maintained to at least Class IIB of the Proposed Interim National Water Quality Standards (INWQS). In this regard, the NREB is imposing strict control of human activities in catchments of rivers.

For example, under section 30A(a) of the Water Ordinance, any person who knowingly does any act or conducts any activity which pollutes or contaminates any inland waters shall be guilty of an offence: penalty, a fine of fifty thousand Ringgit and an imprisonment for five years.

The current river related laws include:

- Environmental Quality Act, 1974
- Natural Resources and Environment Ordinance, 1993
- Sarawak Rivers Ordinance, 1993
- Water Ordinance, 1994
- Water (Amendment) Ordinance, 2000
- Local Authorities Ordinance, 1996
- Public Health Ordinance, 1999

The former Water Supply Ordinance and the current Water Ordinance and the Natural Resource and Environment Ordinance contain provisions for the designation of water supply catchments. However, the effectiveness of these provisions has been variable hitherto. One of the most noticeable consequences of rapid development in the State during the last two decades has been the encroachment of human activities such as agricultural plantations and industrial and housing estates on the catchment areas for water supply. Even though a number of catchments have been recently formally designated, very few catchments have been demarcated on the ground, while many of the smaller rural water supply catchments are unprotected. Local land owners as well as State development agencies have not always been supportive of land use controls in designated catchment areas while there have been instances of catchments that have been excised for development purposes (Memon and Murtedza, 1999).

2.18 River Water Quality Monitoring in Sarawak

In 1999, the NREB Sarawak, started the water quality monitoring with the primary objective to monitor and to establish a baseline data for the water quality of all major rivers and inland lakes in Sarawak. After three years of continuous monitoring work, substantial water quality data have been generated. These raw data are useful for assessing and making decisions in pollution prevention and control.

A total of 29 major rivers and three inland lakes were monitored on a continuous basis with different sampling frequencies, depending on the sensitivity of the rivers concern. Physical-chemical and bacteriological analyses were carried out for the determination of water quality. The rivers and inland lakes water quality was statistically analyzed to define the pollutants in impaired waters, including siltation, bacteria, nutrients, and metals. Runoff from urban areas, agricultural lands and industrial zones were identified as the primary sources of these pollutants.

The program revealed that most of the rivers were identified as moderately polluted. These rivers include Sungai Sarawak, Sungai Samarahan, Batang Sadong, Batang Lupar, Batang Rejang, Sungai Niah and Batang Baram. On the other hand, Sungai Miri, Sungai Maong, Sungai Sekama, Sungai Tabuan, Sungai Bintangor and Sungai Padungan were found to be considerably polluted.

Human activities may modify water composition extensively through direct effects of pollution and indirect results of water development. Therefore, good land and water management are essential for long-term sustainable water resources and the key to improve water quality in our rivers. It is believed that continuous water quality monitoring is crucial to provide an indication of the health of a river or lake and provides an indicator of the health of the catchment as a whole (Natural Resources and Environment Board, 2002b).

2.19 Sources of River Contamination

Suspended solids are often natural contaminants resulting from the erosive action of water flowing over surfaces. A rapid increase in the levels of suspended solids after rainfall is a result of inadequate ground cover or vegetation. This also indicates uncontrolled land clearing activities within the study area. In addition, the source of suspended solids may also be from domestic wastewater.

Sediment pollution also reduces populations of fish and shellfish, and decreases the capacity of waters to assimilate oxygen-demanding wastes. This is caused in part by suspended solids cutting sunlight, thus reducing the growth of aquatic plants and subsequently those animals that feed on plants. Settled solids form an oxygen-demanding sludge. In addition, sediments carry substantial amounts of nitrogen, phosphorus, and low concentrations of pesticides. Nutrients lead to eutrophication and sometimes, hazardous levels of nitrates. On the other hand, pesticides cause fish and animal deaths, and some can be hazardous to humans if they move through the wrong food chain (Poincelot, 1986).

An increase in turbidity normally follows the increase in levels of suspended solids. Turbidity is caused by the erosion of colloidal material such as clay, silt, rock fragments, and metal oxides from the soil.

2.20 Land Use Conflicts

As the State intensifies its effort to develop land through various development projects, conflicting demands for land becomes increasingly prevalent, particularly in designated water catchment areas.

The existence of smallholding agriculture farms within a water catchment area is considered a conflict of use by is a clear example of conflicting uses of land. Although no agriculture is allowed in water catchment areas, some include villages around which shifting agriculture is carried out, thus creating land use conflicts. However, this conflict not only affects the environment, but also the livelihoods of the population, particularly those who depend highly on subsistence farming. Furthermore, protected areas are the foundation of national efforts to conserve biodiversity, maintain functioning ecosystems, and ensure that development is sustainable. Sadly, in protected areas, villagers are seen as encroachers or destroyers of forest resources rather than partners.

To understand why these conflicts occur, a holistic approach should be adapted, whereby the social, economic and environmental dimensions are integrated. Generally, for most farmers practicing subsistence farming, it is mainly about survival, thus they are indirectly 'forced' into these conflicts and environmental issues are then given less attention.

CHAPTER THREE

3 METHODOLOGY

The methodology for this study comprises five (5) main components; namely, collection and analysis of secondary data; field surveys; data processing / analysis; data interpretation; and report writing.

3.1 Collection of Secondary Data

To begin with, the collection of all available and relevant environmental data and information from various sources, including reports (published or unpublished), is vital in knowing the various information gaps. The secondary data obtained, and their sources, are as follows:

(i) Land Use information: Public Works Department (Waterworks Section); Drainage and Irrigation Department (DID)

(ii) Infrastructure: Padawan District Council

(iii) Village Profiles: Padawan District Council; Siburan Health Clinic

(iv) Maps: Topography; Soil; Agriculture Capability

(v) Climate, vegetation and forest types, geology, etc: Past studies, published or unpublished reports obtained from Natural Resources and

Environment Board (NREB) Sarawak; and various environmental consultants.

3.2 Field Surveys

Due to the general shortage of information from secondary sources, a considerable amount of time and effort was allocated for field surveys. Besides shortage of information, field surveys are also important to update and confirm secondary data in the field. Generally, the main reasons for conducting field surveys are:

(a) To collect the required data unavailable from secondary sources; and

(b) To update and to confirm secondary data in the field.

For the purpose of this case study, the field surveys (or commonly known as baseline data study) mainly concentrated on the following environmental components:

(a) Existing Land Use

(b) Physical Environment

- *Water Quality*

(c) Human Environment

- *Settlements and Population*
- *Economic Activities*

(d) Existing Infrastructure

- *Water Supply*

3.2.1 Mapping of Existing Land Use

To determine the extent of the existing land use in the study area, a land use map is vital, among others, to outline the types of development and their potential impacts towards the watershed area. Locations of various land uses were taken using Global Positioning Systems (GPS) receivers. Aerial photographs were also used to assess the existing land use patterns.

3.2.2 Water Sampling

Water sampling was conducted to assess and establish a "baseline" data of the water quality of Sungai Tapah. As Sungai Tapah is the intake point for the Tapah Water Treatment Plant, this baseline data is used to identify the types of pollutants discharged into the river and their possible sources.

The selection of water quality parameters may differ from one river to another depending on the land use pattern and the biogeochemical characteristics of the river (Lau Seng and Murtedza, 2000). Ideally, it would be good to have as many parameters to be analyzed as possible, because these records will be used as reference data for future trends determination. However, the number of parameters analyzed is determined by the availability of resources that include personnel, financial allocation, analytical facilities and the time frame given for this case study.

Four water-sampling points (WS1 – WS4) were selected based on their locations and its suitability in representing the water catchment to the best accuracy (Figure 4.4). All four points were sampled twice, with a period of two weeks between each sampling.

3.2.2.1 Water Quality Parameters

The parameters of interest for this case study are; pH, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), ammoniacal nitrogen, faecal coliform count (FCC), and total coliform count (TCC).

pH - a logarithmic scale that assigns values from 0 to 14 according to levels of acidity or alkalinity in soils or water. A value of 7 is neutral; values less than 7 are acidic and greater than 7 are basic or alkaline. An increase or decrease in pH outside the normal range of a water body (pH 6.5 to pH 8.5) will cause sequential loss of the species depending on their sensitivity. Measurements of pH tell us a lot about the natural condition of a water body as well as indicating whether pollution impacts are occurring.

Turbidity - determined by light transmission through the water and measured by Nephlometric Turbidity Unit (NTU). The cloudy or muddy appearance is mainly indicative of the amount of suspended solids such as clay, silt, finely divided organic material, plankton, etc. in the water and, to a lesser extent, the color of water. Turbidity increases, as the water gets murkier.

DO - the amount of oxygen dissolved in water; expressed either in mg/l or as percentage saturation of the water with O_2 (% sat). DO is needed by wide range of organisms that live in water. For the conservation of the water body, water supply and for fishery the critical value is 5.0 - 7.0 ppm. When the DO drops below 5 mg/l a majority of game fish would have been driven out. If DO is completely removed, all higher animals would be killed and the water becomes blackish as well as foul smelling as the sewage and dead animal life decompose under anaerobic conditions. Low DO conditions are normally attributed to the presence of high oxygen demanding dissolved organics or due to poor water re-aeration because of restricted water exchange. Hence, DO value in a river is an indicator of the general health of the river.

BOD - the amount of oxygen required to break down organic matter. BOD is used to estimate organic loads in water samples; a high BOD value would indicate that the water is of poor quality. BOD_5 is a measure of the amount of oxygen used by bacteria to degrade organic matter in a sample of wastewater over a 5-day period at 25°C, expressed in mg/l. Acceptable values range from 1 mg/l to 3 mg/l.

COD analysis is a quick chemical test to measure the oxygen equivalent of the organic matter content of wastewater (used as a measurement of the amount of organic matter in water) that is susceptible to oxidation by a strong chemical. Normal COD values range from 10 mg/l to 25 mg/l.

