ASSESSMENT ON THE SUSTAINABILITY OF THE TASIK CHINI BASIN AND TASIK CHINI BIOSPHERE RESERVE

AKADEMI SAINS MALAYSIA

FINAL REPORT

ASSESSMENT ON THE SUSTAINABILITY OF THE TASIK CHINI BASIN AND TASIK CHINI BIOSPHERE RESERVE

PREPARED BY
ASM TASK FORCE ON TASIK CHINI

2023

Assessment on the Sustainability of the Tasik Chini Basin and Tasik Chini Biosphere Reserve

Academy of Sciences Malaysia
Level 20, West Wing, MATRADE Tower
Jalan Sultan Haji Ahmad Shah off Jalan Tuanku Abdul Halim
50480 Kuala Lumpur, Malaysia

ASM Advisory Report
Endorsed: June 2023

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

eISBN 978-983-2915-98-0

TABLE OF CONTENTS

ACKNOWLEDGEMENT

This book would not have been possible without the generous support and contributions from numerous individuals and institutions. It is with heartfelt appreciation that we extend our gratitude to all those who have played a pivotal role in bringing this project to fruition.

We would like to express our sincere thanks to the Academy of Sciences Malaysia for their unwavering support and recognition of the significance of our research. The guidance and encouragement received from the Science, Technology, & Innovation Policy and Advisory Committee (STIPAC) members have been invaluable in shaping the direction of our work.

Our deep appreciation also extends to Universiti Malaysia Terengganu, Universiti Tun Hussein Onn Malaysia, Universiti Teknologi Malaysia, and Universiti Kebangsaan Malaysia for providing the necessary resources and facilities that enabled us to conduct our research effectively.

We are indebted to the dedicated administrative team members, including Pn Hazami Habib, Pn Nitia Samuel, Muadz Norazan, Nurul Aina Ismail, Ratnamalar Rajasingam, Afifa Mahamad Saidi, and Muhammad Akmal Hakim Mohamad whose contributions in preparing this book have been exceptional. Their attention to detail and commitment to excellence have enhanced the quality of this work significantly.

We are also extremely grateful to the Academy of Sciences Malaysia for their generous RM20,000 grant, which played a crucial role in facilitating our exploratory missions and ground truthing efforts in the pristine Tasik Chini Basin.

Lastly, we cannot overlook the significance of the local communities and stakeholders in Tasik Mentiga and Tasik Chini. Their warm hospitality, unwavering support, and invaluable assistance in welcoming us into their homes and offices have been essential to the success of this endeavour.

This book is a testament to the power of collaboration, dedication, and a shared vision of understanding and preserving our natural heritage. We hope that the insights and discoveries shared within these pages will inspire future generations of researchers, explorers, and nature enthusiasts to continue exploring the wonders of our world with boundless curiosity and respect.

FOREWORD

In the 27 years of its establishment, the Academy of Sciences Malaysia (ASM) has established its name as the nation's Thought Leader in matters pertaining to Science, Technology, Innovation, Engineering and Economy (STIE). Thus, with this mandate as Malaysia's Thought Leader in STIE, ASM now strives to elevate itself as a Changemaker playing a pivotal role in pushing for progress and accelerating Malaysia's development into an agile and competitive high-tech nation.

The ASM Expert Network has repeatedly, over the years raised concerns on the apparent deterioration in Tasik Chini as reported in media as well as through academic publications. The lake, once iconic for its unique ecosystem dominated by the presence of the sacred lotus, Nelumbo nucifera, plays an important role in sustaining the area's ecological diversity leading to it being recognised as the first biosphere reserve site in Malaysia under the UNESCO's Man and the Biosphere programme (MAB) on 26 May 2009.

Hence, in consideration of the seriousness of the aforementioned issues surrounding Tasik Chini, the ASM Task Force on Tasik Chini was established based on the proposal by the ASM East Coast Chapter to conduct a preliminary assessment on the sustainability of the Tasik Chini Basin and Tasik Chini Man and Biosphere Reserve.

I would like to take this opportunity to thank the Task Force for their unyielding tenacity and perseverance under the leadership of Professor Dato' Dr Mohd Tajuddin Abdullah FASc in compiling all the relevant information for a comprehensive preliminary report on Tasik Chini's sustainability. I sincerely hope that the publication of this report provides valuable inputs that are independent, evidence-based, credible, and timely in the effort of crafting the necessary recovery plans and strategies, therefore ensuring the continuous heritage of Tasik Chini for generations to come.

Professor Emerita Datuk Dr Asma Ismail FASc
President, Academy of Sciences Malaysia

PREFACE

This report presents the desktop research and brief validation of the Tasik Chini Basin (TCB) and Tasik Chini Man and Biosphere Reserve (TCBR) between August 2021 and December 2022. The Academy of Sciences Malaysia (ASM) has appointed the task force members to provide unbiased interpretations of the information during our engagements with stakeholders and documents made accessible at the point of this study.

Tasik Chini was once a pristine natural heritage and a heaven for nature lovers and local communities until the early 1990s. Historically, the inland lake was well known among traders from Khmer *circa* from the 9th to the 15th centuries, now as modern Cambodia. In the Khmer language, Chini refers to 'monkeys' that were found in abundance in the area. The myth of Naga Seri Gumum was famous among the Jakun tribes in Chini. Archaeologists also found evidence of Neolithic human settlement since 5,000 years ago, trading areas with China and Thailand between the 14th and 15th centuries.

Physical changes took place in Pahang during the implementation of the *Second Malaysia Plan* between 1971 to 1975. These environmental consequences of physical development are well described by Albert Abee in 2021 in the book *'Resource Use and Sustainability of Orang Asli'*. In 2005, Mushrifah Idris, Khatijah Hussin, and Abdul Latiff Mohamad documented the declining community and species diversity impacting the aquatic ecosystem of Tasik Chini. Localised invasion of Cabomba species was observed resulting from anthropogenic activities.

Here, we present the recommendations for the bio-physical environment, social, economic, and governance of the TCB and TCBR. We recommend improving the biodiversity of TCB and TCBR that provides crucial ecosystem functions, services, and stability, starting with the planting of fruiting and flowering trees to bring back butterflies, birds, mammals, and other invertebrates. Improvements in the physical state of TCB and TCBR are also necessary by focussing on soil restoration, mining activities mitigation measures, and restoration of the lake hydrological stability. Integrated management of TCB and TCBR must include all stakeholders, including Orang Asli, by using international, national, state, and local agendas as the main blueprint. Lastly, we recommend that the stakeholders focus on collaborative efforts, allowing each stakeholder of TCB and TCBR the opportunity to form a collective decision bound by a united goal for the ultimate purpose of good governance of TCB and TCBR.

We propose immediate habitat and environmental rehabilitations, socio-economic wellbeing of the communities, and strengthening of the governance of TCB and TCBR.

We hope this report can be a supporting document for the state and federal authorities to ensure the perpetual integrity of TCBR and the sustainability of TCB over the following decades.

Mohd Tajuddin Abdullah, Chairperson, PhD, FASc, DIMP
Zulkifli Yusop, Deputy Chairperson, PhD, FASc
Rahimatsah Amat, PhD FASc
Sarah Aziz Abdul Ghani Aziz, PhD
Sharina Abdul Halim, PhD
Muhammad Abdul Latiff Abu Bakar, PhD

ASM TASK FORCE ON TASIK CHINI

Advisors

1. Professor Ts Dato' Dr Mohd Ekhwan Hj Toriman
2. Emeritus Professor Dato Dr Ibrahim Komoo FASc
3. Professor Dato' Ir Dr Wan Ramli Wan Daud FASc
4. Professor Dato' Dr Mazlan Abd Ghafar FASc

Members

1. Professor Dato' Dr Mohd Tajuddin Abdullah FASc (Chairperson)
2. Professor Dr Zulkifli Yusop FASc (Deputy Chairperson & Physical Domain Leader)
3. Professor Emeritus Dato' Dr Abdul Latiff Mohamad FASc (Biological Domain Leader)
4. Associate Professor Dr Sharina Abdul Halim (Socioeconomic Domain Leader)
5. Associate Professor Dr Sarah Aziz Abdul Ghani Aziz (Governance Domain Leader)
6. Dr Rahimatsah Amat FASc
7. Associate Professor Ts Dr Muhammad Abdul Latiff Abu Bakar (Writer)

Research Associates

1. Associate Professor Dr Ong Meng Chuan
2. Associate Professor Dr Nor Zalina Harun
3. Dr Zanisah Man
4. Ms Suhaini Md Noor
5. Tuan Haji Wahialkhan Ibrahim
6. Ms Nor Azizah Ishak

STAKEHOLDERS INVOLVEMENT (as of December 2022)

- *Bahagian Perancang Ekonomi Negeri Pahang*
- Department of Agriculture (DoA)
- Department of Director General of Lands and Mines *(JKPTG)*
- Department of Director General of Lands and Mines Pahang (*JKPTG* Pahang)
- Department of Environment (DoE)
- Department of Environment Pahang
- Department of Fisheries (DoF)
- Department of Irrigation and Drainage Malaysia (DID Malaysia)
- Department of Irrigation and Drainage Pahang (DID Pahang)
- Department of Mineral and Geoscience Malaysia (*JMG*)
- Department of National Heritage
- Department of Orang Asli Development (*JAKOA*)
- Department of Orang Asli Development Pahang (*JAKOA* Pahang)
- Department of Survey and Mapping Pahang (*JUPEM* Pahang)
- Department of Town and Country Planning (PLANMalaysia)
- Department of Town and Country Planning Pahang (PLANMalaysia@Pahang)
- Department of Veterinary Services (DVS)
- Department of Wildlife and National Parks (*PERHILITAN*)
- Department of Wildlife and National Parks Pahang (*PERHILITAN* Pahang)
- Forest Research Institute Malaysia (FRIM)
- Forestry Department of Peninsular Malaysia (*JPSM*)
- Indah Water Konsortium (IWK)
- *Jabatan Kebajikan Masyarakat*
- *Jabatan Kemajuan Masyarakat*
- *Majlis Belia FELCRA Malaysia*
- Malaysian Fire and Rescue Department (BOMBA)
- Malaysian Handicraft Development Corporation (*Perbadanan Kemajuan Kraftangan Malaysia*)
- Malaysian Meteorological Department (METMalaysia)
- Malaysian Space Agency (MYSA)
- Ministry of Agriculture and Food Security (MAFS) [formerly Ministry of Agriculture and Food Industry, MAFI]
- Ministry of Entrepreneur and Cooperatives Development (MECD)
- Ministry of Health (MoH)
- Ministry of Investment, Trade and Industry (MITI) [formerly Ministry of International Trade and Industry, MITI]
- Ministry of Local Government Development

- Ministry of Natural Resources, Environment and Climate Change (NRECC) [formerly Ministry of Water and Environment, KASA; Ministry of Energy and Natural Resources, KeTSA]
- Ministry of Plantation Industries and Commodities (MPIC)
- Ministry of Rural and Regional Development
- Ministry of Science, Technology and Innovation (MOSTI)
- Ministry of Tourism, Arts and Culture (MOTAC)
- Ministry of Women, Family and Community Development (MWFCD)
- Ministry of Works (MoW)
- NanoVerify Sdn Bhd
- National Department for Culture and Arts
- National Landscape Department
- National Solid Waste Management Department (JSJPN)
- National Hydraulic Research Institute of Malaysia (NAHRIM)
- Pahang Forestry Department
- Pahang State Development Corporation
- *Pejabat Setiausaha Kerajaan Negeri Pahang*
- Pekan District and Land Office
- *Perbadanan Kemajuan Pertanian Negeri Pahang*
- Public Works Department of Malaysia (*JKR*)
- *Pusat Penyelidikan Tasik Chini (PPTC) UKM*
- Solid Waste Management and Public Cleansing ManagementCorporation (SWCorp)
- State Health Department
- *Universiti Kebangsaan Malaysia (UKM)*
- *Universiti Malaysia Terengganu (UMT)*
- *Universiti Putra Malaysia (UPM)*
- *Universiti Tun Hussein Onn Malaysia (UTHM)*

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Tasik Chini Basin (TCB) and **Tasik Chini Biosphere Reserves (TCBR)** are one of the most well-known lakes in Malaysia. Since the late 1990s, the area has undergone rapid anthropogenic changes, leading to ecological collapses. Deforestation, mining, and agricultural activities, as well as overexploitation of natural resources, remain the core issues threatening the sustainability of TCB and TCBR. Rapid population expansion demands for human settlements and aggressive socioeconomic activities have ultimately contributed to water and soil pollution within the TCB and TCBR area. On 11th June 2021, a news report by Sahabat Alam Malaysia triggered a nationwide public outcry and awareness of the ecological collapse of Tasik Chini. Subsequently, The Academy of Sciences Malaysia (ASM)'s Science, Technology, Innovation Policy and Advisory Committee (STIPAC) has formed a special task force to provide a report and advisory notes on the sustainability of TCB and TCBR. Our approach was to conduct a desktop study of published and unpublished manuscripts as well as an exploratory visit and active engagement with the stakeholders for TCB and TCBR. Our findings indicate that TCB and TCBR are currently highly disturbed ecosystems and require immediate rehabilitation and restoration program as intervention measures to avoid extinction like Tasik Mentiga. Integrated basin management, rigorous monitoring, regulation, and enforcement should serve as the main agenda for the rehabilitation of the ecosystems. Complementary, inclusivity and concerted governance should be the guiding principle for the recovery, rehabilitation, and restoration of TCB and TCBR. Phase 2 of this study should focus on deep-oriented-management research, data validation, and monitoring for TCB and TCBR recovery and restoration to their natural state.

