



***SG. KEJAPIL WATER CATCHMENT AND MIRI-SUAI
PILOT PROJECT (MISPA) OF SARAWAK INTEGRATED
COASTAL ZONE MANAGEMENT (IZCM): A STUDY ON AMMONIA
NITROGEN AND NITRATE NITROGEN CONCENTRATION LEVEL FOR
SG. KEJAPIL RAW WATER***

SAA @ SA ANAK TAWI

FK 1999 53

**SG. KEJAPIL WATER CATCHMENT AND MIRI-SUAI
PILOT PROJECT (MISPA) OF SARAWAK INTEGRATED
COASTAL ZONE MANAGEMENT (IZCM):
A STUDY ON AMMONIA NITROGEN AND NITRATE
NITROGEN CONCENTRATION LEVEL FOR SG.
KEJAPIL RAW WATER**

By

SAA @ SA ANAK TAWI

**Project Paper Submitted in Partial Fulfillment of the requirements for
the Degree of Master of Science (Emergency Response and Planning)
Faculty of Engineering
Universiti Putra Malaysia**

October 1999

ACKNOWLEDGMENTS

I wish to express my deepest and sincere gratitude to my project supervisors Dr. Mohamed Daud and Dr. Nor Mariah Adam, lecturers and staff in Faculty of Engineering, Universiti Putra Malaysia for their guidance, constructive criticism and keen interest in supervising this project.

I am most grateful and wish to record my thanks to all Emergency Response and Planning Master students for their moral support.

I would like to thank all the Integrated Coastal Zone Team of Miri-Suai Pilot Project Area for their contribution in making this project a successful one.

I am very grateful for the kind assistance rendered by En. Kadir Jabar of Sarawak Agriculture Vocational Training Institute (SAVTI), Kebuloh Miri. You have given me a tremendous assistance.

Lastly but not least, I would like to express my special gratitude to my beloved wife Chua Yin Yin and my three years old daughter Faith Chua Anak Saa, parents, family members and friends for their encouragement, and undying support throughout my study period in Universiti Putra Malaysia.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENTS.....	ii
LIST OF TABLES AND FIGURES.....	v
ABSTRACT.....	vi
ABSTRAK.....	viii
 CHAPTER	
I. INTRODUCTION.....	1
1.1 General and Overview.....	1
1.2 Malaysia and Integrated Coastal Zone (ICZM).....	3
1.3 Sarawak Integrated Coastal Zone Management (ICZM)	4
1.4 Miri-Suai Pilot Project Area (MISPA).....	7
1.5 Concepts and Goals of ICZM in Malaysia.....	10
1.6 Problem Statement.....	12
1.7 Scope of Study.....	16
1.8 Objectives of Study.....	17
1.9 Limitations.....	17
1.10 Definitions of Terms.....	18
 2. LITERATURE REVIEW.....	 19
2.1 Society Demands for Quality Water.....	19
2.2 Legal Arrangement for Protection and Conservation of Water Catchments in Sarawak.....	22
2.3 Raw Water Quality and Rivers Classification	25
2.4 Sg. Kejapil Water Catchment.....	29
2.5 Sg. Kejapil Raw Water Standard of Compliance.....	31
2.6 Replanting of New Oil Palm within Sg. Kejapil Water Catchment.....	32
 3. METHODOLOGY.....	 33
3.1 Case Study Parameters.....	33
3.2 Data Collection.....	33
3.3 Hypotheses.....	34
3.4 Data Analysis.....	36
 4. RESULTS AND DISCUSSION.....	 37

5.	CONCLUSION AND OMMENDATIONS.....	56
5.1	Recommendations.....	47
5.2	Protection and Conservation Sg. Kejapil Water Catchment..	47
5.3	Future Study and Continuous	48
5.4	Recycling of Palm Oil Mill Effluent (POME).....	49
5.5	Gazetting Sg. Kejapil Water Cathment.....	50
5.6	Conclusion.....	52

REFERENCES.....	54
------------------------	-----------

GLOSSARY OF TERMS AND ACRONYMS	56
---	-----------



LIST OF FIGURES

FIGURE		PAGE
1	Map of The Sarawak Integrated Coastal Zone.....	6
2	Maps of Geographical setting of Miri-Suai Pilot Project Area (MISPA)...	8
3	MISPA Organization Chart.....	11
4	Map of Logging Areas within Sg. Kejapil Water Catchment Area	14
5	Map of Landuse within Sg. Kejapil Water Catchment Area.....	15
6	The Diagrammatic representation of flows of Study Functions.....	16
7	Bar Chart Concentration of Ammonia Nitrogen.....	38
8	Line Graph Concentration of Ammonia Nitrogen.....	39
9	Bar Chart Concentration of Nitrate Nitrogen.....	40
10	Line Graph Concentration of nitrate Nitrogen.....	41

LIST OF TABLES

TABLE		PAGE
1	Total Land Area of MISPA by District.....	9
2	The Department of Environment Interim Water Quality	27
3	DOE Water Quality Classes, Malaysia.....	28
4	DOE's Phase II Study on Water Quality Criteria and Standards, Malaysia...	28
5	Actual manuring Schedule adopted for Replanting Program since 1997.....	44
6	Calculated amount of SOA.....	42

Abstract of Research Project submitted to the Faculty of Engineering, Universiti Putra Malaysia in partial fulfillment of the requirement for the Degree of Master of Science (Emergency Response and Planning).