TSS - the total amount of tiny particles (normally tiny particles of eroded soil or small organic matters) held in water. TSS is measured in mg/l by filtering the water and weighing the dried residue. Its measurements are normally used to indicate erosion. Suspended solids can be removed by physical methods such as sedimentation, filtration, and centrifugation. Colloidal particles which do not settle readily cause the turbidity found in many surface water and can be removed by more filtration through membranes and high-force centrifugation. The normal values for SS are 25 to 50 mg/l. A higher value would cause sedimentation and this eventually could endanger aquatic habitats and aquatic organisms.

Ammoniacal Nitrogen - the ammonia dissolved in water, usually indicates fresh pollution of unsanitary nature, such as sewage effluent. This nitrogen (NH3-N) is present in plant nutrients and fertilizers. It is also used for agriculture to promote healthy plant growth. It is also one of the chemicals that can induce eutrophication of the aquatic ecosystem. The critical value is 0.1 - 0.3 mg/l.

Coliform bacteria are non-pathogenic bacteria found in the intestines of warm-blood animals; whose numbers indicate faecal contamination.

3.2.2.2 Sample Collection Methods

The methods for sample collection and preservation are carried out by strictly following the standard preservation and analytical procedures adopted from Standard Methods (APHA 1995). They are as follows:

pH, TSS, TDS and Turbidity: One 3-liter sample in a plastic container, stored in ice, will be sufficient for determination of these parameters.

Ammoniacal Nitrogen and COD: One 2-liter sample in a plastic container. Samples are then acidified by adding 3 ml of sulfuric acid (1+1).

DO (for laboratory determination): One 250 ml narrow neck bottle. To fix the oxygen content, sample is added with 2 ml of manganous sulphate solution, 3 ml alkaliodide solution and 2 ml of concentrated sulfuric acid. The bottle is closed with a stopper to ensure there is no trapped air, and inverted several times to ensure proper mixture.

FCC and TCC: Samples are collected in specially sterilized bottles meant for such samples, then stored in ice.

3.2.3 Informal Interviews

Informal interviews and conversations were conducted to gain information on key issues from various key informants in the study area. Among the information gathered from the conversations were regarding land use activities and the villagers perceptions on water quality of Sungai Tapah.

3.3 Data Processing and Analysis

All primary and secondary data were processed and analyzed for the following purposes:

(a) To identify existing land use activities in the study area; and

(b) To describe the water and socio-economic environment of the area.

3.3.1 Analysis of Primary and Secondary Data

Raw data from field surveys, observations, informal interviews, and secondary data collection were analyzed using various methods, depending on the types of analysis to be done.

GPS coordinates taken during the field surveys were used to develop a land use map of the study area. This will enable us to view in detail the various conflicting land uses within the Sungai Tapah watershed area.

3.3.2 Laboratory Analysis

All water samples were sent to a private accredited laboratory in Kuching for analysis. As mentioned earlier, the parameters of interest include: pH, turbidity, DO, BOD, COD, TSS, TDS, ammoniacal nitrogen, FCC, and TCC.

3.4 Data Interpretation

The water quality data was correlated with the Interim National Water Quality Standard for Malaysia (INWQSM) (Appendix A) by the Department of Environment (DOE) to assess the extent of water pollution (if any) as a result of various land use activities in the study area.

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Environmental Profile

This section will provide an overview of the study area and highlight any environmental issues or problems. The environmental profile consists of several components, as discussed below.

4.1.1 Climate

Climate observations are obtained from the Malaysian Meteorological Service (MMS). The data obtained for this study is taken from the meteorological station located at Kuching International Airport (Latitudes 1°29'N and Longitudes 110°20'E, elevation 21.7 meters above mean sea level).

4.1.1.1 Temperature

The study area climate is equatorial, characterized by warm and humid weather throughout the year. It is also influenced by the

Asian Monsoon System, whereby, the Northeast monsoon lasts from November to March, whereas, the Southwest monsoon lasts from May to September. There is a transitional period between these two seasons. Temperatures range between an annual mean daily maximum of 32.1°C to a mean minimum of 22.6°C. The average relative humidity is 87%, with a mean daily maximum of 99.1% and a minimum of 59.8%.

4.1.1.2 Wind

Wind patterns are greatly influenced by the monsoon system. During the Northeast monsoon season, the prevailing wind is from the northeast. On the other hand, the prevailing winds are from the south and southeast during the Southeast monsoon season. The inter-monsoon periods present a condition whereby wind speeds are light and varied in direction.

The climate of the study area is also influenced to a certain extent by the diurnal wind pattern. The warming of the ground surface generates a local circulation induced by the temperature differential. The sea breeze attains peak strength in the mid-afternoon and then loses its strength when the temperature drops in the evening. The thermal difference that drives the local circulation becomes negligible. The land breeze that sets in during predawn is much weaker with wind speeds not exceeding 5 m/s. During the Northeast monsoon, the sea breeze reinforces the prevailing wind, resulting in strong northerly winds with speeds of up to 8 m/s.

4.1.1.3 Rainfall

Rainfall data was taken from the Kuching International Airport. Latest data from the Department of Statistics Malaysia, Sarawak (2001) shows an annual rainfall of slightly above 3700 mm, however, past records have shown that rainfall can reach up to 5000 mm. It is typical of this region to be drier during the Southeast monsoon period (May to September) when the wind does not carry much moisture from across the mainland. On the other hand, the Northeast monsoon brings prolonged rain, especially during the months of December to February.

4.1.2 Vegetation and Forest Types

The predominant vegetation found in the study area is hill forests and riverine forests. However, a large amount of the area has been cleared for shifting cultivation.

The Hill forest typically consists of mixed Dipterocarp forest. In the study area, the forest types can be subdivided into the following:

- Forest on flat to low undulating terrain with varied species depending on soil type;
- Forest on undulating to low hilly terrain (depending on soil type) in transition to Kerangas forests on more sandy parent materials; and
- Mixed Dipterocarp forest on high, hilly ridges with a mixed species composition in accordance with topography. On sharp ridges, there is a tendency towards replacement by Kerangas forest or dense shrub forest.

On the other hand, riverine (or riparian) forest occurs on riverbanks and frequently in wide, flat valleys filled in by mineral deposits in places covered with very shallow organic deposits. On dry riverbanks, one can differentiate a riverine forest in which belian and engkabang are conspicuous (State Government of Sarawak, unpublished).

4.1.3 Geology

The study area consists of the Padawan Formation, a thick sequence of moderately to steeply dipping marine shale, mudstone, and sandstone, with subordinate beds of conglomerate, limestone, and radiolarite (including a few andesite, dacite, rhyolite and associated tuffs). The age of the Padawan Formation ranges from Late Jurassic to Early Cretaceous (State Government of Sarawak, unpublished).

4.1.4 Soils and Agricultural Capability

Soils and agricultural capability are important elements in defining the natural capacity of the land. The agricultural classes are primarily based on the soil types present in the study area. In addition, topography is also a vital element associated with soil type and agricultural capability.

4.1.4.1 Topography

Generally, the study area is characterized by riverine alluvial plains and hilly terrains. The banks of Sungai Tapah consist of flat to gently undulating upper riverine valleys and levees. On the other hand, the majority of the study area (approximately 60% of the study area) is made of moderately to very strongly / steeply dissected hilly terrains.

4.1.4.2 Soil Types

Based on Sarawak Soil Classification System, the major soil categories are:

- Organic or Peat Soils;
- Alluvial Soils (riverine);
- Gley Soils (riverine);
- Hill soils on less that 26° slopes;
- Hill soils on 26°-33° slopes;
- Hill soils on more than 33° slopes;
- Thionic and saline Gley Soils; and
- Podzols and Arenaceous Soils.

The distributions of soils in the study area are shown below. The mapping units have been simplified to show only the major categories. In addition, these major soil types are somewhat related to the general topography.

The banks of Sungai Tapah consist mainly of Alluvial Soils (Figure 4.1). The main soil mapped here is the Seduau Series. Seduau soils have formed from deposits either derived from mixed sources or mainly from shale. The family is usually found in small floodplain, on levees and on riverbanks in the upper and middle parts of drainage basins. Soil textures comprise more than 15% clay. The profile is characterized by generally deep, homogeneously yellowish brown to yellow colored sandy clay loam to heavy clay soils. Mottling and gleying may occur in the lower subsoil. Small mottles caused by manganese are usually present in the heavy textured soils and stratification is common but not distinct. The soils are generally well to moderately well drained and suitable for many annual and perennial crops. The main limitations are inundation hazards (flooding) especially during the rainy season and potential riverbank erosion.