INTRODUCTION

Lake and Freshwater Ecosystem in Malaysia

Lake range in minimum sizes for a body of water from two to eight hectares waterbodies (Elton, 1954). Lake is an essential provider of ecosystem services for human beings by acting as a watershed for freshwater supply, species refuge, food production, livelihoods of local communities, climate regulation, and recreational use (Millennium Ecosystem Assessment, 2005). There are about 304 million lakes worldwide. Lake ecosystems have been directly threatened by anthropogenic activities from farming, manufacturing industries, dam for hydroelectric generation, flood control, and irrigation, pollution from mining and forest extraction, the introduction of invasive species, exploitation of species, and global climate change (Ho and Goethals, 2019). The sustainability of lakes is directly linked to the environmental domain within the Sustainable Development Goals, namely, goals 6, 13, 14, and 15 (Ho and Goethals, 2019). Drying lakes in Central Asia are related to anthropogenic activities and have accelerated the desertification in the area (Tussupova et al., 2020). Therefore, the shrinking and drying lakes will cause ecological collapse and extinction of the aquatic communities. The most polluted lake in the world is Lake Karachay in central Russia. Blue Lake in New Zealand's South Island is the most pristine and cleanest. Figure 1 shows the distribution of lakes worldwide, and Figure 2 shows the density of lakes worldwide.

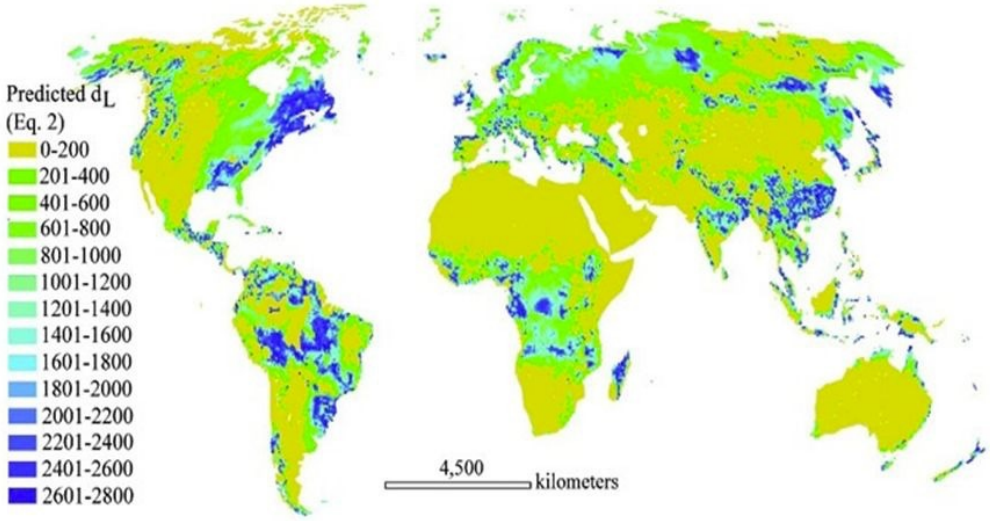


Figure 1: Ponds and Lakes of the World
(source: https://www.lakescientist.com/where-are-lakes/)

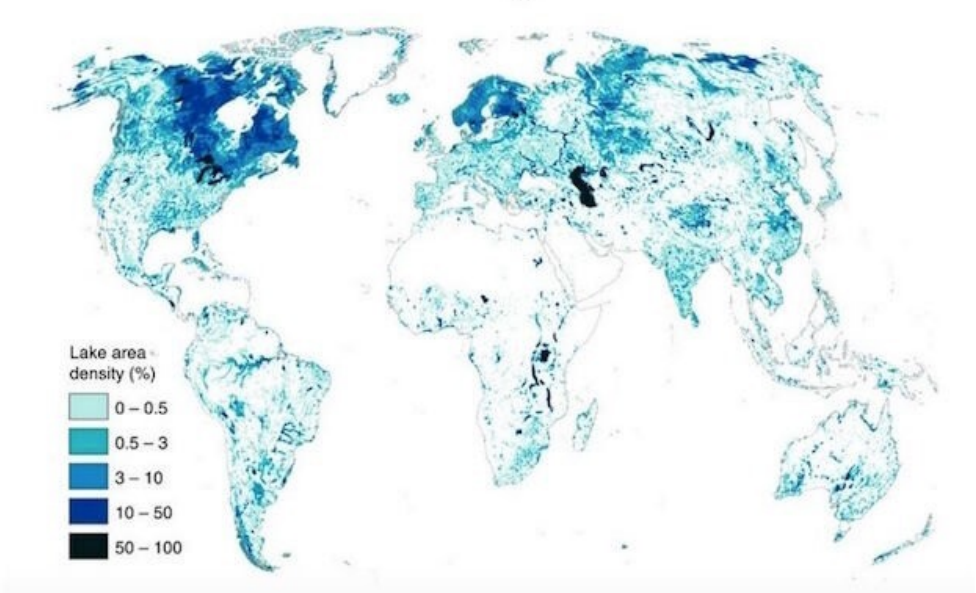


Figure 2: Lake Area Density of the World (Messager et al., 2016)

In Malaysia, there are about 103 lakes and reservoirs (Table 1) in the National Lakes Information Database of Malaysia, compiled by the National Hydraulic Research Institute of Malaysia (NAHRIM) and the ASEAN Committee on Disaster Management (ASEAN Commitee on Disaster Management, 2019). There are 73 man-made lakes built for portable water supply, irrigation, hydropower generation, flood control and recreational activities. The ownership of these waterbodies (catchment areas, reservoirs and dams) are the Ministry of Natural Resources, Environment and Climate Change (NRECC) [formerly KASA and KeTSA], Ministry of Agriculture and Food Security (MAFS) [formerly MAFI], *Suruhanjaya Perkhidmatan Air Negara* (*SPAN*), *Tenaga Nasional Berhad* (*TNB*), Department of Irrigation and Drainage Malaysia (DID), *Syarikat Bekalan Air Selangor* (*SYABAS*), *Lembaga Kemajuan Pertanian Muda* (*MADA*), *Lembaga Urus Air Selangor* (*LUAS*), Sarawak Energy, *Syarikat Air Terengganu Sdn Bhd*, *Syarikat Air Darul Aman* (*SADA*), TaliWorks Corporation Berhad, *Syarikat Air Melaka Berhad* (*SAMB*), *Anak Syarikat Kumpulan Perangsang Selangor Berhad*, *Syarikat Pengeluar Air Sungai Selangor Sdn Bhd* (*SPLASH*), *Pengurusan Air Pahang Berhad* and *Air Kelantan Sdn Bhd* (*AKSB*). Water and land fall under the state government's jurisdiction. The federal government's role is to ensure that the water bodies' management is in line with international best practices.

Table 1: Dams in Malaysia (ASEAN Commitee on Disaster Management, 2019)

States	Total No.	Water Supply	Irrigation	Flood Mitigation	Hydroelectricity	Sedimentation	Recreation
Johor	17	13	1	3			
Kedah	8	2	5				
Kelantan	2		1		1		
N. Sembilan	8	7	1				
Melaka	5	4					1
Pahang	11	4	2		2	3	
P. Pinang	4	4					
Perak	10	2	1		6	1	
Perlis	1			1			
Selangor	9	6	2	1			
Terengganu	6	3	1		2		
Sabah	10	8			2		
Sarawak	9	6			3		
Labuan	3	3					
Putrajaya	1						1
Total	**103**	**62**	**14**	**5**	**16**	**4**	**2**

Gazettement of the operation and basin area is essential to secure the area from encroachment or trespassing and curb pollution and disturbances of the catchment area. The gazettement of these waterbodies is under the jurisdiction of the state government. This may well prevent the land from being developed, which may incur a significant loss of revenue for the state government. The conservation of these areas may also fall under the Protected Areas and Protected Places Act 1959.

Table 2: Selected well-known lakes in Malaysia

State	Name
Pahang	Tasik Bera, Tasik Chini, Tasik Ulu Lepar, Tasik Bintau, Tasik Chereh, Tasik Bintau, Tasik Chereh & Tasik Biru
Kedah	Tasik Pedu & Tasik Dayang Bunting
Perak	Tasik Temenggor, Tasik Chenderoh, Taiping Lake Gardens, Tasik Raban, Tasik Bukit Merah & Tasik Banding
Terengganu	Tasik Kenyir,Tasik Puteri/Bukit Besi, Tasik Berombak
Perlis	Tasik Melati & Tasik Timah-Tasoh
Putrajaya & Kuala Lumpur	Tasik Putrajaya, Tasik Perdana (Lake Garden) & Tasik Titiwangsa
Selangor	Klang Gates, Langat & Tasik The Mines
Pulau Pinang	Bukit Pancur
Melaka	Ayer Keroh
Sarawak	Bakun, Loagan Bunut & Tasik Biru
Sabah	Ox-bow lakes, Kinabatangan River

Malaysia has 189 river basins - 89 in Peninsular Malaysia, 78 in Sabah, and 22 in Sarawak (Table 2). All the rivers originate and flow from the highlands. The following are some of the more popular and bigger lakes in Malaysia, found in the states mentioned, and they are utilised for many different uses.

Pahang is the largest state (35,965 km^2) in Peninsular Malaysia and the third largest in Malaysia after Sarawak and Sabah. Pahang is bounded by Titiwangsa Range which has become the headwater for the primary river systems (Figure 3). Eleven main rivers and basins can be found in the state, covering 47,580.87 km^2 (Table 3), representing 15.15% of total rivers and basins in Malaysia. Eight rivers and basins can be found in Pahang alone, while three other rivers were shared with Johor, Melaka, and Negeri Sembilan. Sungai Pahang is the longest and largest river in Peninsular Malaysia, housing high natural resources, and is vital for the livelihood of the people around it. Sg Pahang is also connected to freshwater lakes such as Tasik Bera, Tasik Chini, and Tasik Mentiga. Tasik Bera is the Ramsar Site, Tasik Chini is the UNESCO site, and Tasik Mentiga is Malaysia's first known extinct freshwater lake. Pahang has four major ecosystems, namely, lowland forest, highland forest, freshwater ecosystem, and coastal and marine ecosystem.