**SG. KEJAPIL WATER CATCHMENT AND MIRI-SUAI PILOT PROJECT
(MISPA) OF SARAWAK INTEGRATED COASTAL ZONE MANAGEMENT
(IZCM):
A STUDY ON AMMONIA NITROGEN AND NITRATE NITROGEN
CONCENTRATION LEVEL FOR SG. KEJAPIL RAW WATER**

By

SAA @ SA ANAK TAWI

October 1999

Supervisor : Dr. Mohamed Daud, Ph.D
Co-supervisor : Dr. Nor Maria Adam, Ph.D
Faculty : Faculty of Engineering

The current development in the coastal zones of the state of Sarawak is characterized by insufficient integration, coordination and cooperation amongst federal, state and local governments and other stakeholders. The direct implication of poor coordination may give rise to complicated and undesirable negative environmental impacts on the state coastal zones.

This study is focused on the Sg. Kejapil water catchment, in Miri Division. The abundant natural resources within the water catchment area such as timber, water and its relief characterized by undulating plain attract many stakeholders. The uncontrolled human activities within the water catchment area have resulted in negative environmental impacts on Sg. Kejapil water catchment and its raw water.

This study has confirmed that there are negative environmental impacts on Sg. Kejapil raw water due land development sited in the upper region of the catchment. Results show that the concentration levels of the ammonia nitrogen and nitrate nitrogen in Sg. Kejapil raw water are increasing from 1997 to October 1999..

Abstrak Projek Penyelidikan yang dikemukakan kepada Fakulti Kejuruteraan, Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan untuk mendapatkan Ijazah Master Sains (Perancangan dan Respon Kecemasan).

**TADAHAN HUJAN SG. KEJAPIL DAN PROJECT PILOT MIRI-SUAI (MISPA)
KESENAMBUNGAN KAWASAN PANTAI SARAWAK (ICZM):
KAJIAN TERHADAP PARAS KEPEKATAN AMMONIA NITROGEN DAN
NITRAT NITROGEN UNTUK AIR MENTAH SG. KEJAPIL**

Oleh

SAA @ SA ANAK TAWI

Oktober 1999

Penyelia :Dr. Mohamed Daud, Ph.D
Penyelia kedua :Dr. Nor Mariah Adam, Ph.D
Fakulti : Fakulti Kejuruteraan

Perkembangan pembangunan sekarang di sepanjang kawasan pantai Sarawak dicirikan dengan ketidaksenambungan, kekurangan kodinasi dan kesepakatan diantara kerajaan pusat, kerajaan negeri dan kerajaan tempatan dan peneroka. Implikasi daripada

kekurangan kodinasi boleh mengakibatkan situasi menjadi kompleks dan kesan negatif terhadap alam sekitar kawasan pantai.

Kajian ini difokuskan kepada tadahan hujan Sg. Kejapil, di Bahagian Miri. Taburan harta asli yang banyak di sekitar kawasan tadahan hujan seperti kayu balak, air dan permukaan bumi yang agak rata menarik para pelabur. Aktiviti-aktiviti yang kurang mementingkan kesan buruk kepada alam sekitar telah mencemarkan tadahan hujan Sg. Kejapil dan air sungainya.

Kajian ini telah menentukan kesan negatif kepada alam sekitar Sg. Kejapil akibat pembangunan yang dijalankan di hulu kawasan tadahan hujan tersebut. Kajian ini telah menentukan bahawa paras kepekatan ammonia nitrogen dan nitrate nitrogen dalam air mentah Sg. Kejapil telah meningkat sejak tahun 1997 sehingga Oktober 1999.

1. INTRODUCTION

1.1 General and Overview

The tropical coastal zones are some of the most dynamic region on earth. Complex habitat mosaics interact to carry out multiple ecological functions which are more than capable of satisfying the basic life support, land use and resource production needs of coastal population growth and economic activities. However, in many tropical countries that experience rapid population growth and uncontrolled economic activities have caused pollution, habitat degradation and depletion and over exploitation of natural resources in the coastal zones.

While most ecological systems in the tropical coastal zones are remarkably resilient to many of these human activities but their capacity to bounce back becomes limited when their resilience thresholds are exceeded. The need for new and innovative coastal zone management arrangements is apparently necessary to enhance sustainable growth of the coastal zones in Malaysia to boost successful economic development.

To promote sustainable economic growth, Malaysia has also wisely participated actively in implementing and regulating several environmental policies to ensure future development is sustainable and favorable. This has been outlined at the national level in the implementation of the 7th. Malaysian Plan and also in the government's interests in supporting the National Conservation Strategy (1993) and Agenda 21 of the Rio de Janeiro Conference on Environment and Development (UNCED). It is a global and collective interest from the highest authority at the Prime Minister's office as major

player in these environmental issues and delegates the authority to the Sarawak State government to regulate and implement the environmental policies (MISPA, April 1999).

In the olden days, the fertile great river basins in the tropical regions had been one of the focused areas of major development such as the Ganges in India, the Indus in Pakistan and the Yantze Kiang in China. Nowadays nowhere has this development been more dramatic than within the area known as the coastal zones of the tropical regions. Integrated Coastal Zone Management (ICZM) has been recognized as an important management tool that can be used to enhance the sustainable use of coastal ecosystems. ICZM has been adopted in more than 50 countries around the world including Malaysia (MISPA , April 1999).

The DANCED (Danish Cooperation for Environment and Development) is currently promoting the transfer of environmental management technology and know-how to developing countries with the objective of improving the global environment has contributed about RM 13 millions for three ICZM pilot projects in three states in Malaysia; the States of Penang, Sabah and Sarawak (Sarawak State Planning Unit et.al. 1998). The ICZM project started in September 1996 will last for three years until September 1999. However, DANCED has recently agreed to extend the project period until June 2000 next year in order to finalize some tasks which are still outstanding.