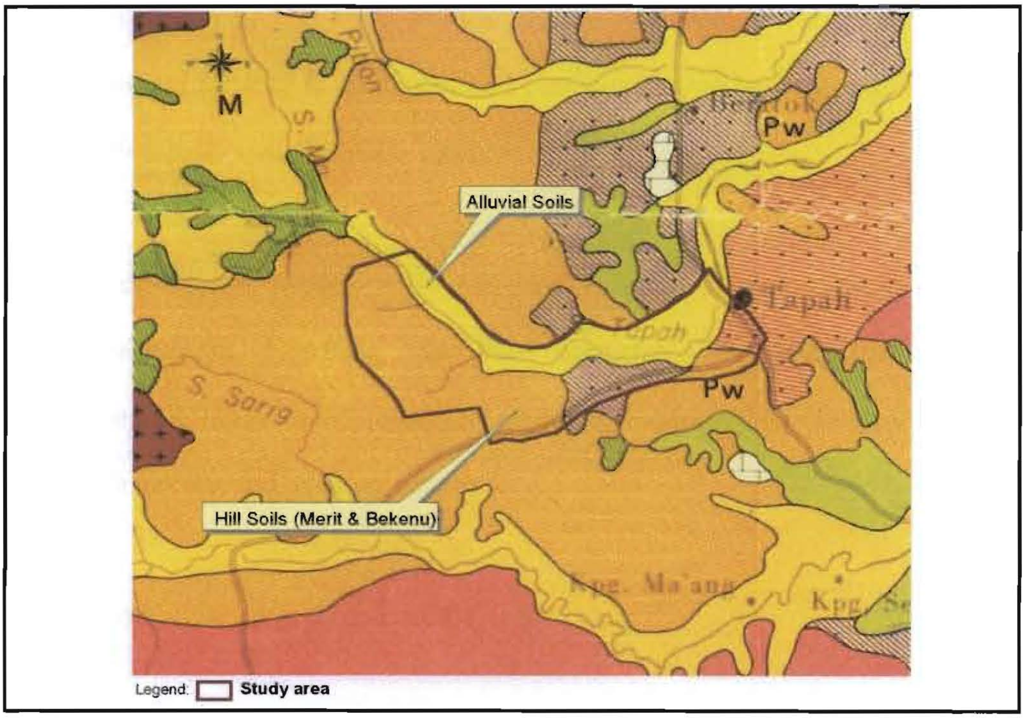


Figure 4.1: Soil Map of Area

On gentler slopes of less than 26°, Merit and Bekenu soils of Red-Yellow Podzolic Soils Group are common in the study area. The Merit Family soils are mapped in the hills and undulating terrain. The soils have formed from argillaceous rocks (shales, phyllites and mudstones) and the textures are clay loam or finer in the A or surface horizon with fine sub-angular blocky structure. However, clay, silty clay or sandy clay textures predominate in the B-horizon. The colour is commonly brownish yellow over reddish yellow at depth, which has firm sub-angular blocky structure. The soils may be mottled or unmottled, imperfectly, moderately or well drained, shallow (50-75 cm) or deep (>75 cm) and with or without iron concretion layers. The chemical fertility is moderate and many crops can be cultivated successfully with fertilizer application.

As mentioned earlier, these soils are suitable for agricultural development. However, the main limitations to agriculture posed by these soils is perhaps minor to moderate erosion, as they are located on steep slopes.

4.1.4.3 Agricultural Capability

Table 4.1 shows that there are five capability classes, (Classes 1 to 5), which have been adopted according to the increasing severity and number of limitations affecting agricultural production. Classes 1 to 3 decline from suitable to moderately limiting in their agricultural capabilities and in their range of crops that can be grown successfully. Class 4 is marginal for agriculture and suited for only a few specifically adapted crops. Major improvements are required before a wider range of crops can be grown. Class 5 is for soils and terrain, which have little or no value for agriculture in their present condition. However, Class 5 lands have potential for forestry projects.

Table 4.1: Capability Classes and their Limitations (Andriesse, 1972).

Class	Number of Limitations			
	Minor	Moderate	Serious	Very Serious
1	0-1	0	0	0
2	2-3	1 or its equivalent	0	0
3	4	2-3 or their equivalent	1 or its equivalent	0
4	0	4	2-3 or their equivalent	0
5	0	0	4	1

In general, there is virtually no Class 1 agricultural land in the study area. With Class 2 land also scarce, most of the agricultural land occurs on Class 3 land, which is considered moderately suitable for agriculture.

The majority of land in the study area has been classified as Class 3 and Class 4 agriculture lands (Figure 4.2). Class 3 lands have two or three moderate limitations restricting the range of crops possible and requiring conservation and some increased fertilizer applications. On the other hand, Class 4 lands have two or three serious limitations affecting the possible range of crops and requiring special conservation practices.

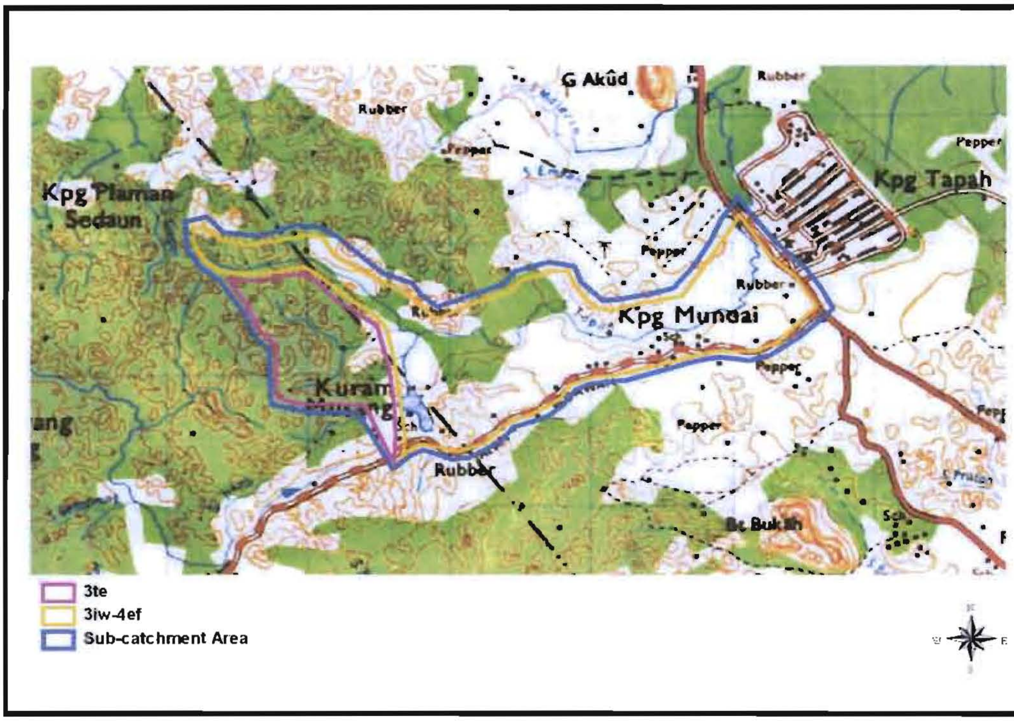


Figure 4.2: Agricultural Capability Map of Area

4.1.4.4 Limitations to Agriculture

Limitations are water-soil-land-terrain related issues affecting the potential of land for agricultural development. These issues will have moderate to very serious environmental implications upon the development of the land. For example, the development of steep lands will cause serious soil erosion, which will result in water pollution and river sedimentation. The main limitations, which have been identified in the study area, are discussed below.

Based on the Agriculture Capability map produced by the Department of Agriculture Sarawak in 1982, the lower reaches of Sungai Tapah have been classified as 3iw-4ef, whereas, the upper reaches consists of 3te and 4te agriculture lands.

The lower reaches of Sungai Tapah are dominated by Class 3 agriculture land. The limitations (recognized at subclass level) to agricultural crops are:

- crop choice is strongly influenced by the probability of flooding;
- high water-table;
- erosion by water increases with steepness and length of slope, removal of ground cover, tillage and a high content of silt and very fine sand in the soil; and
- low nutrient-retaining capacity.

The upper reaches of Sungai Tapah consist of 3te and 4te agricultural lands. The main limitations to agricultural crops in these areas are:

- moderate to steep slopes; and
- moderate to severe soil erosion hazards.

4.1.5 Existing Land Use

As in all rural areas of Sarawak, the dominance of smallholder agriculture in the study area is very prominent. The widespread shifting cultivation of hill paddy (Plate 6) is clearly shown on the land-use map (Figure 4.3). Other major smallholder crops include rubber, wet paddy, pepper, local fruits (Plate 7) and some annuals. This land use pattern follows on the one hand, the quality of soils, and on the other hand, transport networks and proximity to Kuching (State Government of Sarawak, unpublished).

However, according to Andriesse (1972), land use along the Kuching-Serian trunk road is more influenced by economic factors such as ease of communication and transport rather than the productivity of soil.

4.1.5.1 Shifting Cultivation of Hill Paddy and Associated Crops

Through generations of shifting cultivation, the landscape under this traditional form of farming has become a patchwork of hill paddy farms and secondary vegetation under various stages of re-growth. This land utilization type covers a major part of the study area. The actual area cultivated annually is however quite small because a large proportion of the land would be under bush fallow. In the study area, most of the hill paddy farms have a bush fallow period of 5-14 years. In other words, the cropping intensity is about 10%, which is extremely low compared to any form of agriculture. The farm size estimate ranges from 0.2 to 4.0 ha, averaging about 1.4 ha.

The shifting cultivation of hill paddy is characterized by slash and burn; the planting of local traditional varieties; some application of fertilizers which are sold by Department of Agriculture (DOA) at subsidized prices; and increasing usage of weedicide. The yield varies tremendously according to the cropping history; the effectiveness of the burn; incidence and severity of weed infestation, pests and diseases; and general crop husbandry. In the study area, the average hill paddy yield is uncertain. However, most people do not have surplus paddy for sale, and in fact, many households have to purchase at least part of their rice requirements. The traditional practice of hill paddy cultivation involves the planting of secondary crops that may be inter-cropped or planted in relay. The most important ones are local vegetables, maize and tapioca.

4.1.5.2 Wet Paddy

The planting of wet paddy in the study area is very insignificant in comparison with hill paddy. This is mainly due to the unavailability of suitable wet paddy land. Wet paddy is mainly cultivated in the valleys and on the wider floodplains along the lower stretches of Sungai Tapah. The average area planted each year is about 0.5 ha per family. The paddy produced is mainly for the farmers' own consumption. The only area nearby where rice is cultivated as a commercial crop is Sekudut-Chupat near Siburan, which is situated outside the study area.

Due to the lack of extensive alluvial plain, large scale planting of wet paddy is not feasible in the study area. The focus is therefore on identifying pockets of suitable swampy land to produce wet paddy instead of hill paddy.

4.1.5.3 Rubber

Rubber is generally planted on a wide range of soil types, from flat riverine alluvial plains to Red-Yellow Podzolic soils on rolling country to skeletal soils on steep hill slopes. Rubber trees are clearly noticeable in the study area. A large proportion of these holdings comprise old trees planted in the 50s and the 60s through the assistance by the DOA. Some of the gardens had been replanted with pepper, fruit trees, or other crops. Currently, very little are being tapped. The existing gardens are mostly under secondary growth with very little or no maintenance.