Figure 3: Pahang River System (Japan International Cooperation Agency and Department of Irrigation and Drainage Malaysia, 2011)

Table 3: Rivers and Basins in Pahang

No	Name	Area (km^2)	Category	State
1	Sg Muar	6,137.80	River basin shared with more than 1 state	Johor/Pahang/Melaka/ Negeri Sembilan
2	Sg Endau	4,739.06	River basin shared with more than 1 state	Johor/Pahang
3	Sg Pahang	28,682.25	River basin shared with more than 1 state	Pahang/Negeri Sembilan
4	Sg Rompin	3,939.23	River Basin within the state	Pahang
5	Sg Kuantan	1,684.35	River Basin within the state	Pahang
6	Sg Bebar	1,117.40	River Basin within the state	Pahang
7	Sg Mercung	628.259	River Basin within the state	Pahang
8	Sg Pontian	319.723	River Basin within the state	Pahang
9	Sg Penur	146.43	River Basin within the state	Pahang
10	Sg Baluk (Sg Air Putih)	97.819	River Basin within the state	Pahang
11	Sg Cerating	88.541	River Basin within the state	Pahang

Tasik Chini

Tasik Chini Basin (TCB) (i.e. Chini Lake Basin) is located about 100 km from Kuantan. Tasik Chini is the second largest freshwater lake in the country and is endowed with a rich and extensive lush tropical wilderness. Tasik Chini Biosphere Reserve (TCBR) is an area of 6,951.44 ha (Figure 4 and Figure 5) with 12 small lakes (*laut*) covered by logged-over forest and agricultural land (RKK Tasik Chini, 2018). It is home to numerous species of flora and fauna. Between months of August and September, it transforms into a floating garden with thousands of white and pink lotus flowers covering its surface. Tasik Chini is also believed to be the site of a sunken Khmer City, and many archaeologists have mounted expeditions to locate it.

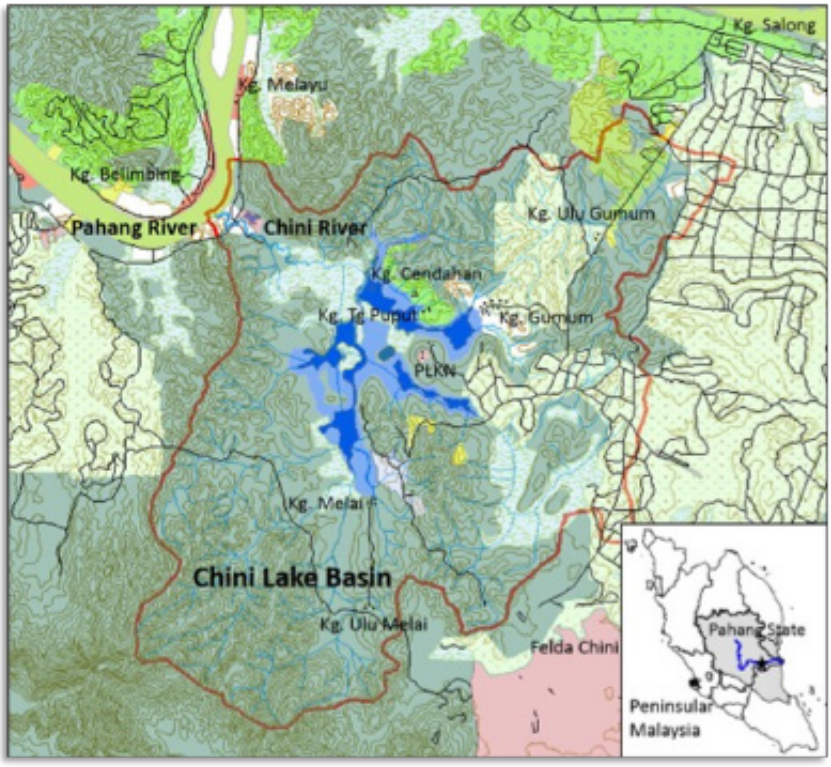


Figure 4: Chini Lake Basin (Sharip et al., 2018)

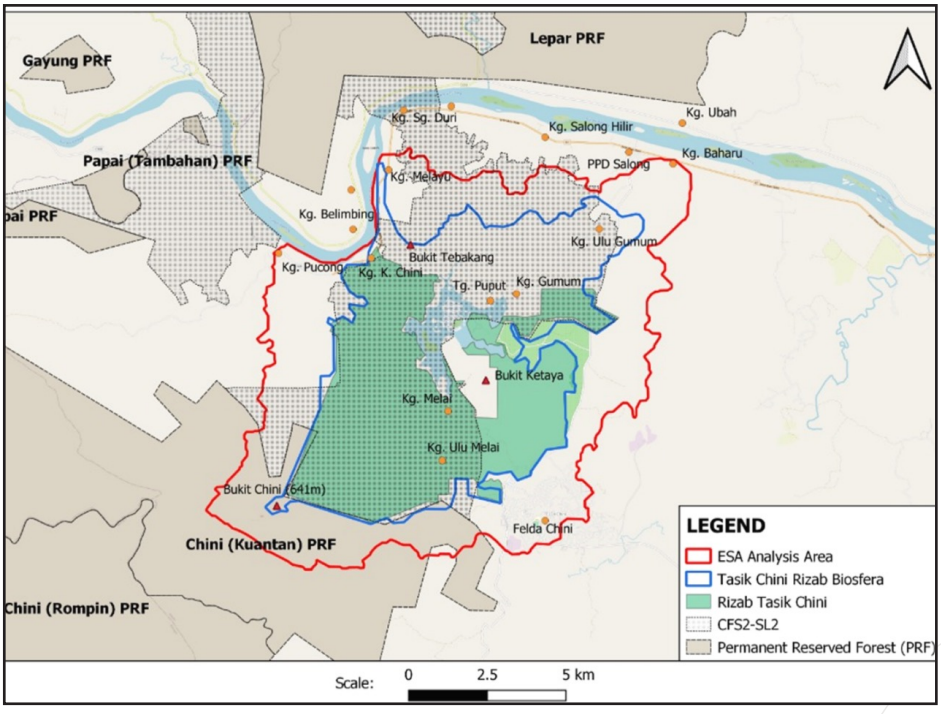


Figure 5: Tasik Chini Basin and Tasik Chini Biosphere Reserve (source: Pusat Penyelidikan Tasik Chini, UKM)

VISION AND MISSION

Objectives

The objectives of this study are as follows:

i. To review and determine the impacts on socioeconomic sustainability due to the threats and risks of existing and planned development for TCB;
ii. To recognise (diagnose) the extent of environmental damage (water and soil) based on rapid assessment techniques;
iii. To provide a brief review of the ecosystem and biodiversity status in TCB;
iv. To evaluate related governance instruments that govern Tasik Chini Basin (TCB); and
v. To recommend appropriate restoration approaches that could help accelerate the recovery process.

Study Approach

TCB and TCBR (Figure 5) are crucial in supporting various ecosystem services and, at the time, are increasingly threatened by various anthropogenic activities that stress the ecosystems (Figure 6). This study will be based on four conceptual approaches, i.e., the ecosystems' governance, socioeconomic, physical, and biological environment (Figures 7 and 8).

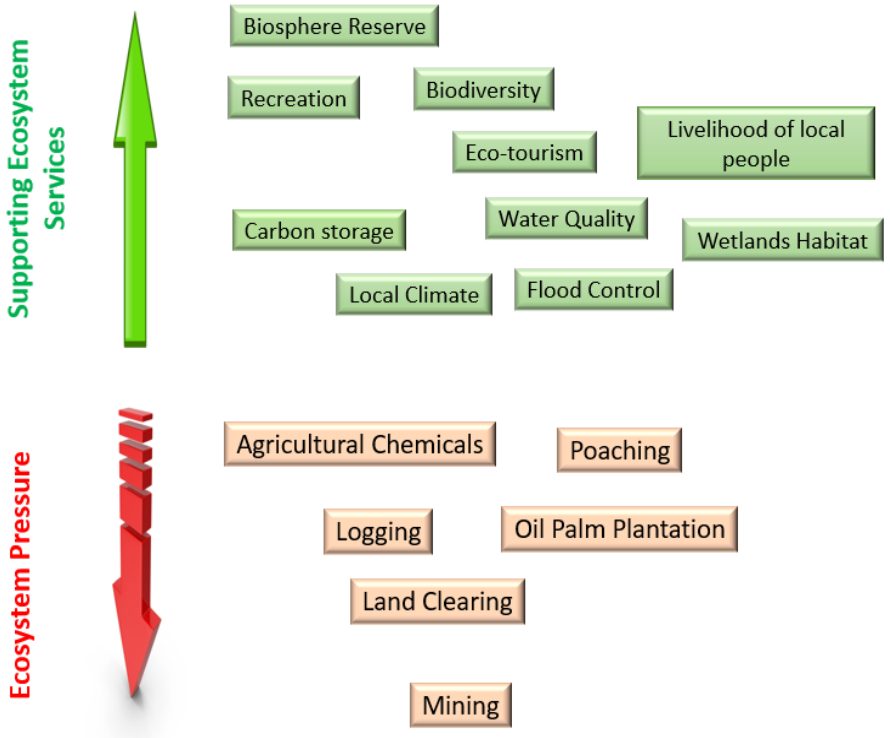


Figure 6: TCB ecosystem services and pressure

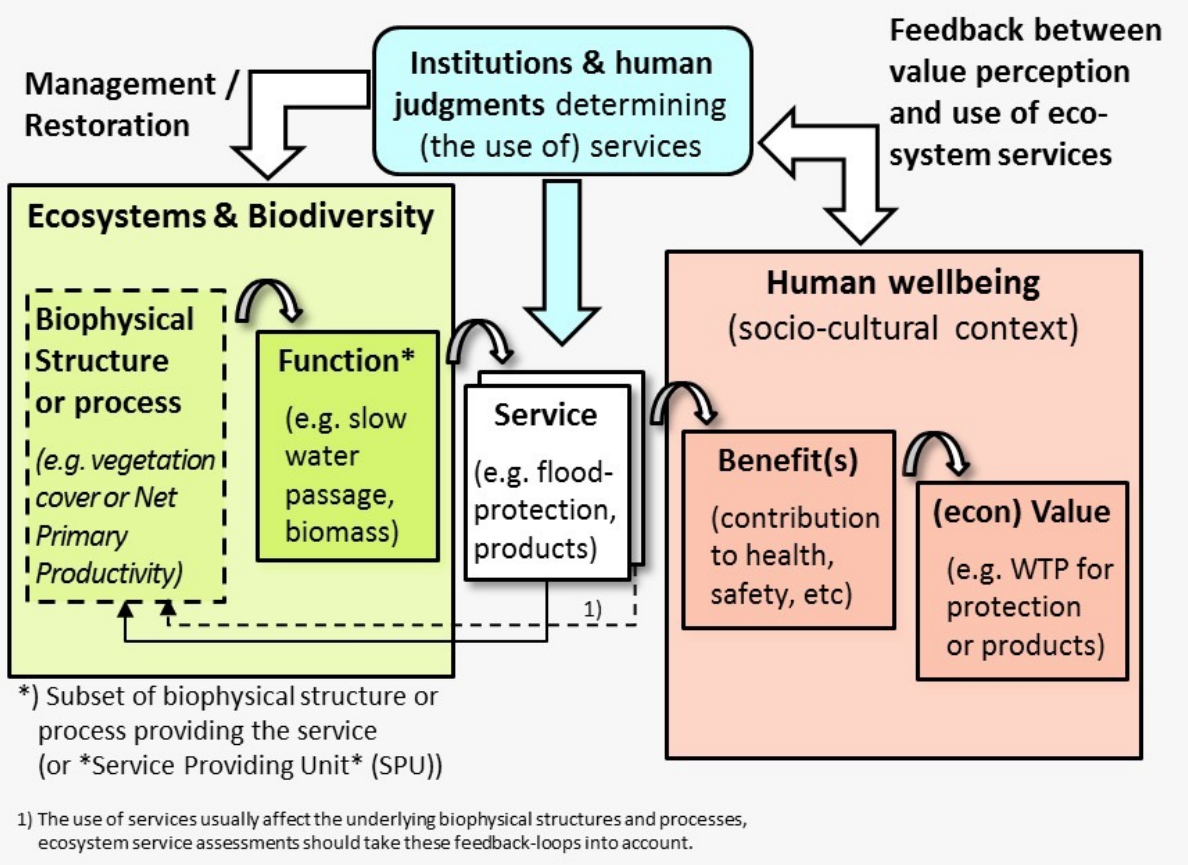


Figure 7: Conceptual framework of governance, socioeconomic and biophysical ecosystems (adapted from https://www.ecetoc.org/report-125/introduction/natural-capital-ecosystem-services/)