In response to this challenge, the Sarawak State government has established two areas as ICZM State Pilot Projects and is basically to test the ICZM tool with regard to

the state local coastal environment. It is hoped that ICZM will be able to make all stakeholders understand the concepts and the complexity of the ecosystem of Sarawak's coastal zones. The two coastal zones selected as areas of ICZM pilot projects in Sarawak are Miri-Suai Pilot Project Area (MISPA) in Miri Division and Daro-Mukah Pilot Project Area in Sibu Division.

1.2 Malaysia and Integrated Coastal Zone Management (ICZM)

The Federal Government of Malaysia through its agency the Economic Planning Unit (EPU) in Kuala Lumpur is the overall coordinator for all ICZM projects in Malaysia. The development of the integrated coastal zone and coastal resources management is one of the goals of the Government of Malaysia as been expressed in the National Conservation Strategy (1993). The Government of Malaysia has contributed about RM 3.6 millions to the ICZM projects that have been implemented at various stages in three states in Malaysia namely the states of Penang, Sabah and Sarawak (Sarawak State Planning Unit, 1998).

Integrated Coastal Zone Management (ICZM) is a coastal zone management tool adopted by the Malaysian Government to manage the resources of the coastal zones in Malaysia. Its success rely on the collaborative participation by all affected economic sectors, government agencies and non-government organizations arose out of concern to strike a balance between competing coastal activities and uses of coastal resources in ways which recognize the potential coastal hazards and its commercial and strategic

interests. ICZM is also an approach that recognizes the need to conserve important resources to ensure sustainable future development.

ICZM is based on the physical, socio-economic and political connection both within and among the dynamic physical system, which when aggregated together define a coastal zone. It can also be seen as a continuous and dynamic process that unites all stakeholders in developing an integrated plan with a coordinated strategy for the allocation of environmental, socio-cultural and institutional resources to achieve the conservation and sustainable use of coastal zone (MISPA 1st. Draft November, 1998).

1.3 Sarawak Integrated Coastal Zone Management (ICZM)

The current development in the coastal zones of the State of Sarawak is characterized by insufficient integration, coordination and cooperation among federal, state and local governments and other stakeholders. There are competing and conflicting interests in the coastal zones and these may lead to unsustainable development in the near future if kept unchecked. The direct implication of poor coordination may give rise to complicated and undesirable negative environmental impacts on the state coastal zones.

In Sarawak State the ICZM Project is guided by the Steering Committee under the Chairmanship of the State Secretary of Sarawak. The State Planning Unit (SPU) has been appointed as the coordinating body for the project and the ICZM Unit provides supports to the DANCED consultants involved in the project. The ICZM Unit comprises

a Project Manager and a Chief Technical Advisor from the DANISH Joint Venture companies and several Counterparts from other government agencies such as the National Resource Environmental Board (NREB), Department of Irrigation and Drainage (DID), Land and Survey (L&S) and Marine Fisheries Department.

However, the other ICZM members from the other relevant ministries and government agencies are called in to participate as per output basis such as State Jabatan Kerja Raya at the divisional level in Miri Division which is represented by the author. The local consultants are also engaged to assist in the effectiveness and smooth implementation of the project. Eventually, the ICZM mechanism will be integrated onto government administrative system and processes probably after the pilot projects period expires in June 2000 next year.

The Sarawak ICZM requires a definite area to be defined as Coastal Zone in order that the collaborative planning and management that makes the processes of ICZM can be made effective (as shown in Figure 1). The Coastal Zone areas of the State of Sarawak include coastal waters, the coastline itself and the coastal lowland. To date there is no international convention exists as to how far the Coastal Zone extends and defines. However, the boundary lines are often determined by issues which form the basis for the creation of an ICZM programme.

It has been agreed by the Steering Committee for the DANCED-ICZM SARAWAK that the Coastal Zone boundary of State of Sarawak includes:

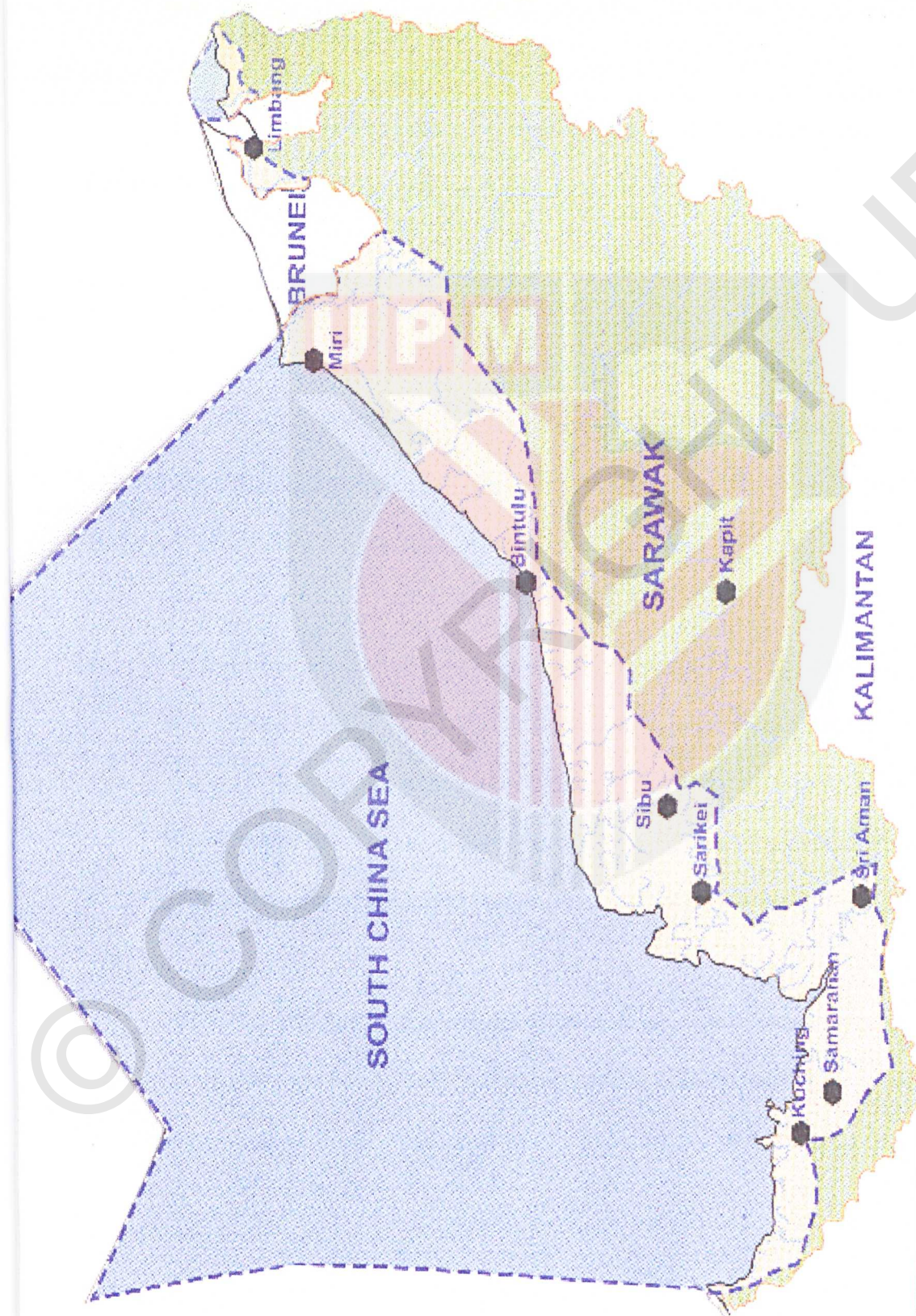


Figure 1: The Sarawak Integrated Coastal Zone is demarcated in orange on land and blue in the sea. It is an area bounded by 30 meters elevation contour on the land and 200 miles Exclusive Economic Zone of South China Sea. The other area in green is not part of the Sarawak Coastal Zone.

Source: Integrated Coastal Zone Management of Miri-Suai Pilot Project Area

- 1 Offshore areas which extend up to Exclusive Economic Zone (EEZ).
- 2 Inland areas which encompass the wide coastal lowland, with about 300 km sandy beaches, 100 km rocky beaches, 83 km mud plains and 330 km mangrove beaches, along its 816 km coastline, which are influenced by tidal waters.

The map as shown in Figure 1 demarcates the consolidated boundary of the Coastal Zone of State of Sarawak.

1.4 Miri-Suai Pilot Project Area (MISPA)

On 10th. August 1998, the Sarawak State Government launched the Integrated Coastal Zone Management (ICZM) Miri-Suai Pilot Project (MISPA) for Miri Division. MISPA is established for two reasons:

- 1 To implement ICZM on a smaller scale (called Miri-Suai Pilot Project Area abbreviated as MISPA) to better understand the immense complexity of Sarawak social, ecological and economic subsystems that make up the coastal system.
- 2 It serves as a learning experience that will contribute to the overall strategy and implementation of the ICZM Action Plan for Sarawak State in future.

MISPA is also part of the broader effort to create a new and innovative management arrangements to help lead to sustainable development of the coastal ecosystem (social, ecological and economic) particularly in Miri Division coastal zone