The average dry latex (rubber sheet) yield of ordinary and clonal rubber in the study area is about 0.9 and 1.8 kg/tree respectively. With an average plant density of 400 trees/ha (recommended 510 seedlings/ha to be thinned to 400), the average yields are 360 and 720 kg/ha respectively. These are higher than the DOA's 1988 statistics of 141 kg/ha, but still very low compared to the Peninsular figures which regard anything below 1,000 kg/ha as being unacceptable even from smallholders (DOA Sarawak, 2000).

With renewed interest in rubber, both for the latex and timber, there is therefore a potential for new planting and/or replanting. Within the study area, rubber is a potential crop as it is adaptable to the soil and terrain conditions here. In addition, the added value of the rubber tree as timber apart from the latex renders the crop even more attractive.

4.1.5.4 Pepper

Pepper has all the while been an important cash crop for most of the farmers in the study area. With the recent surge in the price of pepper, farmers have been spurred to take up planting. Due to the high value of pepper, especially the premier grade termed Natural Clean Black (NCB) and Creamy White (CW), the income derived from growing pepper adopting the low cost package could be very remunerative. The requirement of clean stream water for processing could easily be fulfilled from the nearby river, Sungai Tapah. This crop definitely has a potential for cultivation within the study area, but being very labor-intensive, the total planted area will not take up much of the good agricultural land. However, the exact number of hectares planted with pepper is unsure.

4.1.5.5 Fruits, Vegetables and Annual Crops

Other crops that may not be shown in the land-use map include tapioca, maize, vegetables and local fruits such as durian, langsat, rambutan and cempedak.

For the population in Kampung Mundai, most of these crops are grown for home consumption, with no plans to venture into larger and more intensive planting. The shifting cultivators usually plant maize and tapioca in association with hill paddy. Some of the maize and tapioca are consumed, but a large proportion of these are for animal feed (chicken and pigs). Very few people in the village plant vegetables because of the abundant availability of wild vegetables such as *paku, daun sabong, midin,* etc. These wild vegetables are usually harvested by the people themselves, but very little are being marketed.

Fruit cultivation is a traditional undertaking in the study area, mainly as a form of backyard crop or as a form of landmark to delineate ownership boundary. The main fruits cultivated include durian, rambutan, local mangoes, mangosteen, langsat, and a host of other tree fruits. Some enterprising farmers also plant papaya, banana, guava, star fruit and citrus on a commercial scale mainly to cater for the local fruit markets.

Vegetable cultivation is very popular around the Siburan-Tapah areas, which are the main sources of the local vegetables supplied to Kuching. The vegetable gardens in the study area are located on flat alluvial plains or gentle slopes. The cultivation intensity depends on the labor availability and the size of the holding. The Chinese vegetable farmers, owning less land area, normally practice more intensive cropping. Large varieties of vegetables are cultivated including leafy, tuber and fruit vegetables. Over the years, pesticide residues in vegetables, especially the leafy ones, have become a concern because the farmers tend to use overdosed concentrations and a concoction of very toxic chemicals without observing the directions of use, such as the required pre-harvest intervals. This is partly caused by ignorance on the part of the farmers, and the build-up of pests and their resistance due to prolonged usage of certain chemicals. Due to better awareness among the consumers, there is now a more concerted effort and push for organic farming and the production of pesticide-safe vegetables under the netting system.

4.2 Land Use Conflict Indicators

In general, "indicators" refer to single measurements of factors or biological species, with the assumption being that these measurements are indicative of the biophysical or socioeconomic system.

For example, ecological indicators, such as plants, have long been used as indicators of water and soil conditions, especially as these conditions affect grazing and agricultural potentials.

Environmental indicators have also been suggested as useful tools for monitoring the state of the environment in relation to sustainable development and associated environmental threats (Peavy et al., 1985).

For this case study, land use conflicts are indicated by the deterioration of water quality in the study area.

4.3 Water Quality

4.3.1 Water Quality Standards

The Interim National Water Quality Standard (INWQS) established by the Department of Environment (DOE) is used as a guideline in the assessment of water quality. The standard classified water bodies into five categories based on prevailing quality of the water in relation to its various uses. The Interim Standard is shown in Appendix A.

4.3.2 Water Quality Analysis Results

Water samples were taken from 4 locations (Figure 4.4), whereby 3 samples were taken from various points along Sungai Tapah, whereas one sample of discharge water was taken from the water treatment plant (Plates 8, 9 and 10). For this case study, water sampling was conducted twice, with a period of two weeks between each sampling. A description of the water sampling points are shown in Table 4.2; whereas Appendix B and C shows the original laboratory analysis results. Table 4.3 and Table 4.4 are the analysis results for Sampling 1 and Sampling 2 respectively.

Table 4.2: Description of Water Sampling Points

Points	*Description*	*Time*		*GPS Coordinates*	*Sampling Conditions*	
		03/02	*18/02*		*03/02*	*18/02*
WS1	Upstream of Sungai Tapah. Located in secondary forest area. Stream is fast flowing.	1531	1307	01" 17.369' N 110" 23.528' E	Cloudy weather; heavy rain the previous day; high tide; murky waters.	Fine weather on sampling day and the day before; low tide; relatively clear water.
WS2	Water treatment plant pumping station.	1601	1329	01" 17.469' N 110" 24.231' E		
WS3	Discharge water from the treatment plant. The discharge water is returned into Sungai Tapah via discharge drain.	1612	1335	01" 17.395' N 110" 24.295' E		
WS4	Sample taken at Sungai Tapah bridge, along Kuching-Serian trunk road.	1650	1352	01" 17.962' N 110" 24.363' E		

Table 4.3: Water analysis results 1

Parameters	**Sample Marking**			
	WS1	**WS2**	**WS3**	**WS4**
pH Value	6.0 @ 19.0°C	6.3 @ 19.5°C	6.2 @ 19.5°C	6.6 @ 19.5°C
Dissolved Oxygen (DO), ppm	4.95	5.26	4.90	5.19
BOD_5 @ 20°C, mg/l	<2.0	<2.0	<2.0	<2.0
COD, mg/l	31.3	25.9	22.2	36.9
Suspended Solids, mg/l	61	74	772	87
Total Dissolved Solids, mg/l	18.8	16.9	37.9	18.2
Turbidity, NTU	38	49	540	51
Ammonical Nitrogen (as NH_3-N), mg/l	ND (<0.02)	ND (<0.02)	0.30	ND (<0.02)
Total Coliform Count, MPN/100ml	≥1600	1600	≥1600	≥1600
Total Faecal Coliform, MPN/100ml	26	500	1600	≥1600

Note: Conditions - Cloudy; heavy rain the previous day; high tide; murky waters.

Table 4.4: Water analysis results 2

Parameters	Sample Marking			
	WS1	WS2	WS3	WS4
pH Value	6.9 @ 18.0°C	6.8 @ 19.0°C	6.6 @ 19.0°C	6.9 @ 18.5°C
Dissolved Oxygen (DO), ppm	4.53	4.49	4.71	4.75
BOD_5 @ 20°C, mg/l	<2.0	<2.0	2.6	<2.0
COD, mg/l	26.7	32.6	41.9	17.4
Suspended Solids, mg/l	11	15	876	39
Total Dissolved Solids, mg/l	18.7	15.5	35.0	21.3
Turbidity, NTU	10	6	447	25
Ammonical Nitrogen (as NH_3-N), mg/l	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)
Total Coliform Count, MPN/100ml	240	240	80	≥1600
Total Faecal Coliform, MPN/100ml	240	240	80	≥1600

Note: Conditions - fine weather on sampling day and the day before; low tide; relatively clear water.

It is noted that Sampling 1 was conducted during high tide and prior to sampling there was heavy rain. On the other hand, Sampling 2 was conducted during low tide and two days prior to sampling there was no rain. In addition, Sampling 2 was conducted two weeks after the first sampling was taken.

In general, a comparison between the analysis results of Sampling 1 and 2 indicates that there is a significant increase in the levels of suspended solids for WS1, WS2 and WS4 after rainfall. This is evidence of the presence of soil particles in run-off waters due to inadequate ground cover. Increasing levels of suspended solids will also cause higher turbidity, as light penetration through water is decreased. The wastewaters from Kampung Mundai may also contain a variety of turbidity-producing materials such as soaps and detergents that results in turbidity. Although turbidity measurements are not commonly run on wastewaters, discharges of wastewaters may increase the turbidity of natural bodies of water. Interestingly, the levels of suspended solids increase as water flows downstream, indicating that sediments are deposited downstream. It is noted that sample WS3 was taken from the wastewaters from the treatment plant, thus high levels of suspended solids and turbidity is expected.

The total coliform count for Sampling 1 is much higher than that of Sampling 2, which indicates the presence of faecal contamination in the run-off waters after rainfall. This contamination may be a result of animal waste washed down into the Sungai Tapah or from latrines located near the river. This matter is of concern because of its connection with open toilets in the nearby village. Furthermore, intake points for public water supply should not contain high levels of TCC and FCC.

4.4 Tapah Water Treatment Plant

Located near Kampung Mundai, along Jalan Padawan (Lat 01° 17.395' N, Long 110° 24.295' E), the Tapah Water Treatment Plant supplies treated water supply to an estimated 14,100 people in Tapah, Beratok and Siburan. This water treatment plant is under the jurisdiction of the Public Works Department (JKR), which is responsible in planning, implementing and maintaining the water supply system.

4.4.1 Design Capacity

The plant has a design capacity of 2.2 million gallons per day (MGD) or 10 million litres daily (Mld). At present, the plant produces treated water at a rate of 4.28 Mld and there is room on-site to add a further 10 Mld treatment capacity.

Raw water is abstracted from Sungai Tapah and Sungai Serin via water supply system that consists of two raw water intakes and pumping system (Plates 11, 12 and 13). In addition to that, there are two storage reservoirs at Bukit Bukah/Bukit Iring and distribution pipelines (water is distributed from the two reservoirs when the treated water pumps are not under operation).

4.4.2 Plant Operations / Processes

Raw water from the river undergoes various processes or stages before it is distributed to the end-users. In-house water analysis is also conducted for several parameters (Plate 14). The main purpose is to ensure that the water supply quality meets the minimum requirements of the recommended drinking water quality standards (Table 4.5).