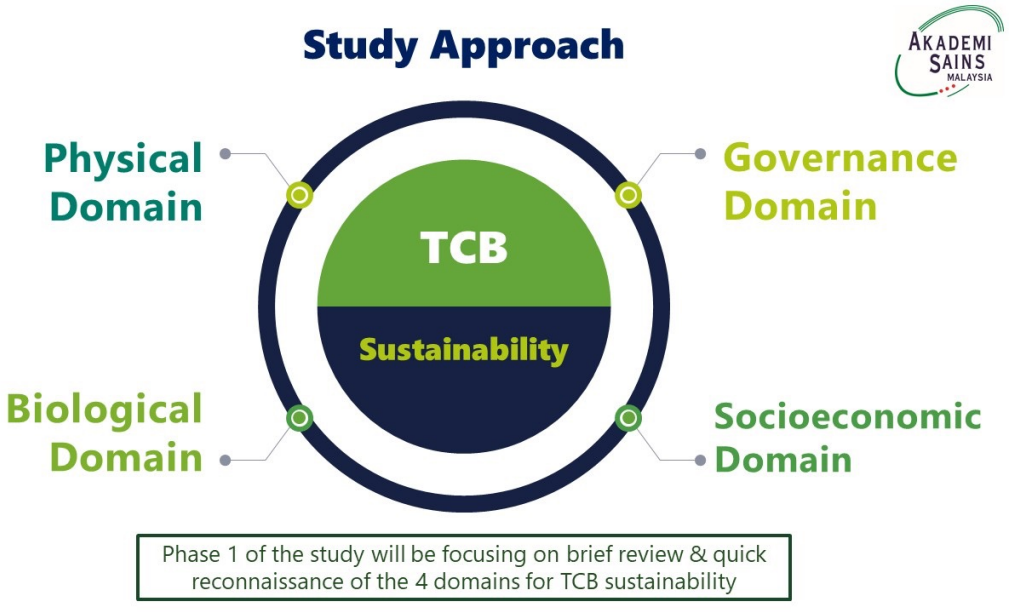


Figure 8: Overall study approach for TCB

SWOT ANALYSIS

The following Table 4 shows the overall SWOT analysis of TCB across the four domains of the study.

Table 4: SWOT analysis of TCB

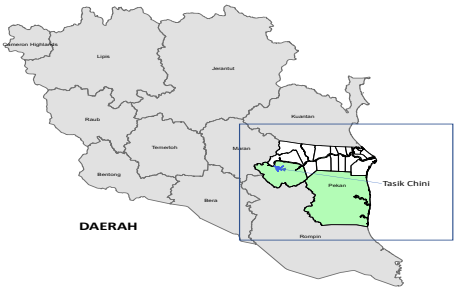
Internal	**Strengths** • Tasik Chini was designated as a UNESCO Man and Biosphere Reserve in 2009 • Extensive research has been done previously • New laws passed by the Pahang State Government on biodiversity conservation will benefit the preservation of TCB. • East Coast Economic Region (ECER) and *Rancangan Tempatan Pekan*, amongst others, may well serve as an instrument to protect TCB. • State and federal agencies, NGOs, and CSOs are both working closely and are concerned about the protection of Tasik Chini. • A deep connection to the lake, especially among the Jakun community. • Potential integrated heritage tourism activities for livelihoods diversification. • Sense of place among local communities towards TCB. • The biophysical environment is very attractive for leisure and outdoor recreational activities and nature-based tourism products. • The natural lake and swamp serve as important natural flood mitigations. • Some flora and fauna with high conservational value (Critically Endangered (CR), Endangered (EN), Endemic) should be protected and preserved from extinction. • At the community level, the area's biodiversity component has significant ecological roles and functions that benefit the whole TCB.	**Weaknesses** • Invasive anthropogenic activities such as mining, logging, and industrial plantations since the 1960s. • Long-term pollution that has been affecting local flora and fauna. • Unavailability of a system to facilitate two-way access to information by stakeholders. • Purposive governance systems, not framed for specific Lake or Lake Basin Governance. • Unavailability of a communication platform and opportunities between all agencies, stakeholders, and communities to participate. • Unclear responsibilities and accountabilities associated with the management of TCBR. • Unpublished reports on previous studies by universities and agencies. • An unclear decision-making support system can be utilised by stakeholders such as federal, state, and researchers. • Underutilisation of Tasik Chini as a functional ecosystem and green economy instrument. • Localised extinction of flora and fauna, especially the endangered and endemic species. • Reducing the appealing natural attractions for tourism activities.
External	**Opportunities** • Long-term rehabilitation project focusing on waterbodies, biophysical characteristics including flora and fauna. • Ecological and bioengineering opportunities to rehabilitate the area. • Inclusion of indigenous and local communities for lake co-management. • Strategic governance measures to ensure the sustainability of the TCB. • Capacity-building that considers indigenous and local knowledge adaptation. • Restoration and rehabilitation of natural and cultural resources. • Positive reception and collaboration with NRECC (formerly KASA and KeTSA), Forestry Pahang. • Sustainable Tourism involves communities.	**Threats** • Losing UNESCO Man and Biosphere Reserve status. • Unsustainable mining and logging practices and activities disrupting the ecological balance. • Dysfunctional biogeochemical cycles affect the natural biophysical functioning of the tropical rainforest. • Unclear measures of enforcement and political will to protect the natural heritage of the basin. • Drastic land use change. • Logging and mining activities affect overall sustainability. • Ecosystem value and long-term damage.

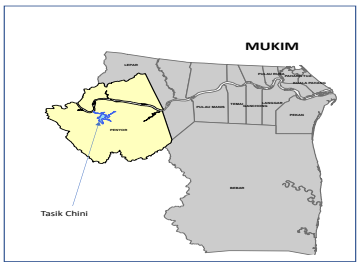
SOCIOECONOMIC DOMAIN

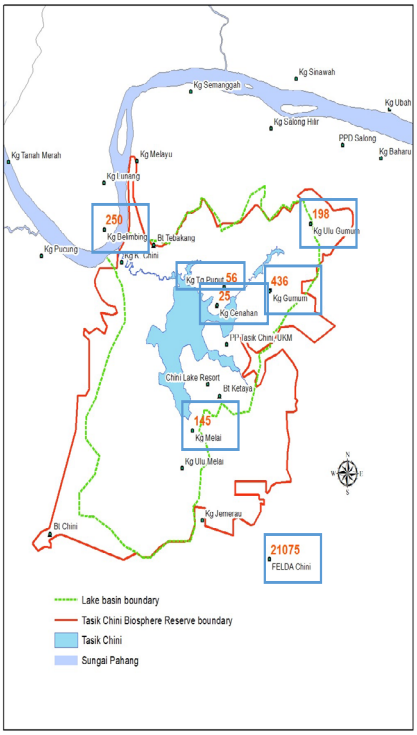
Introduction

Today, many lakes suffer from the impact of several pressures, which act simultaneously and interact in a complex manner influencing all levels of the ecosystem (Jenny et al., 2020). In such cases, the ecological status varies according to the sensitivity of lake ecosystems and the combination of pressures (Cardoso et al., 2009). With increasing development activities, the threat to water resources is also increasing; thus, there is a need to save traditional and historical water resources from being depleted completely (Singh et al., 2022). Similarly, for TCB, while development is inevitable, the impact of over the years unsustainable activities has seriously affected Tasik Chini ecosystem (Mohd Ekhwan and Sulong Mohamad, 2004).

The dire situation of TCB calls for immediate attention to be addressed, particularly in understanding the vulnerability of the indigenous and local communities to risks associated with environmental change (Sujaul et al., 2010). Over the last 30 years, Tasik Chini has been experiencing continuous development, including logging and agricultural development that started in the 1970s (Sharip and Jusoh, 2010). Thus, a basin perspective helps in the analysis of the interactions among various types of land uses and other uses. In the process, it enhances the understanding of the physical, environmental, social, and economic influences that impinge on the productivity of land use systems. It is hoped that the participation of a larger number of stakeholders can be sought and land use planning can be more effectively carried out. The broader view through a river basin is able to capture dimensions that are not normally included in a land use management approach, such as the causes (and not only the effects) of natural resource degradation, related disputes and livelihood options.







Jadual 3.14: Taburan dan Bilangan Penduduk Mengikut Pusat Petempatan, 2015

Petempatan	Bilangan Penduduk	Peratus (%)
Orang Asli		
Kg Gumum	436	1.71
Kg Ulu Gumum	198	0.78
Kg Cendahan	25	0.10
Kg Tanjung Puput	56	0.22
Kg Melai	145	0.57
Kg Resam/Kg Tanah Merah	260	1.02
Kg Tasik Mentiga	680	2.67
Jumlah Kecil	1,800	7.07
Gugusan Felda Chini		
Felda Chini 1	4632	18.20
Felda Chini 2	4455	17.51
Felda Chini 3	3642	14.31
Felda Chini 4	3454	13.57
Felda Chini 5	4892	19.23
Jumlah Kecil	21,075	82.82
Kg Tradisi Melayu		
Kg Belimbing	250	0.98
Kg Salong	230	0.90
Kg Kuala Mentiga	264	1.04
Kg Mambang	665	2.61
Kg Sungai Duri	429	1.69
Kg Baru Salong	733	2.88
Jumlah Kecil	2,571	10.10
Jumlah Keseluruhan	25,446	100.00

Nota: Zon Utama (Core Zone) Zon Penalihan (Transition Zone)

Sumber: Jabatan Kemajuan Orang Asli (JAKOA) 2016, Pahang
Pejabat Penghulu Bancian 2015
Unit Tanah, Felda Wilayah Kuantan, 2016

Figure 9: Map of TCB, TCBR, and population table

Many studies have shown that encroachment on forest reserves and wetlands as well as major changes in land cover and use in the TCB have severe concerns on the sustainability of these changes, their effect on the livelihoods of the local communities and the environmental health of TCB is raising concerns. In addition, land use changes in the TCB region have been associated with land degradation, especially soil erosion and depletion of nutrients. Previously, the basin is endowed with rich natural resources of the lake and its environment, now most of these resources are threatened with environmental challenges (Habibah et al., 2013a). The basin is also home to approximately population comprising of Orang Asli villages (7.07%); FELDA Chini settlers (82.82%); and Malay

village settlements (10.10%), most of them live below the poverty line under the category of B40 group (Figure 9). In a sense, the TCB is something of a paradox: between striking the balance of conservation and development. Interventions are critically required to initiate sustainable development within the TCB to protect the critical watershed areas and the aquatic systems for the sake of present and future generations.

The effects of socioeconomic development and land-use changes on the ecology of lakes and wetlands in the humid tropical systems, Tasik Chini as an example, are still poorly understood (Sharip, Majizat and Suratman, 2018). The main reasons for this lack of understanding are generally due to continuing management challenges resulting from sectoral practices and differences in demands of multiple stakeholders. There has also been significant socioeconomic baseline data collected from 2010-2012 for the East Coast Economic Region Strategic (ECER) Strategic Implementation Plan. However, not much consideration and implementation activities were carried out by relevant agencies based on the outcomes of the Strategic Implementation Plan (Crabtree et al., 2016).

Social Fabric of Tasik Chini Basin

Understanding social fabric of TCB encompasses numerous complex and interrelated phenomena, including demographic and economic factors, behavioural issues (e.g. investment choices, political dynamics), social institutions (e.g. families), social organisations (e.g. municipalities), and social networks, or relationships amongst people. The social fabric is underpinned by people's beliefs and sentiments, including a sense of belonging and identification with a particular social unit. The social fabric not only reinforces the economic system (Hayden, 2011) but also specific themes such as heritage, health and "sense of place". This is particularly important for the indigenous communities residing there, where myth and legend are part of the Jakun oral tradition in Chini.

It is believed that at the bottom of the lake is the site of an ancient Khmer city, from an era when the Khmer empire extended into the peninsular. The existence of seven pyramid-like hills near Tasik Chini has sparked interest in the likelihood of a lost Khmer City that could date back to the 12th century. These hills are believed to be part of a lost city submerged in water after the fall of the Khmer empire in the 15th century. Based on pieces of porcelain found in the area, the city could have been built when the Khmer empire was at its zenith. Local legend revolves around the dragon known as Naga Sri Gumum, who lives in the lake and guards the sunken ancient city. Over the decades, there have been occasional reports of sightings, but as in the case of the Loch Ness monster, these have never been scientifically proven. The legend has stood the test of time, but not the lake (Zainor, 2021).