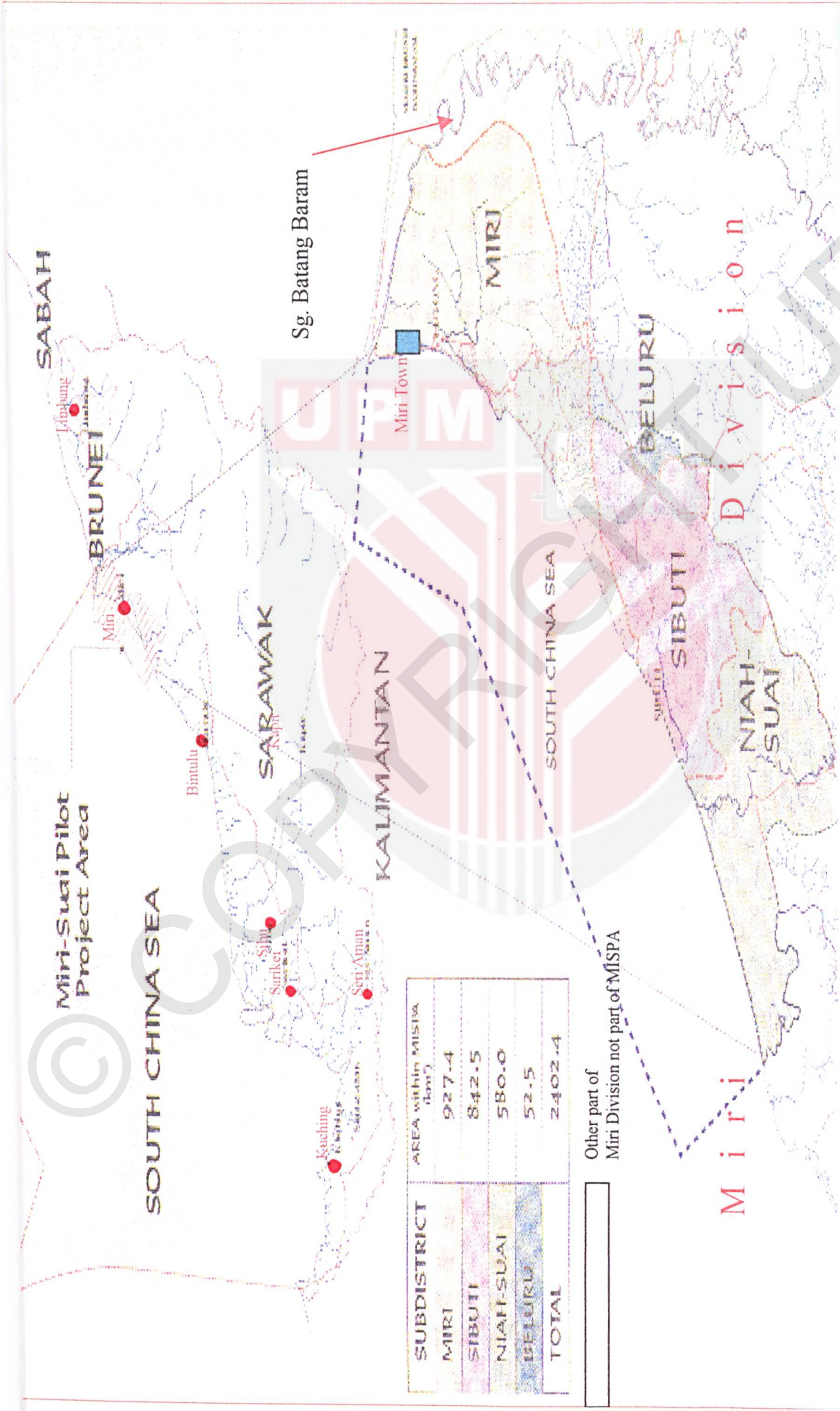


Figure 2: Geographical setting of Miri-Suai Pilot Project Area (MISPA). It is divided into four sub-districts, Miri, Sibuti, Niah-Suai and Beluru. It has a total area of 2402.4 kilometers square.

(MISPA. Ist. Draft November 1998). However, it is important for all readers to be reminded that MISPA dose not cover the whole Miri Division. It only covers a designated area of Miri Division coastal zone as shown in maps of Figure 2.

The MISPA is defined as the coastal area that is bounded by the 12 nautical-mile territorial waters in the South China Sea and within the landward boundary. On land it is bounded by Sungai Batang Baram to the east and Sungai Batang Baram Catchment to the west. The land boundary generally follows the district boundary, road and the river catchment boundaries. MISPA has approximately 84 km of coastline and covers approximately 2,402 kilometers square of land area and 1,124 kilometer square of sea area. The approximate land areas of Miri and Subis sub-districts in MISPA are shown in Table 1 below.

District/Sub-district	Area (kilometer square)
Miri	927.4
Sibuti	842.5
Niah-Suai	580.0
Beluru	52.5
Total MISPA Area	2,402.4

Table 1. Total Land Area of MISPA by Districts

Source: MISPA April 1999

1.5 Concepts and Goal of ICZM in MISPA

The project is financially and technically supported by the Government of Malaysia through the Economic Planning Unit in the Prime Minister's office and Denmark through the Danish Co-operation for Environmental and Development (DANCED) (Sarawak State Planning Unit. 1998, October 2nd. Draft).

A proactive ICZM Team for MISPA was formulated in August 1998. Jabatan Kerja Raya Miri Division was represented by the author. The MISPA Organization Chart is as shown in Figure 3. One of the tasks of the ICZM Team is to identify some of the major issues that either catalyst or divert the path towards a more sustainable development of MISPA, the coastal zone. It also attempts to synthesize existing information gathered from various government agencies and other stakeholders who have vested interests in MISPA and structure it in such a way that it can be used to understand the current situation of MISPA.

The ultimate goal of ICZM is to create a dynamic process which will suggest alternatives and recommendations to encourage more efficient uses of coastal resources. By this it means that ICZM also helps to enhance more efficient economic development and environmental management towards a more sustainable development of MISPA.

The basic concept of ICZM in MISPA is to refer all issues to three dimensions of the Coastal Zone System (i.e Social, Ecological and Economic best abbreviated as SEE formula of the Coastal Zone System) as well as the institutional and legal framework.