Table 4.5: Recommended Drinking Water Quality Standards

Parameter	*NDWQSP Standard*	*JKR Treated Water Quality*
Turbidity	5.0	5.0
Color	15.0	5.0
pH	6.5 – 8.5	7 – 7.5
Free Residual Chlorine	0.2	0.2 – 0.4
Combined Residual Chlorine	1.0	1.5
Total Dissolved Solids	1000	500
Chloride	250	200
Ammonia	0.5	0.05
Nitrate	50	45
Iron	0.3	0.3
Fluoride	0.5 – 0.9	1.0
Hardness	500	500
Aluminum	0.1	0.15
Manganese	0.2	0.05
Mercury	0.001	0
Cadmium	0.003	0.003
Selenium	0.01	0.01
Arsenic	0.05	0.05
Cyanide	0.01	0.01
Lead	0.05	0.05
Chromium	0.05	0.02
Silver	0.05	0.05
Copper	1.0	1.0
Magnesium	1.5	1.5
Zinc	5.0	5.0
Sodium	200	200
Sulphate	400	250
Phenol	0.002	0.001
Chloroform	0.2	0.2

Figure 4.5 is a simplified diagram showing the various stages involved in the water treatment process.

4.4.3 Issues of Concern

Sample WS3 indicates high SS levels. This sample was taken from the discharge outlet of the water treatment plant, thus, the high levels of SS was expected, as sediments collected from raw water taken from Sungai Tapah and Sungai Serin accumulate here. However, the discharge water is directly returned to Sungai Tapah via discharge drain. This contributes to river sedimentation downstream of the treatment plant.

With regards to the supply of treated water, respondents agree that the current water supply is sufficient, however, with the present rate of development within the Tapah area, they are worried it may not be sufficient if the Authorities do not increase the production rate in the near future.

4.5 Impacts from Land Use Conflicts

The forest resource base in the study area is slowly depleting as a result of watershed mismanagement, notably due to the presence of non-sustainable farming systems. Shifting cultivation and small-scale farming within the catchment area has been identified as the main cause of environmental problems such as pollution of river water, loss of topsoil as a result of heavy downpours, and so forth. Traditional shifting cultivation systems are being disrupted, modified, and replaced as population pressures rise and as farmers unfamiliar with indigenous land use practices attempt to farm newly cleared land. Typically, this results in shortened fallow periods, fertility decline, weed infestation, disruption of forest regeneration, and excessive soil erosion. In addition, the existence of settlements within the catchment area also contributes to the pollution of river water.

4.5.1 Habitat Loss and Biodiversity Change

The floral resources in the study area support a diverse species of mammals, resident birds, invertebrates, insects, reptiles, and aquatic life. Based on informal conversations with the locals, forest clearing for shifting cultivation has caused some habitat loss and biodiversity change. In addition, habitat loss and biodiversity change could reduce soil fertility and productivity, resulting in the disappearance of certain floral and faunal genetic resources, reduce population density of ecologically useful fauna while at the same time increase the number of species considered as pests and disease-vectors, and influence the disease-vectors to move to populated areas or human settlements.

4.5.2 Damage to Aquatic Habitats

Very often the damage is due to soil erosion and re-channeling of waterways. This may serve as barriers to movement of some species especially during spawning.

4.5.3 Soil Erosion

The most serious impact detected during this case study is soil erosion. As a matter of fact, natural erosion always occurs due to the force of nature. However, farming activities in the area has accelerated the process, and so natural erosion becomes accelerated erosion. Thus, exposed land is easily eroded due to rainfall and surface run-off.

Soil erosion also results in the loss of topsoil, whereby fertile topsoil that is rich in nutrients and humus is removed. The remaining subsoil is often more compacted and less fertile, making it difficult for vegetation to grow.

Riverbank erosion is also a result of land use conflicts. Erosion of riverbanks is only a localized problem and would be caused by surface run-off over the edge of the bank. The potential damage is greater when vegetation is cleared right to the edge of the bank. The land lost by bank erosion is completely and irretrievably lost. The eroded soil becomes a source of sediment, which pollutes the streams because all the soil goes into the water with no possibility of any of it being trapped.

4.5.4 Impacts on Surface Water

Surface water refers to the rivers and streams. As mentioned earlier, surface water is govern by the hydrologic cycle. The removal of cover crops and vegetation has the potential to affect this cycle adversely. From the field observations and water analysis results, the following impacts have been determined.

4.5.4.1 Surface Runoff

Runoff is water that travels over the ground surface to the stream. It occurs only when rainfall rate exceeds infiltration capacity of the soil. Several studies have shown that under primary forest cover about 21%-36 % of the rainfall is intercepted by the canopy layers and recycled back to the atmosphere through evaporation (Soepadmo, 1979). The balance of 64%-79% of the rainfall reaches the forest floor. Depending on slopes, soils, etc, about 28%-51 % of the total rainfall may pass through the forest as run-off. Surface runoff could cause accelerated erosion of the surface soil, contribute to flash flooding, cause water pollution due to the eroded soils and nutrients it carries, and contribute to the sedimentation of waterways.

Estimates of surface runoff can be gauged using field trial plots, such as those carried out at the Agricultural Research Centre in Semongok, Kuching. Results from the trials are shown in Table 4.6.

Table 4.6: Surface Runoff Estimations (Sarawak Land Consolidation and Rehabilitation Authority, 2003).

Forest Type	Surface Runoff (m^3/ha/yr)	Percentage of total rainfall
Secondary forests	1240	3.1%
Primary forests	1360	3.4%
Bare surface	5400	13.5%

Note: Annual rainfall is 4000 mm/yr, 20°-slope angle.

The main implication from these trials would be that runoff could be substantial during the land-clearing phase of shifting cultivation until adequate vegetation cover is established.

Studies have shown that for adequate protection against erosion, at least 70% of the ground surface must be covered (Morgan, 1980).

4.5.4.2 Water Pollution

The pollution of surface water in the streams is most probably caused by eroded soils and wastes from the nearby settlements. Pollution due to fertilizer usage is insignificant in the upper reaches of the watershed; however, it is an issue of concern towards the lower reaches where areas of vegetable farms are vast.

In general, water pollution reduces water quality; cause eutrophication due to phosphorus; hazardous to aquatic life; reduces aesthetic value of waterways; becomes a health hazard to humans, and would increase the cost to purify the water for human consumption. Laboratory results of the water analysis were compared with the INQWS, thus, any parameter that exceeds the standard value is considered as significant water pollution impact. For this case study, it has been noted that significant parameters are turbidity and suspended solids.

High SS and turbidity levels were detected in the water samples taken from the discharge outlet of the water treatment plant (WS3). Sediments accumulated during the water treatment process are directly discharged back into Sungai Tapah via discharge drains.

Due to TSS composition, high TSS concentration may threaten the public health and cause environmental problems. Suspended particles can clog fish gills and may reduce fish growth and reproduction. In addition, high TSS concentration blocks the light and prevents aquatic plants from performing photosynthesis. Reduced rate of photosynthesis causes less dissolved oxygen (DO) and may lead to plant death. The biochemical demand on the available DO will increase as a result of the decomposition of dead plants. By these processes, excessive suspended solids may virtually eliminate the aquatic life in streams and rivers. Suspended particles may also facilitate the transport of harmful bacteria and chemical pollutants, which attach to mobile sediments and are released downstream. This directly contributes to river sedimentation, particularly downstream of Sungai Tapah.

4.5.4.3 River Sedimentation

Based on the water analysis results, it is evident that eroded soils have reached the natural waterways. The particles move in stream as suspended sediment in flowing water, and as bed load that rolls along the channel bottom. Those particles of grain size and larger, or bed-material load could be re-deposited along the riverbed. The rate at which the capacity of the river is reduced by sedimentation depends on the quantity of sediment inflow, the percentage of this inflow trapped in the river, and the density of the re-deposited sediment. However, the percentage of the particles actually trapped is difficult to estimate. In a still water situation Stokes' Law may apply but not under the actual river conditions. This is because the flow in a river is always turbulent, and under such situation the gravitational settling of particles is counteracted by upward movement in turbulent eddies. Nevertheless, from experience, it is recognized that uncontrolled accelerated soil erosion could lead to significant river sedimentation. In addition, one could also say that the amount of measured sediment (e.g. TSS) would give some indication on the severity of potential riverbed sedimentation. A river with constantly high values of turbidity and TSS could be expected to suffer more sedimentation than a river with much lesser values.

4.6 Possible Factors Causing Encroachments by Farmers

There are several factors that cause encroachments by smallholding farming into water catchment areas, of which, socio-economic factors may be the main reason, with regards to this case study. These encroachments cause land use changes in the study area.

Grainger (1990) argued that land use changes could be attributed to three sets of underlying causes: socioeconomic factors, physical environment factors, and government policies. It is assumed that national land use morphology (the relative proportions of different land uses, each with different biomass, productivity, and sustainability characteristics) changes over time in response to these underlying causes.

4.6.1 Socioeconomic Factors

Socioeconomic factors, such as population growth and economic development, are the key driving forces causing pressures for village communities to utilize whatever available land, including lands that are within water catchment boundaries and marginal lands.

In some cases, large-scale agricultural activities have occupied most of the available land, thus small-scale farmers who wish to continue farming have no other option but to move toward primary forests and marginal lands.

4.6.2 Physical Environmental Factors

Physical environmental factors affect land use because land clearing is a spatial phenomenon, with land use changes occurring because of the diffusion of people, economic activity, and new techniques into forested areas from existing settlements. The diffusion process is channeled by physical factors such as ease of access by rivers and roads, topography and soil type. Some of these factors promote the expansion of agriculture; others constrain it (Grainger, 1990). The secondary road (Jalan Padawan) connecting the Kuching-Serian road to Padawan town has had major influences in the establishment of smallholding farms in the catchment area, as it is directly located alongside the area. Farmers can easily commute to Tapah bazaar or Siburan to sell their produce or purchase items for farming.