Heritage is often a product of the social fabric, as people, families, and cultures create material and non-material products that last for generations; heritage, in turn, affects people's sense of place and may strengthen the social fabric when people organise to protect these cultural products. In particular, collective memory is important for the creation of social fabric. The health sector is also directly linked to the social fabric, this may be reflected in weak health conditions and typical poverty-linked diseases affected by poor nutrition and housing. However, based on available knowledge, there is no clear evidence to date to suggest that human health and well-being or perceptions of the communities around Tasik Chini have been considered in the expansion of mining into their areas or their daily sensory and emotional experiences of living in the TCB vicinity (Crabtree et al., 2016).

In terms of the socioeconomic profile of the Jakun community, educational attainment remains low as many of them have not attended school or have only completed primary education. Unemployment is high and average incomes are at a mean of RM 527/month. For the Malay villagers and FELDA settlers, their income range is typically between RM 1,001 to RM 1,999. Thus, they are under the category of the B40 income group. The central issue is how to better engage with people in TCB towards improving their livelihoods and well-being amidst development challenges. Omar (2011) emphasises that the people must be allowed to define working areas for themselves and not be reliant on what has been determined by others, be it government, NGOs, or higher education institutions.

Typically, the economic activities of Orang Asli are mostly as boatman, fisherman and forest product collectors, although their dependence on forest products and fishing has decreased due to the deteriorating conditions of the lakes and rivers (Sharip, Majizat and Suratman, 2018). Meanwhile, the Malay villagers and FELDA Chini settlers are involved in agriculture and farming activities, they are either working on their own small plot of land or working in FELDA plantations. The younger generations are mostly involved in tourism-related sectors, rubber and oil

palm plantations while some Orang Asli still collect jungle products as their side or personal consumption.

Strengthening the social fabric of the people in TCB involves all, concerted collaboration between communities, agencies, and other interest groups, in working together to stop deforestation that threatens the land. This emphasis the spirit of cooperation resonates in the pantun at the beginning, when Noorhayati essentially highlights the present-day problems that have affected Tasik Chini and the question of why we are so detached from the ecological havoc that is happening there like "shadows" and "foreigner". However, it is encouraging to observe greater public awareness from headlines in newspapers, i.e., 'Act Now to Save Tasik Chini (NST, 2019a); 'Can a Dying Lake be Revived? (The Star, 2016)'; 'Chini Lake is Crying (2013)', etc, in the newspaper, whilst media, NGOs and activists working on the ground to bring the plight of the lake to the fore are indirectly reactions to Noorhayati's question on the feeling of 'detach' towards Tasik Chini. The call for more proactive, political will, transparency and commitment in managing the TCB's environment are crucial to ensure successful rehabilitation and recovery processes (Picture 1, Picture 2 and Picture 3).

Save our lake: Jakun tribe members Nor Airisha Janius, four, holding up a badge to spread awareness of Tasik Chini's plight while (from left) Nurhayati Idam, 32, Nor Samira Shafie, nine and Sarina Sarip, 18, look on
(Rahim, 2012)

Former Prime Minister Dato' Sri Haji Mohd Najib bin Tun Haji Abdul Razak launched the Tasik Chini Freshwater Laboratory as part of the Tasik Chini Research Centre (PPTC)
(New Straits Times, 2016)

Land being cleared near Tasik Chini
(Alagesh, 2017)

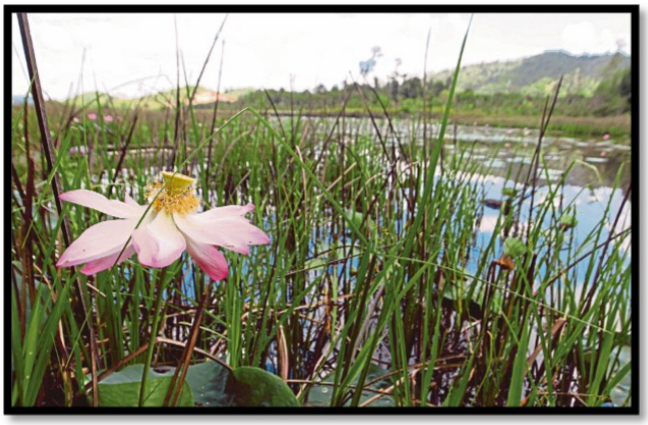
A man fishing at Tasik Chini
(Alagesh, 2017)

Figure 10: Selected newspaper reports on Tasik Chini related to environmental and socioeconomic conditions

Tasik Chini's ecosystem is claimed to be in critical condition due to unregulated agriculture, logging and mining
(Alagesh, 2017)

The New Straits Times had recently reported that Tasik Chini, the second largest freshwater lake in Malaysia, was at risk of destruction due to rampant iron ore mining at Bukit Ketaya near the lake
(Anon, 2019a)

The Pahang state government has gazetted an area of 4,900 hectares in Tasik Chini as a permanent forest reserve
(Bernama, 2019)



Surrounding area of Tasik Chini Resort
(Bernama, 2020)

Figure 11: Selected newspaper articles on Tasik Chini related to environmental and socioeconomic conditions

Associate Professor Dr Rosdiadee Nordin (second from left), Dr Kentaro Ishizu (centre), Dr Nor Fadzilah Abdullah (fifth from left) and Dr Fumihide Kojima (right) with the Airborne IoT Network
(Rafidi, 2019)

This file pic dated June 15 shows the mining and deforestation activities taking place around Bukit Kampung Melai, Tasik Chini
(Bernama, 2021a)

A picture of Tasik Chini which recently went viral shows mining activity taking place in the vicinity of the lake. — Picture via Facebook
(Aldrie, 2021)

Boatmen Amran Yahya, 63, (left) and his son Muhammad Azarol Hafiz, 32, used to bring tourists to see the various sights around Tasik Chini until the lake resort was closed in November 2019
(Alagesh, 2020a)

Figure 12: Selected newspaper articles on Tasik Chini related to environmental and socioeconomic conditions

Table 5: Selected desktop review of socioeconomic related issues in TCB

ISSUES	CHALLENGES	ADAPTATION INTERVENTIONS
• Forest exploitation for unsustainable agricultural, mining, and logging activities have altered the ecological & environmental balance in the area, reducing Tasik Chini's suitability as a tourist destination • Opportunities for diverse livelihoods • Demolition of the weir • Critical need in improving Tasik Chini's water quality • Traditional livelihood dependence on forest products and natural resources • Providing better facilities for tourism activities is required • Traditional economic modes and sources of income for cultural preservation • Appreciation of scenic landscape and surroundings	• Not many studies emphasise on the quality of life of the Jakun community • The Jakun of Tasik Chini's readiness and participation to be involved in tourism activities are still low • Land ownership matters • The Orang Asli community has no place to participate • Tasik Chini matters are being addressed by a number of overlapping authorities (agencies, departments) with little communication amongst them • Limitations of the indigenous community's rights for survival and livelihoods • Health threats and infectious diseases due to poor environmental conditions	• Cooperation between the community and relevant agencies is essential • Ecotourism activities based on Orang Asli and local culture, homestay and kampung stay concepts should be considered • Expand community advocacy and awareness on sustainability matters are needed • Rehabilitation of forest and sustainable resource utilisation, scientific and Indigenious Knowledge and Local Knowledge (IKLK) • Inclusion and respect towards knowledge of Orang Asli and local communities to ensure they are actively involved • Promote citizen scientists and local ranger's programmes amongst the Orang Asli and local communities • Governance mechanisms to be strengthened, more transparency & accountability • Community-based agroforestry, capacity-building and life-long learning • Community disaster preparedness and resilience in local context • Policy design especially for the poor and low-income communities to lessen the impacts of disaster.
Sources: Sharip and Jusoh, 2010; Hezri and Chan, 2012; Sharip, Majizat and Suratman 2018; Ahmad, 2021; Haliza, 2021; van der Helm n.d; Bernama, 2019; Anon, 2019b; Bernama, 2021a; Chan, 2021; Zubaid, 2021	**Sources:** Omar, Man and Yussoff, 2011; Habibah, Hamzah and Mushrifah, 2010; Crabtree et al., 2018; Sharip, Majizat and Suratman, 2018; Parker et al., 2019; Zanisah and Yeoh, 2019; Rareez, 2020; Ahmad, 2021; Ida and Rahaya, 2021; Haliza, 2021; Jerry, 2021; Norazwani, 2021	**Sources:** Crabtree et al., 2016; Nasrudin et al., 2018; Sharip, Majizat and Suratman, 2018; Sadeka, Mohamad and Sarkar, 2020; Ida and Rahaya, 2021; Asrol, 2021a,b; Alagesh, 2021

Approach

Vulnerability Concept

Vulnerability is conceptualised as a function of exposure to environmental stresses and adaptive capacity to cope with these stresses. In general, indigenous knowledge, local knowledge, and social learning help communities to cope and adapt to environmental change. However, the speed of environmental change has undermined and challenged communities in continuing their everyday lives. Relationships between indigenous communities and local communities with place are particularly important in that they provide a foundation for belief systems, identity, knowledge, and livelihood practices that underlie mechanisms through which environmental change is experienced, understood, resisted, and responded to. Initiatives to identify adaptation interventions in improving local adaptive capacity start with understanding the vulnerability of the TCB in terms of who is vulnerable, to what stresses, in what way and what capacity exists to adapt to changing risks.

Therefore, the socioeconomic domain of this study serves two-fold objectives, first is to understand vulnerability to risks associated with environmental change; and second is to discuss existing adaptation interventions carried out in addressing socioeconomic impacts faced by the communities in the TCB. The analysis of this domain utilises the vulnerability framework (Turner et al., 2003) that illustrates human–environment conditions of the system to determine its sensitivity to any set of exposures, as illustrated in Figure 10 with details of the exposure, sensitivity, and resilience components. These conditions include both social and biophysical capital that influences the existing coping mechanisms, which take effect as the impacts of the exposure are experienced, as well as those coping mechanisms adjusted or created because of the experience (Turner et al., 2003).

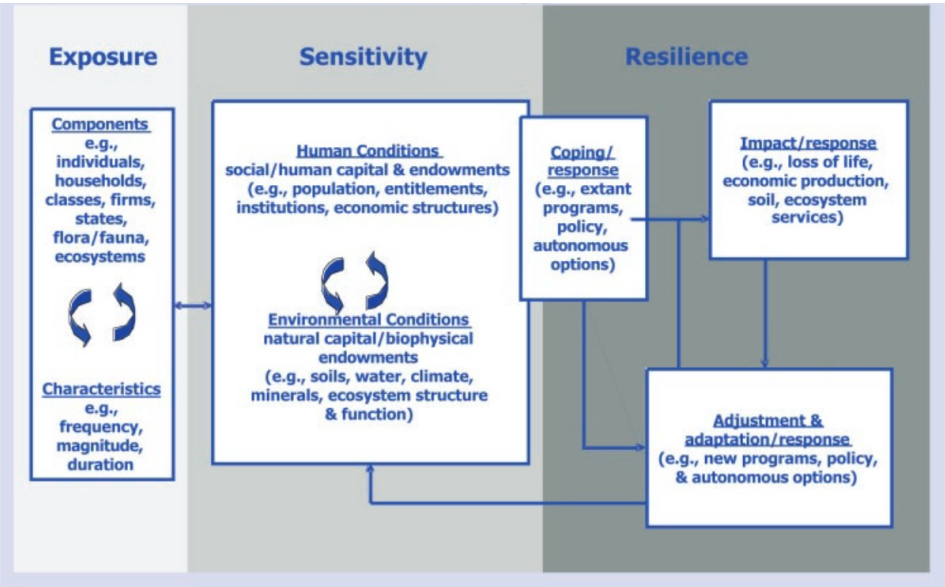


Figure 13: Vulnerability framework (adapted from Turner et al., 2003)

The natural hazards literature contains many definitions of vulnerability, which can be generalised as "the potential for a loss" (Cutter, 1996). Throughout much of the 20th century, hazard research viewed vulnerability as a purely physical phenomenon. It was not until the later part of the century that researchers began to recognise that social and economic factors contribute to vulnerability as well (White, 1975; Flanagan et al., 2011). The hazards of place model, developed by Susan Cutter, groups community vulnerability into biophysical and social vulnerability. Biophysical vulnerability arises from a community's geographic context and the probability that it will be exposed to a hazard. Social vulnerability arises from the community's "social fabric", which includes socioeconomic and demographic characteristics that affect community response, coping, and recovery from a hazardous event (Cutter, 1996).