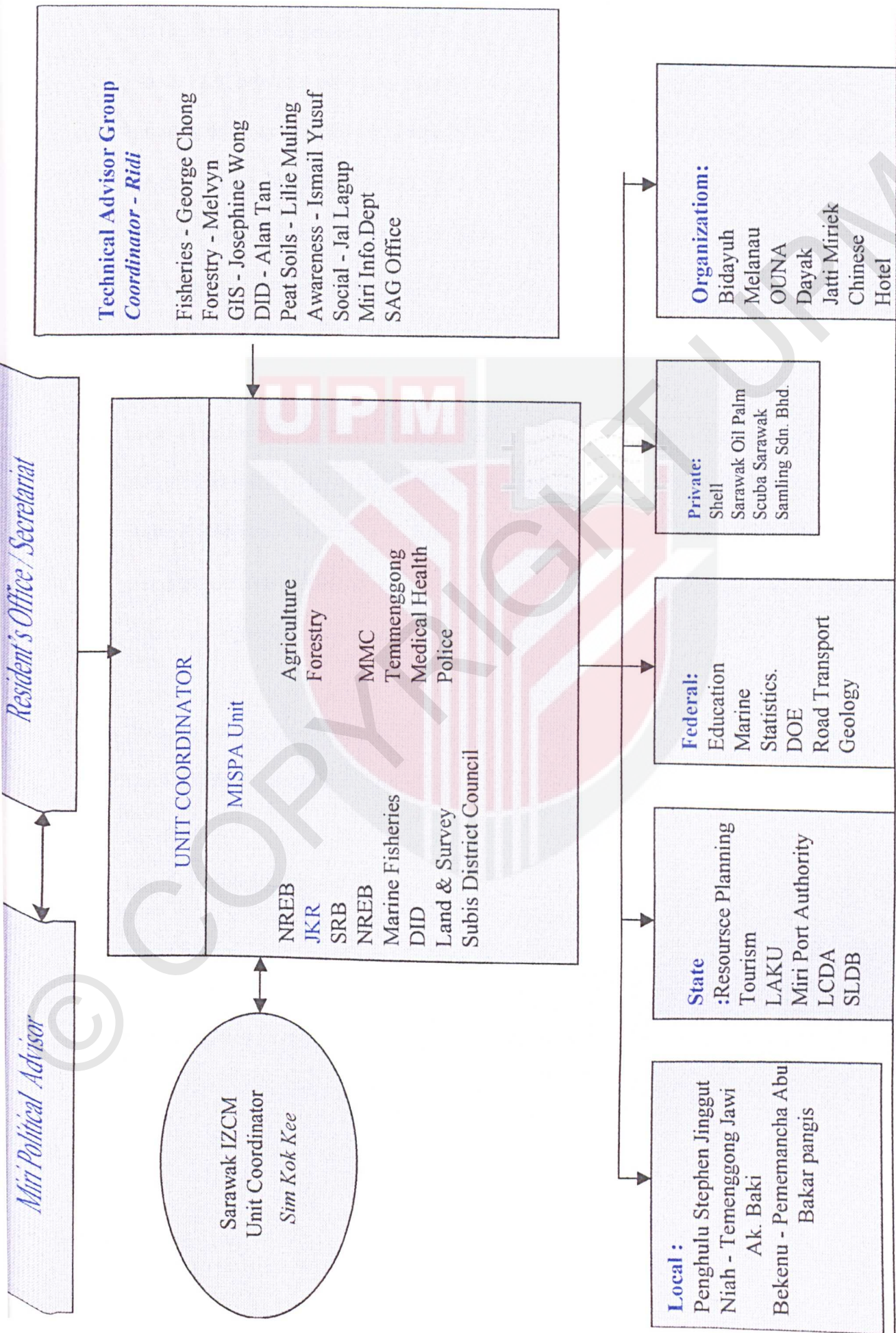


Figure 3 : MISPA Organization Chart

Source: Extracted from Miri-Suai Pilot Project Area (MISPA) Coastal Zone Environmental Profile April 1999

ICZM also serves as dimensional snapshots for ICZM Team to identify the priority issues, their causes and effects (in terms of social, economic and ecological aspects) and provides potential opportunities in making future suggestions to higher authority or other relevant parties that have vested interest in MISPA. Feasible and noble suggestions are documented as supporting document for drafting the ICZM Action Plan (as been stated in Item 1.3. Integrated Coastal Zone Management. Miri-Suai Pilot Project Area. Coastal Zone Environmental Profile 1998. Draft Final) which is to be completed by June 2000 and shall be implemented in MISPA.

The formation of ICZM Team in MISPA begun in August 1998 when ICZM was launched for MISPA by Sarawak State Government. The formation and the formulation of the ICZM Team was a gradual process as it started from a very small group whereby members were comprised of representatives from various local agencies and government departments particularly within Miri Division.

However, as more and more related issues were discussed the group started to expand. The MISPA Organization Chart is as shown in Figure 3.

1.6 Problem Statement

In earlier discussion (Sarawak Integrated Coastal Zone Management), it was mentioned that the current development in the coastal zones of the State of Sarawak is

characterized by insufficient integration, coordination and cooperation among various stakeholders that have vested interest in the region.

This is because there are no existing general protocol or basic guidelines to coordinate the implementation of various activities within the region.

The direct implication of this shortcoming may give rise to complicated and undesirable negative environmental impacts due to uncoordinated human activities.

It is very important to recognize the resilient thresholds of the coastal zone in order to avoid future environmental disaster which may not be confined to the coastal zones only but may exerts damages to the other parts of ecosystem outside the coastal zones. Such dramatic negative environmental impact has a very adverse implication to sustainability of ecosystem within the coastal zone.

However, it is not possible to state the whole problem of the coastal zones of Sarawak. It is intended in this study that the actual focus of subject area is within MISPA the Sibuti sub-district as shown in map of Figure 2 earlier page. The physical boundary of the study area is Sg. Kejapil Water Catchment area as shown in maps of Figures 4 and 5.

The general parameters of study are human activities within the catchment region and their impacts and influences on raw water at the raw water intake point of JKR Bekenu Water Treatment Plant. The specific domain of the study is the concentration of nitrogen compounds in the form of ammonia nitrogen ($\text{NH}_3\text{-N}$) and nitrate nitrogen