4.6.3 Government Policies

The encroachment by farmers is also influenced by Government policies. As the State intensifies its efforts to develop vast areas of rural land through joint-venture land development programs, land becomes scarce, thus conflicting demands for land becomes more prevalent. This scenario is evident in lands that have been designated as water catchment areas.

A good example of Government policies that fails to prevent encroachments by agricultural activities is the Natural Resources and Environment (Prescribed Activities) Order, 1994. The Environmental Impact Assessment (EIA) provisions are selective with respect to land clearing. Land clearing in excess of 500 hectares (for areas which have previously been logged) is listed as a prescribed activity under the Natural Resources and Environment (Prescribed Activities) Order, 1994 (Natural Resources and Environment Board, 1995). According to Memon and Murtedza (1999), the practice of shifting cultivation is long standing in Sarawak and is not subject to any regulation as such. Thus, technically, shifting cultivators in the study area are not against the law, as it is uncommon for shifting cultivators to clear lands in excess of 500 hectares. However, the cumulative impacts of the vast pockets of shifting cultivation areas create environmental issues of concern.

Figure 4.3: Land Use Map

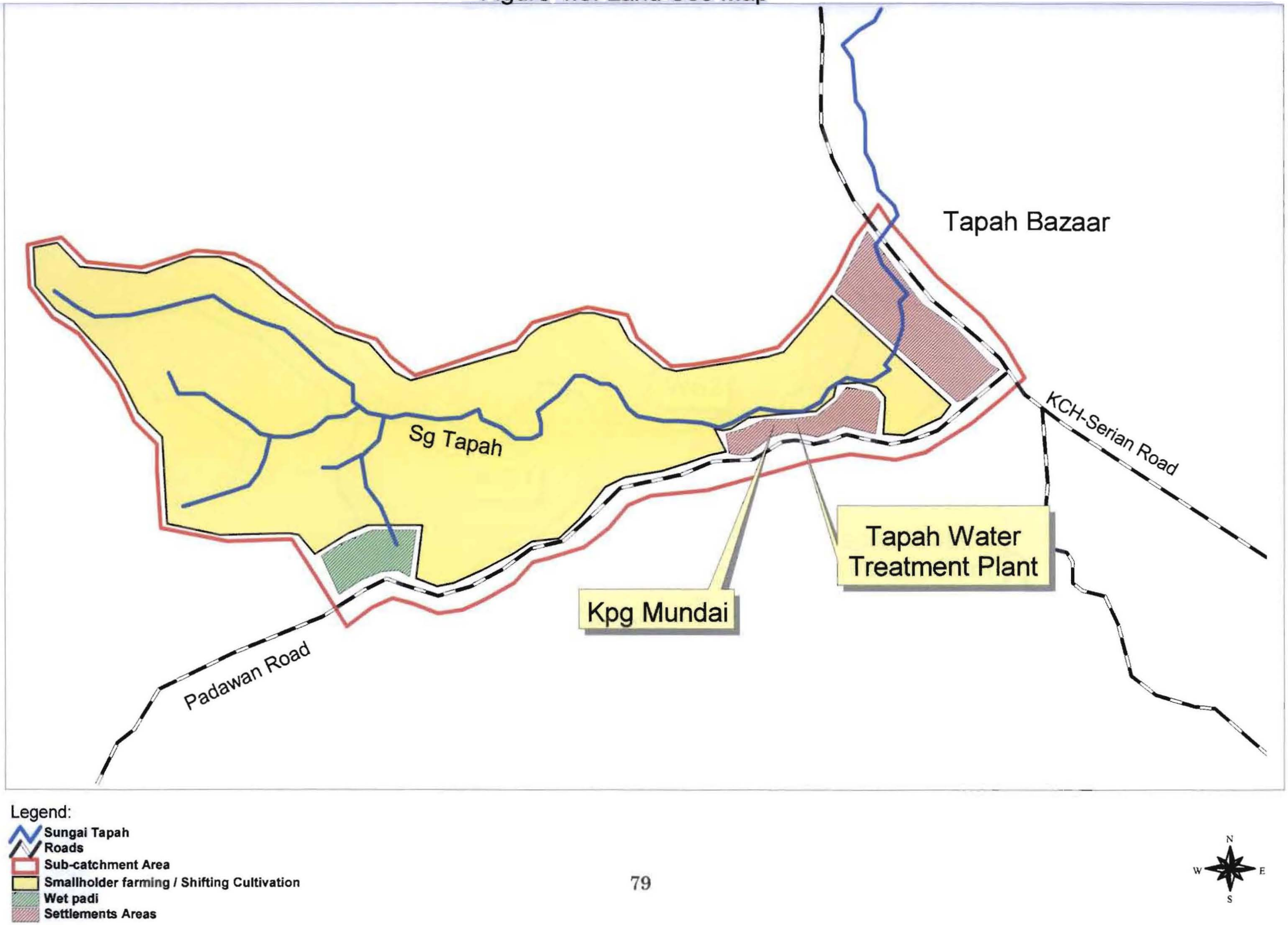
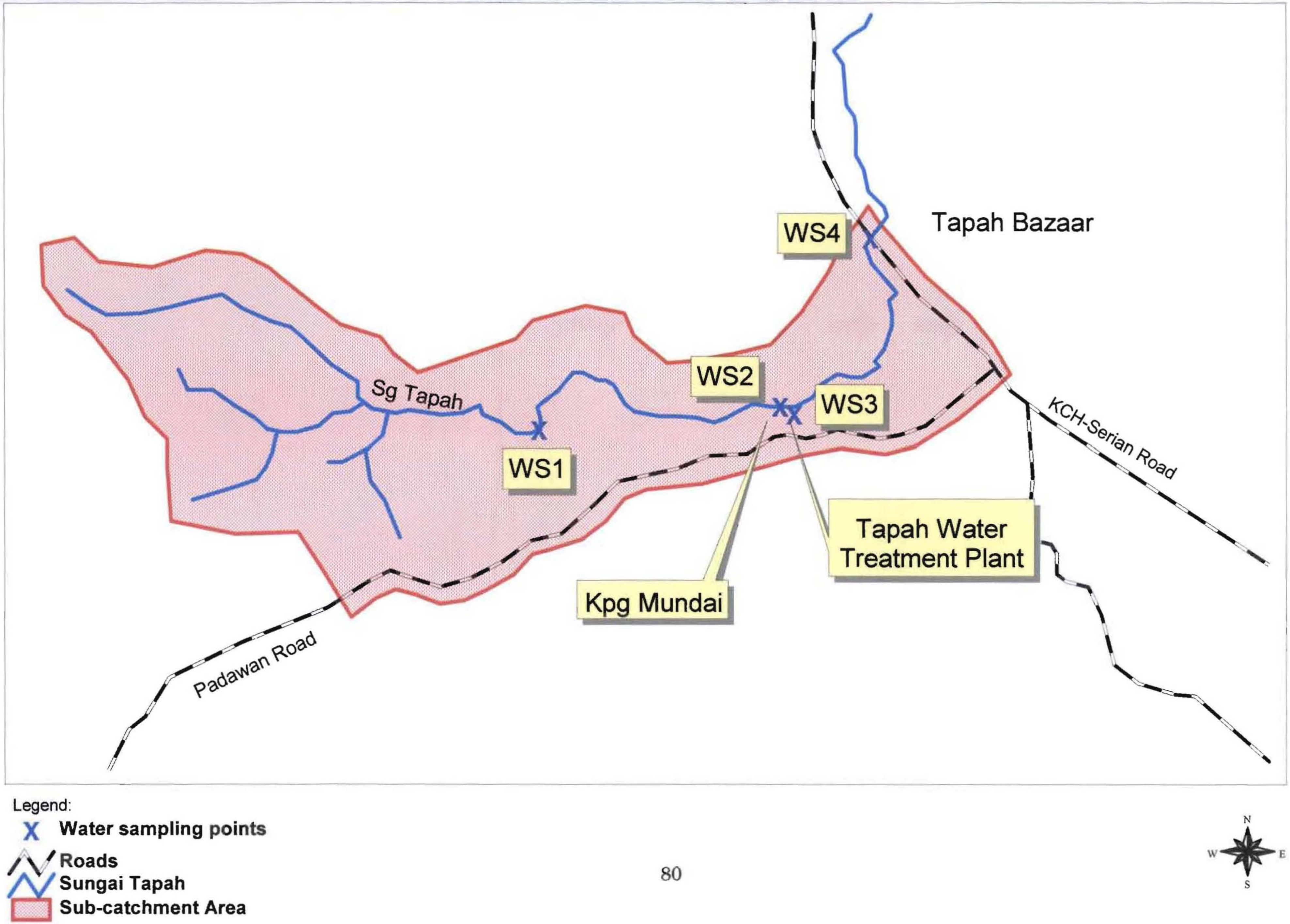