Social capital is another factor that has been shown to be important in community disaster recovery (Aldrich, 2012; Norris et al., 2008; Nakagawa and Shaw, 2004). Social capital is defined as "social networks and the norms of reciprocity and trustworthiness that arise from them" (Putnam, 2000). Communities with strong social networks

are more likely to work together during the recovery process and are more likely to have connections with government agencies and aid organisations that can provide resources for recovery. Social capital can also reduce vulnerability as strong social networks can facilitate the sharing of hazard warnings allowing people more time to prepare or decide to evacuate. Communities with higher levels of social capital may also be more successful in coordinating and sharing resources in preparing for disasters.

Turner et al., (2003) state that comprehensive vulnerability analysis ideally considers the totality of the system. In reality, this is unrealistic due to real world data and other constraints invariably necessitate a 'reduced' vulnerability assessment. Thus, for the purpose of this study, the vulnerability analysis of the socioeconomic domain would only be able to discuss components of i) linkages to the broader human and environmental conditions ii) stress that emerge from these conditions iii) elements of coping, impacts and adaptation responses. Utilising this framework assists in understanding the growing role of multiple stakeholders in defining vulnerability problems, particularly for localised concerns such as TCB's human-environment systems.

Data Sources

Data was collected primarily using secondary sources. Secondary data collection involved a review of existing reports (unpublished, grey, and published reports) from the library, documentation centres, the internet, and archival records. A total of 156 references were obtained from eight different sources, (Figure 11), of which 44 are journal articles (Figures 11 and 12) from various indexing and non-indexing systems (Table 6). Apart from that, 18 common keywords were found in these 44 journal articles (Figure 13). These predominant keywords provides an overview of the issues discussed in the articles, namely local involvement; Orang Asli; water quality; heavy metal; natural capital; degradation and life quality; land use and land cover change; and local tradition and indigenous knowledge.

Expert panel interview discussion was conducted to gain in-depth insight on TCB-related matters from researchers, namely Associate Professor Dr Mustaffa Omar (Albukhary University), Dr Rozita Ibrahim (Pusat CITRA, UKM) and Pn Nur Amelia Abas (Pusat Penyelidikan Tasik Chini, UKM) on the 26th of October 2021, via Google Meet online. The main issues discussed were mostly addressing sustainability of TCB, consisting of level of community engagement, education, skills and employment opportunities and capabilities, children and youth potentials, motivation and community aspiration, challenges of declining natural resources as well as institutional support, leadership, and political will.

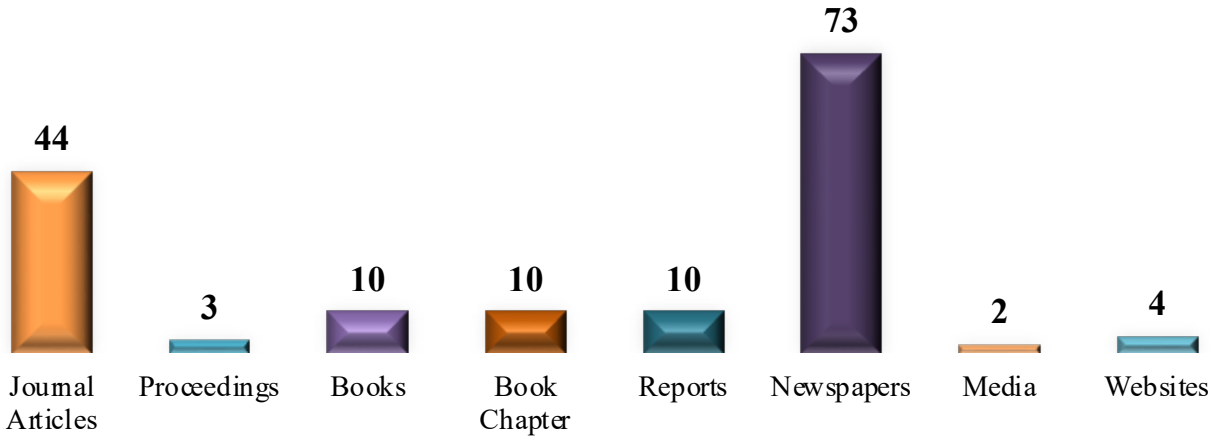


Figure 14: Type of references utilised for review related to socioeconomic impacts of Tasik Chini Basin (N= 156)

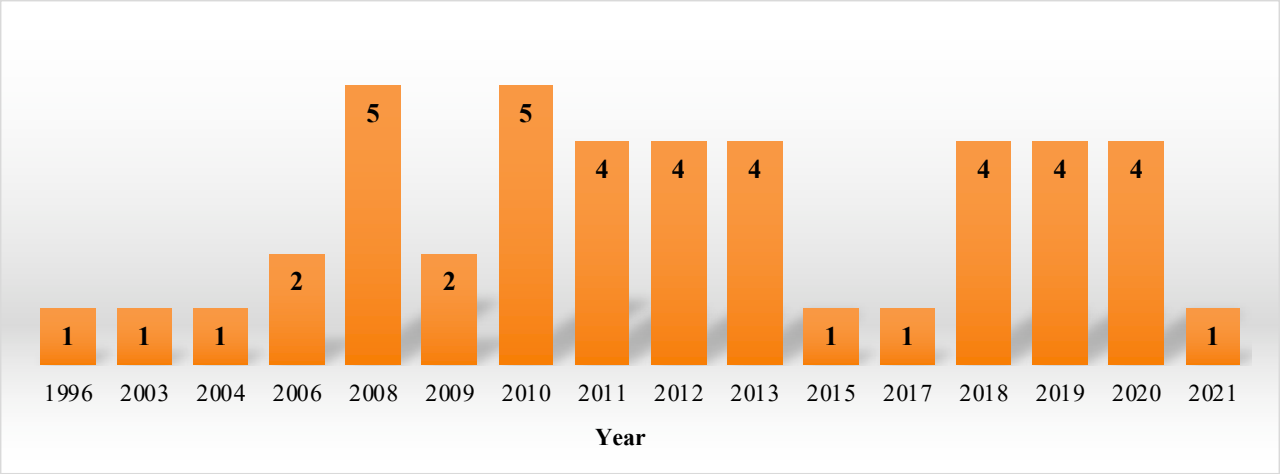


Figure 15: Selected journal articles related to socioeconomic impacts of Tasik Chini Basin (n=44)

Table 6: Types of indexed journal for selected article journals on Tasik Chini socioeconomic study (n=44) (Refer Appendix 1)

Index	Total
SCOPUS	23
Web of Science	8
MyCite	1
Non-Index	12

Figure 16: 18 Common keywords generated from 44 different journal articles related to issues on socioeconomic impacts of Tasik Chini

In addition, fieldwork to Chini was conducted on 16-19 March 2022 (Picture 4 and Picture 5) and informal interviews were conducted with the villagers in Kg. Gumum, Kg. Ulu Melai, Kg. Dusun and FELDA Chini. Besides that, several formal discussions were held in Kuantan at the Department of Orang Asli (*JAKOA*), PLANMalaysia, and District Office of Pekan. Stakeholder engagement workshop was also carried out via online on 7 April 2022 with attendees mostly from government agencies, NGOs, and university researchers. These informal and formal sessions were purposefully held to gauge a better understanding of the recent activities in TCB, particularly in the context of socioeconomic matters, income-generating activities, land use changes, and coping strategies at community and institutional levels.

Figure 17: Fieldwork on 16-19 March 2022 at Tasik Chini, FELDA Chini & Kg. Dusun

Figure 18: Water storage container for houses in FELDA Chini

Key Findings

Objective 1: Vulnerability to risks associated with environmental change

a) Linkages to the broader human and environmental conditions

Participation has the potential of increasing resource conservation by allowing local community and stakeholders to manage resources in a sustainable manner. Ultimately, participation should be considered as early as possible and throughout the process of resource conservation.

b) Stress that emerges from these conditions

The people with the most to lose are those living with or closest to natural resources, in this case, the Jakun communities of Tasik Chini. They should be given proper tools and incentives to assist in conservation programmes.

Poverty alleviation, empowerment and cultural integrity are needs of the community to be addressed together with the management and utilisation of natural resources. Local and indigenous communities' knowledge should be given adequate attention in developing and managing land and water resources. In most cases, the involvement of local and indigenous communities is lip-serviced to satisfy certain established demands for projects to take on.

The ability of communities to remain self-sufficient is being substantially eroded by the cumulative environmental damage. Their options to take monies for palm oil holdings offer no real solution to poverty, as individual families cannot manage the crops themselves or expand their holdings or even the intensity of crop production (Crabtree et al., 2016). This situation further exacerbates them to the position of state dependents and, in doing so, push them even more into marginalised and disadvantaged position than before.

Objective 2: Interventions carried out in addressing socioeconomic impacts faced by the communities

c) Coping and adaptation responses

In 2012, the Orang Asli of Tasik Chini had submitted a 'Memorandum untuk Memulihkan Kemerosotan Tasik Chini, Pahang' to the former Prime Minister Dato' Sri Haji Mohd Najib bin Tun Haji Abdul Razak (Picture 6) expressing their concerns about the lake and its surrounding environment. To date, no specific actions have been taken in response to the Memorandum.

Participation integration of local communities and Orang Asli in TCB will support the sustainable management of the lake basin (Sharip, Majizat and Suratman, 2018). This integration facilitates local and indigenous knowledge together with scientific evidence provided by relevant agencies to conserve the environment.

Typically, this integration process is seen in other case studies such as in Kalahari (Reed, Dougal and Taylor, 2007) and South Africa (Novoa et al., 2016) to ensure adaptation to land degradation and reduce conflicts through participatory involvement of stakeholders.

The forest is like the people's bank, and the lake their supermarket' as expressed by Mr Nubi of Tasik Chini (Crabtree et al., 2016). Therefore, rehabilitation of forest trees (i.e. gaharu, rattan, bamboo) should be enhanced to sustain local communities' needs for their food, identity, and cultural survival.

Figure 19: Local community representative at the submission of memorandum to the YAB Prime Minister of Malaysia

Way Forward: Considerations

Priority area 1: Rehabilitation of forest and sustainable resource utilisation, utilising scientific and Indigenous Knowledge Local Knowledge (IKLK)

- Limitations of the indigenous community's rights and dependency for survival and indigenous knowledge preservation (Omar, Man and Yussof, 2011).
- Educational and capacity-building aspects are affecting the level of confidence amongst local community participation in working together with agencies for sustainable resource management.
- Inclusion and respect towards knowledge of Orang Asli and local communities to ensure they are actively involved in managing resources sustainably.
- Local communities' suggestion for rehabilitation includes the removal of weir.

Priority area 2: Proper training and motivation in the form of employment creation and re-skilling should be provided for the community. The outcome will be a win-win situation for the community and TCB in terms of improving livelihoods improvement.

- Local communities in the TCB, particularly Orang Asli, have limited opportunities to participate in diversifying their livelihoods.
- Appropriate policy and organisational steps to enhance the community in the participation of community-based resources management. The right mix of top-down and bottom-up initiatives. More research on the potential of cooperative and community-centred initiatives.
- Sustainable agriculture production through organic farming run by Orang Asli and local communities.
- Ecotourism activities based on Orang Asli and local culture, homestay and kampung stay concepts.
- Existing social, financial, and physical capital capacities amongst Orang Asli and local communities in ensuring the success of informal and formal initiatives to improve livelihoods and well-being.

Priority area 3: Pro-active involvement of the stakeholders and the prudent management of local resources in TCB, particularly in ecotourism development.