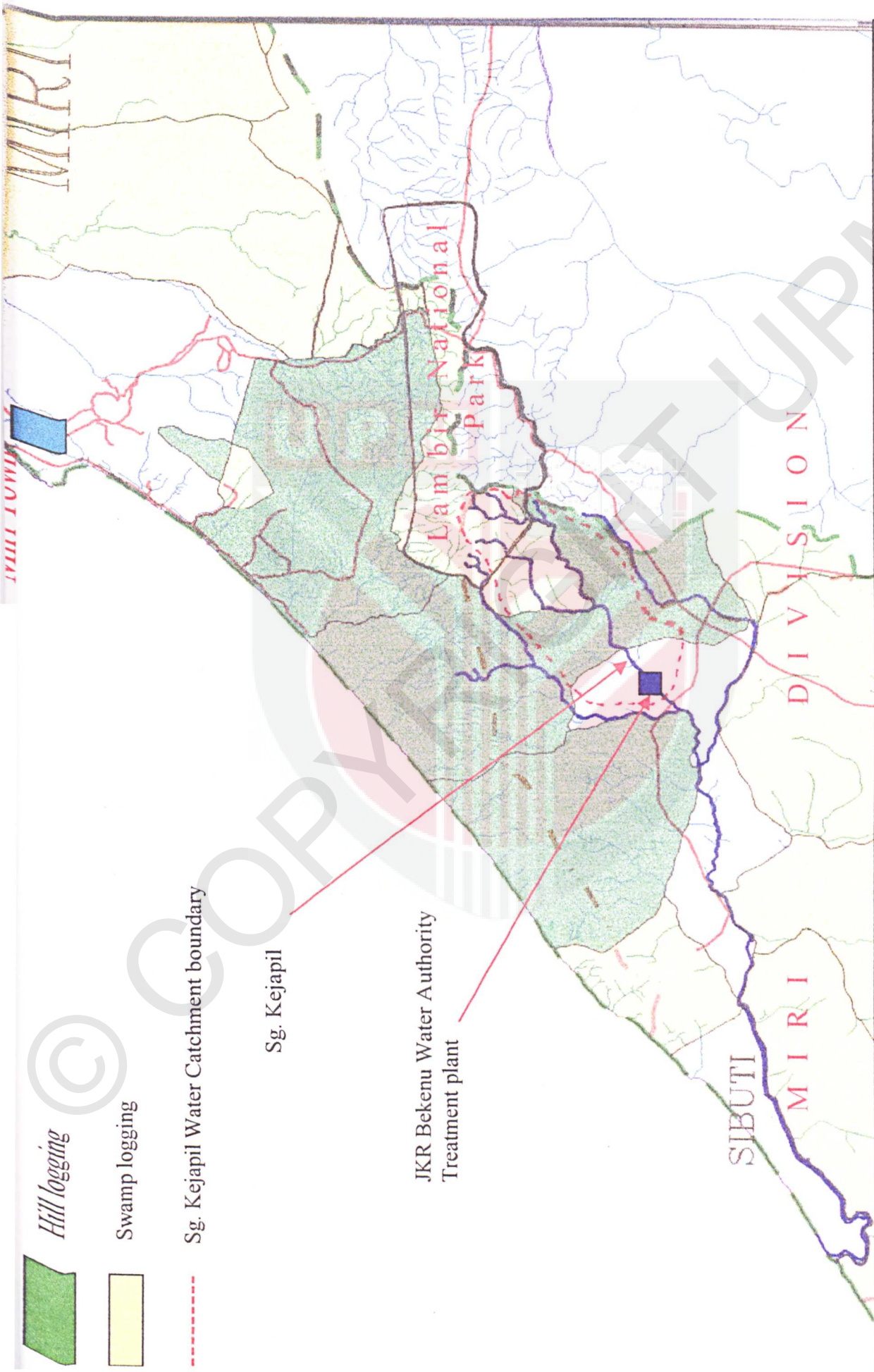


Figure 4: Logging areas within Sg. Kejapil water catchment area.

Some areas that have been removed of timber are developed into oil palm plantation as shown in Figure 5

Source: Extracted from Forestry Department, JKR Department, Land & Survey Department and Miri-Suai Pilot Project Area (MISPA)

(NO₃-N). Figure 6 below shows the diagrammatic representation of the flows of the study functions.

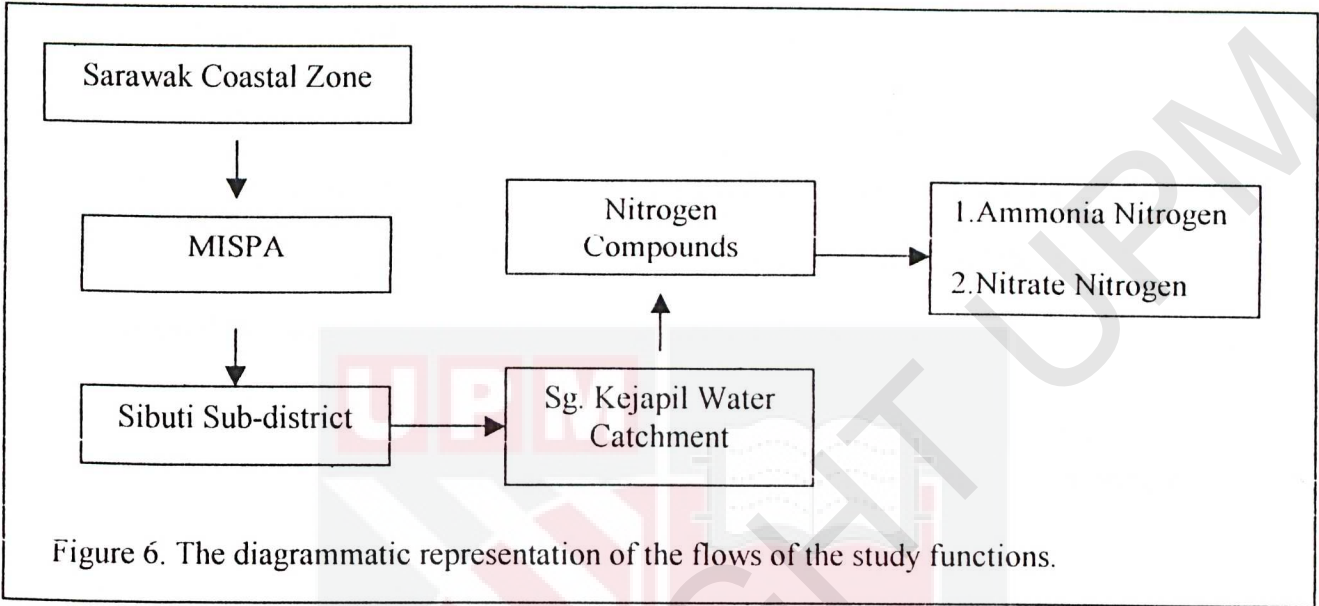


Figure 6. The diagrammatic representation of the flows of the study functions.