Figure 4.4: Water Sampling Points



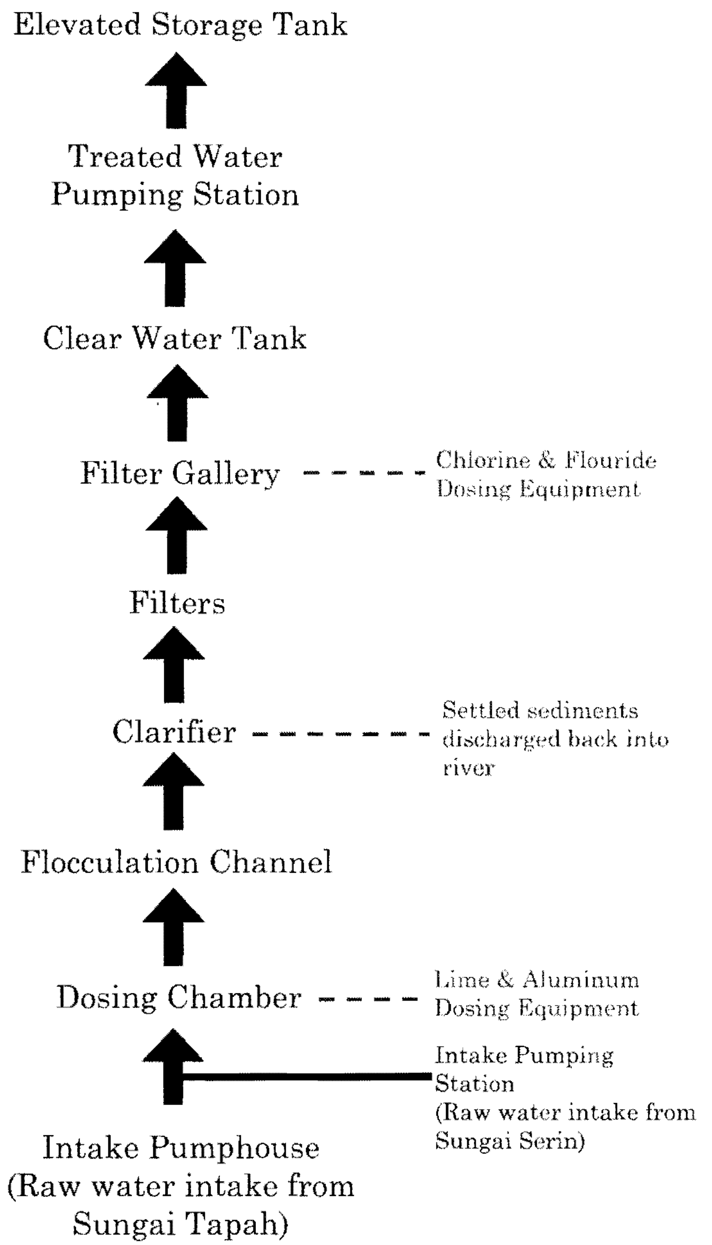


Figure 4.5: Water Treatment Process

CHAPTER FIVE

5 CONCLUSION

5.1 General Conclusions

Land use conflicts within water supply catchment areas are not new issues in the State. At the moment, shifting cultivation and smallholding farming remains a dominant form of land use in Sarawak, and current studies present evidence that the area under this form of cultivation method is increasing at a steady rate. Although no form of agriculture activity is permitted in water supply catchment areas, encroachments by shifting cultivators still occur. This may be attributed to the lack of monitoring and enforcement by relevant authorities; lack of public awareness programs to promote the importance of catchment protection; lack of public participation in the formulation and implementation of development strategies and policies; and weak Government policies. Interestingly, shifting cultivation in the State normally involves clearing of small areas of land, and does not require any Environmental Impact Assessment (EIA) study, as it is not a prescribed activity under the Natural Resources and Environment (Prescribed Activities) Order, 1994. However, the existence of substantial pockets of shifting cultivation can be detrimental towards the environment, as it is found to be a major cause of soil erosion and river sedimentation in the study area. At present, the State has yet to adapt a holistic approach in tackling this problem, meaning, to integrate physical, biological and social aspects in ensuring the protection of water supply catchment areas. To do so, an Integrated Water Resource Management Master Plan is crucial to ensure that social, economic and environmental dimensions are taken into consideration in the development and management of water resources. Furthermore, a master plan of such will enable the formulation of management frameworks and effective strategies in order to ensure that water resource management and development is at par with the forecasted rate of development in the State.

5.2 Water Quality

As mentioned in 1.3.1, the general objective is to identify land use conflicts and its impacts on water quality. The laboratory analysis of water samples taken during this case study will be need as reference point for future environmental monitoring for Sungai Tapah. This baseline data will help to determine the increase or decrease in pollution loads introduce into the water environment. This information is in-turn useful to identify the direction of future control programmes in order to minimize the problems and to strengthen environmental management measures.

The water analysis results show that sediments have reached the waterways in the event of a downpour. This is indicated by the high values of suspended solids with no rain prior to sampling. This problem is due to inadequate ground cover as a result of land clearing for agricultural activities along the hilly parts of the study area.

Interestingly, the wastewater from the water treatment plant is directly discharged back into Sungai Tapah despite having a Class V level of suspended solids. This contributes to river sedimentation at the lower reaches of the river and may endanger certain aquatic species.

Although the overall water quality of Sungai Tapah is still acceptable, there is a need to control the amount of sediments washed into the waterways. This problem should be of priority, as water pumped from Sungai Tapah is the main source of water for the surrounding population.

5.3 Limitations of the Study

The main limitation or constraint during the course of this case study is access to the various government departments. For example, information such as land use maps requires consent from various individuals, thus lengthening the process of acquiring data. In most cases, the required data is not obtained at all. In addition, most government departments have yet to compile a comprehensive report regarding their activities in the study area.

Secondly, questionnaires and interview sessions received lukewarm response from various quarters. Initially, a sample size of 10% was selected, however, most of the villagers refrained from being interviewed due to unclear reasons. Thus, informal conversations were the only feasible way of gaining some insights into land use issues in this village. Even so, respondents' names are not disclosed in this report due to confidentiality and by the request of the respondents themselves.

CHAPTER SIX

6 RECOMMENDATIONS

The major problems highlighted in Chapter 4 can be categorized as the cause and impacts of land use conflicts towards the environment. The recommendations presented here will cover ways to minimize land use conflicts, as well as mitigation measures for the impacts resulting from land use conflicts. In addition, recommendations to improve certain processes in the water treatment plant will also be included.

6.1 Minimizing Land Use Conflicts

6.1.1 Integrated Water Resources Management

The rate at which the State development activities are proceeding requires an integrated approach in dealing with the development and management of water resources. This involves the integration of social, economic and environmental dimensions in the formation of effective strategies and management frameworks.

According to Memon and Murtedza (1999), the fact that the causes of many problems of water quantity and quality and their solutions are frequently related to the management of the terrestrial system has led to the ecosystem approach to water management.

At present, it is quite common for water resources management for various purposes to be controlled by national agencies that are quite separate from those responsible for ecological and habitat management (referring to the management of forests, wetlands, and other habitats that play a role in the water regime of the river basin). Such a fragmented approach naturally leads to conflicting policies, laws and practices.

6.1.2 Public Participation

The local communities should be actively involved, as much as possible, when designing and protecting water supply catchments. The involvement of community consultation for the establishment of National Parks should be taken as an example with regards to this.

Community leaders should be utilized and given responsibilities to ensure the protection of designated water catchment areas in their jurisdiction, as they are more likely able to influence the community as compared to representatives from Government agencies.

6.1.3 Fallow Periods

The local community should be educated on the importance of adequate fallow periods in order to maintain shifting cultivation at a sustainable rate, thus, gaining ecological and social benefits. Along with appropriate fallow periods, fallow plants that accumulate nutrients in their biomass at a faster rate than the natural fallow should be intentionally introduced. According to Sanchez et al. (1990), sustainable shifting cultivation systems are effective buffers against further encroachments into tropical forests.

6.1.4 Reviews of Existing Policies

Policy review under way at local and national levels must be broadened to consider the negative effects that existing policies have had on land use. For example, the major drawback of the current Federal and State EIA procedures is that a number of activities on land and water, which may impact on water fall outside their respective fields. Not all activities that have significant environmental impacts come within purview of the respective lists of prescribed activities for reasons of the limited scale of the projects or the type of project activity being proposed (Memon and Murtedza, 1999). In addition, the policy review should be undertaken by multidisciplinary teams in order to integrate infrastructure, land use and development policies.

6.2 Mitigation Measures for Soil Erosion

6.2.1 Correct Land Use

To effectively control soil erosion the basic policy is to grow crop on land, which is suitable for that crop. The technique, which makes it possible to determine the most suitable use for any area is Land Capability Classification as discussed earlier. Then, the next step is to match that crop requirements with land suitability in order to determine which crop is suitable for that land. Based on this policy, erosion can then be more effectively controlled by the proper timing of field operations, installation of mechanical measures and adoption of biological controls. The whole objective is to reduce soil erosion below the tolerable level of 11.2 t/ha/year.

6.2.2 Control of River Bank Erosion

Erosion of rivers and streams can be controlled in 2 ways; namely, controlling stream-flow and riverbank protection. The principle in controlling stream-flow is to either deflect the water away from vulnerable points or to slow it down and make it less erosive. On the other hand, riverbank protection requires measures such as buffer zones that are maintained uniformly on both sides of the river.

6.3 Other Recommendations

6.3.1 Sedimentation Ponds at Water Treatment Plant

Based on the findings in section 4.4.2, sedimentation ponds are required as part of the water treatment process. At present, sediments are discharged back to the river, thus contributing to river sedimentation downstream of the treatment plant. Therefore, sedimentation ponds will permit only the surface water, which has lower contents of sediments, to flow back into the river. An example of a suitable sedimentation pond is shown in Plate 15.

6.3.2 Water Quality Monitoring

Periodical water quality monitoring should be conducted for the entire sub-catchment area to detect changes in the levels of water pollution. At present, water samples are only taken at the Tapah Water Treatment Plant, thus more sampling points should be included to accurately determine the sources of pollution.