- Integrated and collaborative research amongst scientists, local communities, and stakeholders.
- Community Learning Centre (CLC) set up is a local educational institute outside of the formal education system for rural areas, usually developed and managed by local people to provide various lifelong learning opportunities.
- As of 2013, more than 10 programmes have been organised to cater various SAVE tourists (Scientist, Academic, Volunteer and Educational). The introduction of SAVE tourism is currently managed by Pusat Penyelidikan Tasik Chini (PPTC), UKM, as an ideal experiential learning. More platforms and opportunities to run these programmes for awareness and capacity-building.
- Orang Asli communities involved as boat drivers for their livelihoods have been affected since 2017 and conditions are worse during COVID-19 pandemic. The 'Visits Pahang Campaign' does not bring any promotion to highlight ecotourism activities in Tasik Chini due to the lack of new tourism products that could potentially attract more tourists (Mamat, 2020).
- Communication platform between local communities and various agencies to be further improved.

Priority area 4: Disaster preparedness programmes to be enhanced with local community coping mechanism.

- Crucial to address their socioeconomic vulnerability as they are also prone to disaster.
- Low level of disaster preparedness amongst the Orang Asli families (Sadeka et al., 2020).
- Inclusive disaster preparedness policy for the Orang Asli families towards building a disaster-resilient community.
- Different organisations are currently working in Tasik Chini to reduce disaster risks and improve the livelihood of the Orang Asli people.

PHYSICAL DOMAIN

Geology

Geologically, Tasik Chini area comprises four stratigraphic groups. The oldest to the youngest is the carboniferous metasedimentary rocks, the mixed Permo-Triassic sedimentary and volcanic rocks, the Jurassic-Cretaceous sedimentary rocks, and the Quaternary sediments. Plutonic and volcanic rocks are also widespread and exposed as small separate bodies. The detailed geological formation of Tasik Chini area has been described by Basori (2014).

The Carboniferous Sequence are observed in the northeastern part of the Tasik Chini area (Figure 14), which correlates to the Eastern Belt of rock distributions. The sequence is a part of the Kuantan Group of Foo (1983) which is locally developed in the Kuantan area. The lithology is characterised by metamorphic rocks of interbedded slate, phyllite, schist and quartzite (metasandstone) Department of Mineral and Geoscience Malaysia, 2004). The age of the Kuantan Group is constrained as the Early to Late Carboniferous (Metcalfe, 1980), and its depositional condition is interpreted as a shallow marine environment (Foo, 1983).

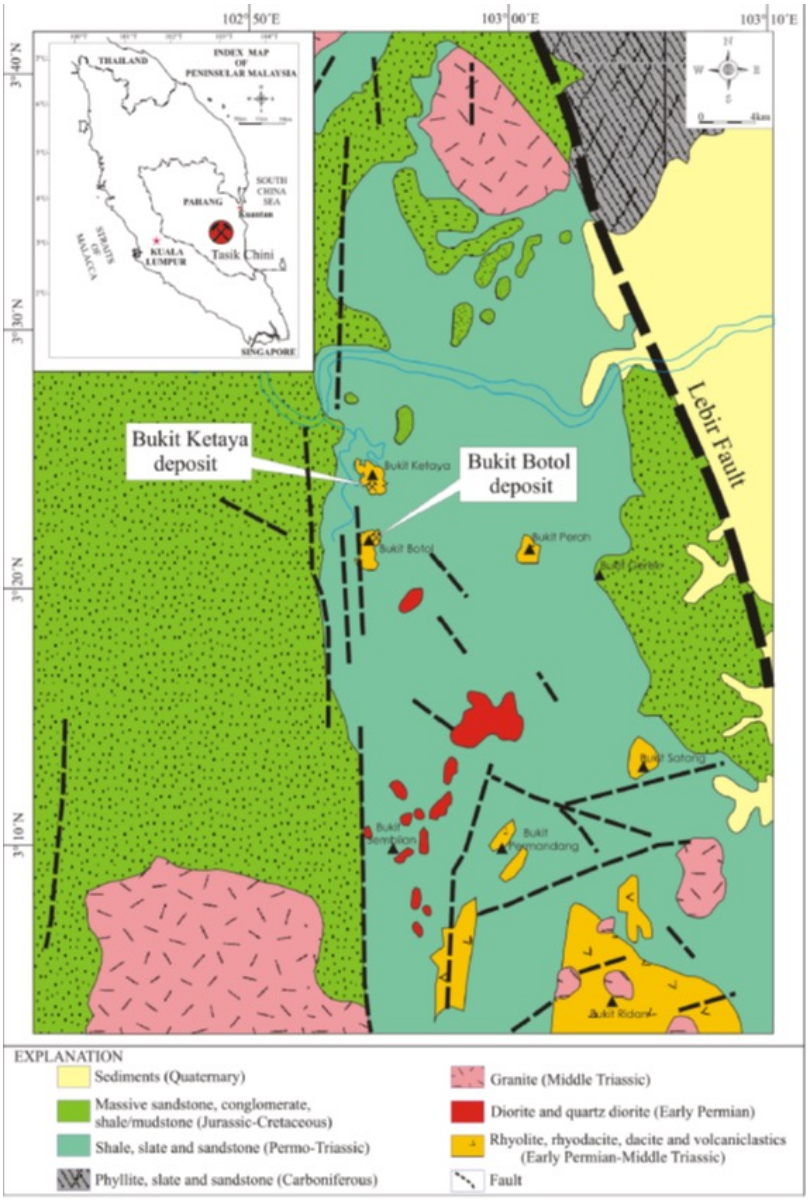


Figure 20: District-scale geology of the Tasik Chini area (source: Basori, 2014)

The oldest rocks in the area are of Permocarboniferous age, underlain predominantly by the Bera formation. They are associated with volcanic facies, siltstones, mudstones quartzite-conglomerate, quartzite, shale, chert, phyllite, schist from the cretaceous formation and referred, provisionally, to the Triassic. The Bertangga Sandstone occurs at the southwestern corner of the area, while the low-lying areas around the lakes and along the main rivers are underlain by Quaternary deposits.

Pahang is rich with various metal and non-metal minerals. Mining industries are one of the significant contributors to the state's revenue. Throughout 2020, the mining industry in Pahang continued to operate with 72 active mines. The main minerals are gold, tin ore, iron ore, manganese, silica sand, and kaolin. By comparison with other states in Malaysia, Pahang has 39 out of 58 iron ore mines in Malaysia, seven out of 14 gold mines, 11 out of 23 Manganese mines and seven out of 14 tin mines. There were 243 applications involving various types of tenement applications in 2020. The value of mineral production from the mineral tenement in the state of Pahang in 2020 is RM756.27 million, which is 36% of the total production value of the country's mining sector. The total royalty collected by Pahang Land and Mines Office is RM41.02 million (Department of Mineral and Geoscience Malaysia, 2020). Overall, it is found that the mining industry in Pahang is still showing positive growth. TCB is also rich with iron, manganese, and gold. The mining areas are located just south of Tasik Chini (Figure 15). As of 2022, two mining concessions are still active, three are in the registration process for a new mining operation, three applications were rejected,

and one is preparing Environmental Impact Assessment (EIA) report as part of the requirement for a mining license application. The lake is protected by a perimeter buffer (Figure 15, in blue). The buffer width, however, may not be adequate to protect the water body from land use activities.

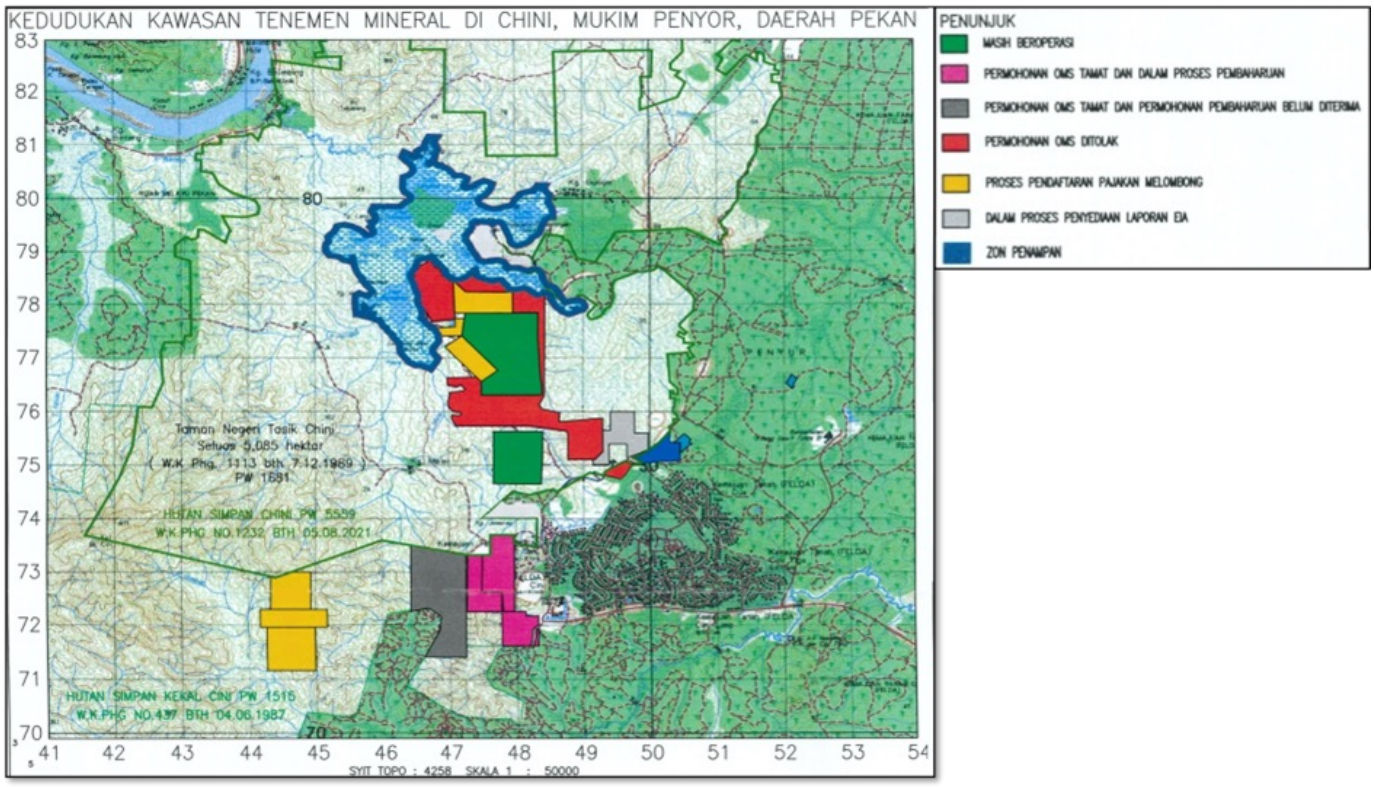


Figure 21: Status of mining concessions in the Tasik Chini Basin
(source: Department of Director General of Land and Mines Pahang (*JKPTG* Pahang))

Hydrology

Tasik Chini is in an area of humid tropical climate with a daily average temperature ranging from 21 – 32°C and an annual average rainfall of 2,700 mm (Harris et al., 2014). Larger portions of the rainfall are recorded during the northeast monsoon and the transition of the southwest to northeast monsoon between October and January (Gasim et al., 2009). February, March, and April are dry months with monthly rainfall ranging from 16.2 mm to 554 mm. The average annual amount of rainy days is 178.

The lake hydrology seemed to be affected by the extended dry period during the late 1930s as reported by Briddon et al., (2020). This reduced the lake water level and subsequently caused hydrologic isolation of the sub-basin area near the outlet of Sg. Jemberau (Barker et al., 1994).

Water enters the lake via multiple rivers including Sg. Melai, Sg. Jemberau, and Sg. Gumum. The lake outflows to the northwest via Sg. Chini into Sg. Pahang, which can become an inflow during periods of high precipitation, resulting in the inundation of the lake and elevated concentrations of suspended solids (Mir et al., 2010; Shuhaimi-Othman et al., 2008). Stream flow from various feeder rivers into the Tasik Chini is relatively low, ranging from 0.0042 to 0.9083 m^3/s (average = 0.1674 m^3/s). The highest flow of 0.9083m^3/sec is from Sg. Kuala Merupuk and the lowest of 0.0042 m^3/sec is from Sg. Melai.