The readers are reminded that the study functions as shown above are mainly the general outline of the study to assist the author to have focus throughout his work. It is not meant to discard other possibilities or parameters that may arise as parts of the study as the researcher progresses towards his findings to justify the study hypotheses.

1.7 Scope of Study

There are two parameters involved in this study. They are two nitrogen compounds in the form of:

1. Ammonia nitrogen ($\text{NH}_3\text{-N}$)
2. Nitrate Nitrogen ($\text{NO}_3\text{-N}$)

1.8 Objectives of study

There is a need to measure the environmental impact due to rapid land development in Sg. Kejapil water catchment especially for the past few years. Therefore, the specific objectives of this study are to analyze the concentration levels of:

1. ammonia nitrogen ($\text{NH}_3\text{-N}$)
2. nitrate nitrogen ($\text{NO}_3\text{-N}$) from the raw water sampled from this water catchment for the last five years from 1995 to October 1999.

The Sg. Kejapil water catchment area is shown in maps of Figure 4 and 5 in the previous pages.

1.9 Limitations

The limitation of the study is that the result of this study will not be representative to represent the situation in other water catchments in Sarawak state. The findings and results only reflect the situation within Sg. Kejapil water catchment area though the causes may be contributed partially or wholly from outside the catchment area.

It is a specific study focusing specifically on the concentration of nitrogen compounds as ammonia nitrogen and nitrate nitrogen that has risen abnormally in concentration level for the last few years especially the last half of 1990s.

1.10 Definition of Terms

Ecosystem: The combination of living things together with their non-living habitats. Fundamental processes for an ecosystem include the flow of energy through the system via food chains and food webs and the cycling of nutrients.

Integrated Coastal Zone Management (ICZM): Integrated Coastal Zone Management is a system to manage the resources of the coastal zone through the collaborative participation by all affected economic sectors, government agencies, and non-governmental organizations. It is based on the physical, socio-economic and political connection both within and among the dynamic physical systems, which aggregated together will define a coastal zone.

Stakeholder: Any party that has vested interest in the water catchment area of Sg. Kejapil.

REFERENCE

- Bacteriology & Chemical Analysis Report (1999). Bekenu Water Supply
- Clair N.Sawyer, Perry L. McCarty, Gene F. Parkin. (4th.ed.1994) Chemistry for Environmental Engineering. McGraw-Hill International Editions.
- Hardi Othman (1997). Attachment Report. Unpublished Report for Sarawak Agriculture Vocational Training Institute (SAVTI), Kebuloh Miri
- K.F. Maxcy, Report on Relation of Nitrate Nitrogen Concentration in Well Waters to the Occurrence of Methemoglobinemia in Infants. Natl. Acad. Sci.-Research Council Saint. Eng. And Environment Bull. 264, 1950
- Lim C. H., P'ng T. C. and Chan. K. W. Nutrient Recycling through Utilization of Palm Oil Mill Effluent.
- Murtezda Mohamad and Ali Memon (1999). Water Resource Management in Sarawak, Published by Centre for Technology Transfer & Consultancy Universiti Malaysia Sarawak (UNIMAS).
- MISPA (1st. Draft November 1998). Environmental Coastal Profile. State Planning Unit & Danish Cooperation for Environment and Development.
- MISPA April (1999). Integrated Coastal Zone Management. MISPA Profile. Sarawak State Planning Unit, Chief Minister's Department and The Resident & District Office, Miri.
- PORIM (1995). PORIM National Oil Palm conference. Technologies in Plantation. The way Forward. Seminar Paper 11th-12th July 1995. Hilton Hotel, Kuala Lumpur.
- Resilient threshold is the natural capacity of the environment to bounce back to its state of new equilibrium.
- Sarawak State Planning Unit (1998, October 2nd. Draft). Sarawak Coastal Zone Environmental Profile Report
- Saa, S.A.T., Normariah, A. (1999). Domestic Water Supply to Rural Longhouse, Rh. K Kana, Nanga Lingah, Pakan, Sarawak, Malaysia. Unpublished report for Faculty of Engineering, UPM, Serdang.
- Second Miri Water Supply Master Plan Study. (December 1998) Interim Report Part 2.

Sarawak State Planning Unit (1998). Chief Minister's Department Sarawak and Danish Cooperation for Environment and Development (DANCED)

SAVTI Kebuloh, 1999 Sarawak Vocational Training Institute.

Unchie. Anding (May 1996). Study on the Impact of Urbanization on Water Quality of Sg. Damansara, Petaling Jaya, Selangor. School of Engineering ITM Shah Alam, Selangor.

Water Supply Handbook. March 1981 (Rev.1982). Jabatan Kerja Raya Sarawak.

Water Supply Regulations, 1958 as Amended by The Water Supply (Amendment) Regulations, 1964

Water Ordinance, 1994 Laws of Sarawak Chapter 13.