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APPENDIX A

Interim National Water Quality Standards for Malaysia

Parameters	Units	Classes					
		I	**IIA**	**IIB**	**III**	**IV**	**V**
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.
BOD_5	mg/l	1	3	3	6	12	> 12
COD	mg/l	10	25	25	50	100	> 100
DO	mg/l	7	5-7	5-7	3-5	<3	<1
pH		6.5-8.5	6-9	6-9	5-9	5-9	
Colour	TCU	15	150	150			
Electrical Conductivity*	µmhos/cm	1000	1000		6000		
Floatables		N	N	N			
Odour		N	N	N			
Salinity		0.5	1			2	
Taste		N	N	N			
T.D.S.	mg/l	500	1000			4000	
T.S.S.	mg/l	25	50	50	150	300	>300
Temperature	°C	Normal	Normal	Normal	Normal	Normal	Normal
Turbidity	NTU	5	50	50			
F. Coliform **	counts/100ml	10	100	400	5000[1]	5000[1]	
Total Coliform	counts/100ml	100	5000	50000	50000	>50000	

N - No visible floatable materials/debris
or no objectionable odour
or no objectionable taste

* - Related Parameters, only one recommended for use

** - Geometric Mean

1 - Maximum not to be exceeded

Parameters	Units	Classes					
		I	IIA	IIB	III	IV	V
Al	mg/l				(0.06)	0.5	
As	mg/l		0.05	0.4	(0.05)	0.1	
Ba	mg/l		1				
Cd	mg/l		0.01	0.01	0.001	0.01	
Cr(VI)	mg/l	N	0.05	1.4	0.05	0.1	
Cr(III)	mg/l			2.5			
Cu	mg/l	A	1			0.2	
Hardness	mg/l		250				
Ca	mg/l	T					
Mg	mg/l						
Na	mg/l	U				3 SAR	
K	mg/l						
Fe	mg/l	R	0.3	1		1 (leaf) 5(others)	
Pb	mg/l		0.05	0.02	(0.01)	5	
Mn	mg/l	A	0.1	0.1		0.2	
Hg	mg/l		0.001	0.004	(0.0001)	0.002	
Ni	mg/l	L	0.05	0.9		0.2	
Se	mg/l		0.01	0.25	(0.04)	0.02	
Ag	mg/l	L	0.05	0.0002			
Sn	mg/l			0.004			
U	mg/l	E					
Zn	mg/l		5	0.4		2	
B	mg/l	V	1		(3.4)	0.8	
Cl	mg/l		200			80	
Cl_2	mg/l	E			(0.02)		
CN	mg/l		0.02	0.06	(0.02)		
F	mg/l	L	105	10		1	
NO_2	mg/l		0.4	0.4	(0.03)		
NO_3	mg/l	S	7			5	
P	mg/l		0.2	0.1			
Si	mg/l	N	50				
SO_4	mg/l		250				
S	mg/l	A	0.05		(0.001)		
CO_2	mg/l						
Gross - a	Bq/l	T	0.1				
Gross - b	Bq/l		1				
Ra - 226	Bq/l	U	<0.1				
Sr - 90	Bq/l		<1				
CCE	µg/l	R	500				
MBAS / BAS	µg/l		500	5000	(200)		
O & G (mineral)	µg/l	A	40 ; n	N			
O & G (emulsified edible)	µg/l		7000 ; N	N			
PCB	µg/l	L	0.1	6	(0.05)		
Phenol	µg/l		10				
Aldrin / Dieldrin	µg/l	L	0.02	0.2	(0.01)		
BHC	µg/l		2	9	(0.1)		
Chlordane	µg/l	E	0.08	2	(0.02)		
t - DDT	µg/l		0.1	1	(0.01)		
Endosulfane	µg/l	V	10				
Heptachlor / Epoxide	µg/l		0.05	0.9	(0.06)		

Parameters	Units	Classes *					
		I	IIA	IIB	III	IV	V
Lindane	μg/l	E	2	3	(0.4)		
2, 4 -D	μg/l		70	450			
2,4,5 - T	μg/l	L	10	160			
2,4,5 - TP	μg/l		4	850			
Paraquat	μg/l	S	10	1800			

* At hardness 50 mg/l $CaCO_3$
@ Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N Free from visible film, sheen, discoloration and deposits

Class Uses

I Conservation of natural environment
Water supply I - practically no treatment necessary (except by disinfection or boiling only)
Fishery I - very sensitive aquatic species

IIA Water supply II - conventional treatment required
Fishery II - sensitive aquatic species

IIB Recreational use with body contact

III Water supply III - extensive treatment required
Fishery III - common, of economic value, and tolerant species

IV Irrigation

V None of the above

APPENDIX B

Water Analysis Results 1

CHEMLAB

Teknologi Kimia Chemical Technology

CHEMICAL LABORATORY (MALAYSIA) SDN BHD (27822-K)

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ASSAYERS, ANALYTICAL CHEMISTS, MICROBIOLOGISTS AND INDUSTRIAL CONSULTANTS

AKREDITASI SAMM MALAYSIA ISO/IEC 17025 TESTING SAMM NO. 172

CERTIFICATE OF ANALYSIS

Company	:	Jaynsen P. Sibat (Student ID: 02-03-0753) 1st Floor, Lot 993A, BDC Commercial Centre, 93350 Satria Jaya, Kuching.
Lab No.	:	KCH-TSY/WE/4982/04
Sample Description	:	Four (4) Samples of River Water
Sample Marking	:	As Below
Date Sample Received	:	04/02/2004
Date Sample Reported	:	17/02/2004
Page	:	1 of 2

RESULTS OF ANALYSIS

Parameters	Sample Marking			
	WS1	WS2	WS3	WS4
pH Value	6.0 @ 19.0 °C	6.3 @ 19.5 °C	6.2 @ 19.5 °C	6.6 @ 19.5 °C
Dissolved Oxygen (DO), ppm	4.95	5.26	4.90	5.19
BOD_5 @ 20°C, mg/l	<2.0	<2.0	<2.0	<2.0
COD, mg/l	31.3	25.9	22.2	36.9
Suspended Solids, mg/l	61	74	772	87
Total Dissolved Solids, mg/l	18.8	16.9	37.9	18.2
Turbidity, NTU	38	49	540	51
Ammoniacal Nitrogen (as NH_3-N), mg/l	ND (<0.02)	ND (<0.02)	0.30	ND (<0.02)
Total Coliform Count, MPN/100ml	≥1600	1600	≥1600	≥1600
Total Faecal Coliform, MPN/100ml	26	500	1600	>1600

APPENDIX C

Water Analysis Results 2

CHEMLAB

CHEMICAL LABORATORY (MALAYSIA) SDN BHD (27822-K)

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AKREDITASI SAMM MALAYSIA ISO/IEC 17025 TESTING SAMM NO. 172

CERTIFICATE OF ANALYSIS

Company	:	Jaynsen P. Sibat (Student ID: 02-03-0753) 1st Floor, Lot 993A, BDC Commercial Centre, 93350 Satria Jaya, Kuching.
Lab No.	:	KCH-TSY/WE/5035/04
Sample Description	:	Four (4) Samples of River Water
Sample Marking	:	As Below
Date Sample Received	:	20/02/2004
Date Sample Reported	:	08/03/2004
Page	:	1 of 2

RESULTS OF ANALYSIS

Parameters	Sample Marking			
	WS1	WS2	WS3	WS4
pH Value	6.9 @ 18.0 °C	6.8 @ 19.0 °C	6.6 @ 19.0 °C	6.9 @ 18.5 °C
Dissolved Oxygen (DO), ppm	4.53	4.49	4.71	4.75
BOD$_5$ @ 20°C, mg/l	<2.0	<2.0	2.6	<2.0
COD, mg/l	26.7	32.6	41.9	17.4
Suspended Solids, mg/l	11	15	876	39
Total Dissolved Solids, mg/l	18.7	15.5	35.0	21.3
Turbidity, NTU	10	6	447	25
Ammoniacal Nitrogen (as NH_3-N), mg/l	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)
Total Coliform Count, MPN/100ml	240	240	80	≥1600
Total Faecal Coliform, MPN/100ml	240	240	80	≥1600

Plate 1: Sungai Tapah

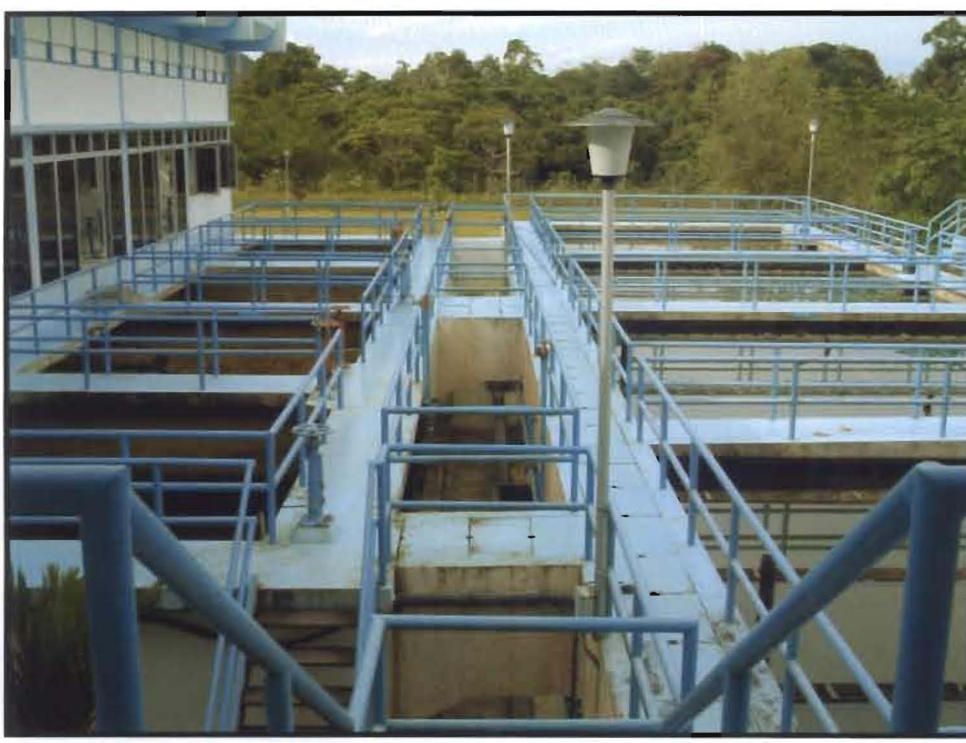

Plate 2: Tapah Water Treatment Plant

Plate 3: Aerial Photo of Area


Plate 4: Jalan Padawan

Plate 5: Kampung Mundai


Plate 6: Hill Padi


Plate 7: Fruit Gardens

Plate 8: Water Sampling at WS2

Plate 9: Water Sampling at WS3

Plate 10: Sampling Point WS4

Plate 11: Water Pumping Station

Plate 12: Intake Pipes

Plate 13: Dam at Water Treatment Plant

Plant 14: Laboratory at Water Treatment Plant

Plate 15: Example of a Sedimentation Pond

(Courtesy of PSS Resources Sdn Bhd)