The inflow to the lake is generally small, resulting in low water levels and disrupted navigation especially for the tourists. To overcome this, a weir was constructed in 1995 near the outlet of Sg. Chini to Sg. Pahang. The weir construction has increased the lake water level by about 2 m and expanded the surface water body by 2.4 km^2. However, this has caused unintended repercussions as follows:

- Depletion of *Nelumbo nucifera* (water lily) as a sudden increase in water level. especially during flood, will detach or snap the plant root from the soil. A water lily is a floating plant with its root embedded in the lakebed.
- Changing the lake system from semi-lotic to lentic system.
- Increase C/N ratio of the lake sediment due to plant decay.
- Change in the assemblage of diatom with an increase in autochthonous production relative to allochthonous.

According to Sharip et al., (2012) the survival of native species *N.nucifera* is badly affected by rapid changes in the water level due to large floods. In particular, the monsoon floods in September 2009 and April 2010 had damaged and removed *N. nucifera* and subsequent invasion of *Cabomba furcata* (Misai Kuching).

Water Quality

Most of the existing reports describe the lake and river quality in terms of water quality standards based on the six parameters. Arafat et al., (2016) examined the water quality at ten locations in the lake Chini and another five locations at selected tributaries. The lake water quality generally falls under Class II while three out of five tributaries were under Class III. The main sources of pollutants come from human habitation and agricultural runoff. Though the sampling was conducted during normal and wet seasons, the sampling campaign did not clearly specify the flow condition (rising or falling hydrograph). For a small catchment, the river quality responds rapidly to storms with marked increases or dilutions with increasing discharge and is strongly influenced by first flush phenomena (Chow et al., 2013).

The concentration of heavy metals in water and sediment in Tasik Chini was reported by Ebrahimpour and Mushrifah (2008). High concentration of lead was detected at locations where boating activities take place. Though heavy metals concentration in water is still not alarming, an acidic water environment may dissolve metal complexes and release heavy metals (Pb and As) into the water column.

Changing in nutrient status from poor (oligothrophic) to nutrient-rich (eutrophic) due to increased loading of phosphorous via agricultural runoff associated with fertiliser application in oil palm plantations and other agricultural land was reported by Zati et al., (2014). The eutrophication effect is evident from the widespread growth of macrophytes. Nutrient enrichment in Lake Chini is a concern and may have a strong impact on the composition of the plant community and the population dynamics of *C.furcata* and *N.nucifera* (Zati et al., 2012).

In more recent work, Zati et al., (2016) found that the lake water quality is influenced by macrophyte production. However, the dissolved and particulate organic carbon accounted for the major fraction of organic matter content. Advective transport driven by wind stress was the dominant physical force that shaped the water quality variations during the dry season. Convective circulation intermittently influenced the circulation during calm conditions.

Erosion and Sedimentation

Soil risk assessment in the TCB was carried out by Sujaul et al., (2012) using the Revised Universal Soil Loss Equation (RUSLE). As shown in Figure 16, the soil risk was classified into five categories, namely very low (< 10 ton/ha/yr), low (10-50 ton/ha/yr), moderately high (50-100 ton/ha/yr), high (100-150 ton/ha/yr), and very high (>150 ton/ha/yr). About 71.5% of the soil in the basin area falls under the very low-risk category and about 13.25% is under very high-risk category. Besides land use, the erosion risk is strongly influenced by the soil texture or, specifically, the erodibility. The highest erosion risk in TCB is found for Kedah series which is characterised by low organic matter contents and clay loam in texture. It's important to note that the existing mining areas are in the high erosion risk category.

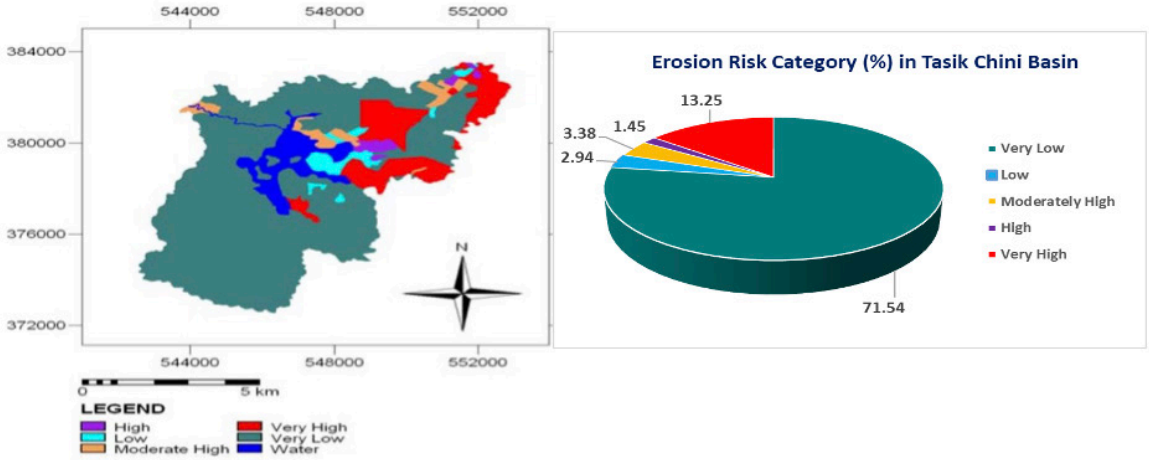


Figure 22: Erosion risk category in TCB (source: Sujaul et al., 2012)

Most of the existing reports describe the lake and river quality in terms of water quality standards based on The average sediment concentration measured from Sg Chini was 31.02 mg/L during normal season, 37.78 during rainy season and 19.18 mg/L during post raining season (Kamarudin et al., 2016). The value for normal season is quite high but the rainy season concentration is low compared to reported values in forested and agricultural catchments. For example, Mokhtar (2010) found the mean concentration of Suspended Solids (SS) for ten storm events ranging from 40.4 mg/L to 1425.7 mg/L in a matured oil palm plantation in South Johor. A maximum concentration of 2710 was recorded during one of the storm events. In another study, Yusop and Anhar (1994) found that mean stormflow concentrations of SS were up to 50 folds higher than the based flow concentration in two catchments recently affected by selective logging. This discrepancy highlights the importance of having intensive sampling during storm events to cover the range of concentration on the rising and falling limbs of the hydrograph. Weekly or periodic sampling tends to miss critical samples leading to a gross underestimate of the SS concentration and other parameters that are often subjected to first flush phenomenon (Chow et al., 2013).

Despite the high rate of predicted soil loss by RUSLE, the measured sediment yield based on SS concentration and flow values were much lower, ranging from 0.06 – 0.17 ton/ha/yr for various river tributaries. It is expected that the predicted soil loss will be higher than the measured sediment yield at the catchment outlet because the former does not consider the redeposition process along the hillslope and in streams. For a comparison, sediment yield values from forested and agricultural catchments are plotted as shown in Figure 17. The average sediment yield from primary and matured secondary forests was 0.81 ton/ha/yr with a minimum of 0.17 ton/ha/yr. Disturbed catchments, mainly by selective logging and land conversion, have a much wider range of sediment yield values with a maximum of 28.3 ton/ha/yr for logging activities on steep terrain. The mean for various disturbed catchments was 12.82 ton/ha/yr. TCB recorded the lowest sediment yield, which may suggest that most of the sediment is deposited in the lake and only a small fraction is transported out through Sg. Chini to joint Sg. Pahang. In addition, inadequate storm samples during the water level rise could also contribute to the extremely low sediment yield.

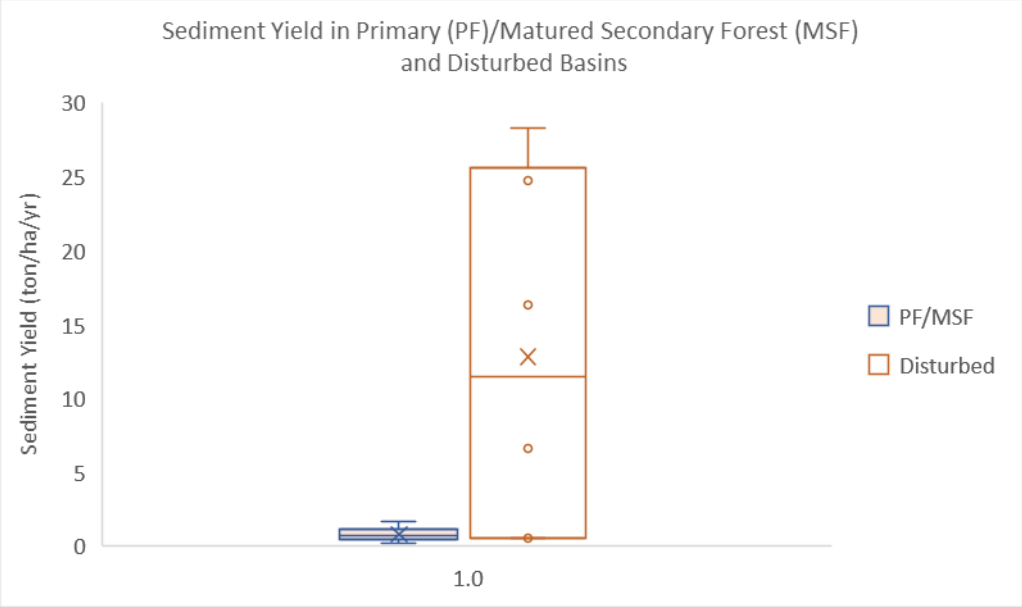


Figure 23: Comparison of sediment yield from primary/matured secondary forest and disturbed catchment.

(Note: The values were taken from Yusop, Z. (2010), Table 4. The sediment yield for TCB was taken from Kamaruddin et al., (2016) but was adjusted to consider sediment sources from the entire TCB Area as Sg. Chini is the only outlet from the basin.)

BIOLOGICAL DOMAIN

Introduction

Gazetted as an important Man and Biosphere (MAB) Reserve in 2009, Tasik Chini is home to diverse groups of animals and plants. Tasik Chini, rich with biological resources, also has recreational value and ecological importance in biodiversity (Adilah and Nadiah, 2020). Tasik Chini catchment has been transformed from forests to agricultural and ecotourism areas, mines, and settlements. This lake is essential for local people to provide fish sources and a primary facility for transportation such as boating. Due to the uncontrolled flowing-in of pollutants, water bodies often experience algal blooming, floating, and deterioration of biodiversity. The worse effect of these changes was damage to the plant community and aquatic ecosystem which affected the wildlife in Tasik Chini area.

Even though Tasik Chini holds diverse species of wildlife, the living is threatened, primarily due to continuous anthropogenic activities that lead to the declining wildlife population. Lacking publications on Tasik Chini biodiversity are likely to reflect more species loss in the future as biodiversity in this area is not being highlighted as an essential aspect compared to the economic values. Hence, updated documentation on the biodiversity study is crucial as more species need to be explored in Tasik Chini to offer the framework for a long-term management strategy. Here, we review the biodiversity-related research in Tasik Chini that may help future conservation actions for protecting this freshwater ecosystem. This study also emphasises the gap in information focusing on the aspect studied and based on the group of wildlife being reviewed. This is because a lack of information regarding wildlife existence contributes to less attention from researchers, government, and local communities to develop the effectiveness management plans for Tasik Chini management. The freshwater ecosystem takes a long time to recover. It is crucial to conserve this ecosystem as its critical wildlife habitat instead functions as a water supply, source of economy, and biodiversity. Striving for solutions that could assist biodiversity conservation in Tasik Chini while providing essential human necessities is significant. At the national level, by referring to National Policy on Biological Diversity (2016 – 2025), the lake ecosystems receive little attention as the word 'lake' was only mentioned three times in the whole document and ironically mentioned in the subtopic Alien Invasive Species.

Data Mining

Bibliographic searches were used to obtain data on previous studies in Tasik Chini. Peer-reviewed articles were searched in the Scopus database and Google Scholar according to the indexed title, abstract, keywords, and topics by using the keyword "Tasik Chini". Any studies, including theses and reports relevant to biodiversity study, were included. The search results were further filtered to see if the studies provided and discussed the information needed by reading the articles.

Initially, the keyword "Tasik Chini" was used for searching before filtering. Information on the year of publication, species studied, and category of study (management, diversity, ecology) were utilised to form a few infographics to see the research gaps and future research attention. In total, 35 manuscripts were successfully exported (21 extracted from the Scholar database and 14 recorded in the Scopus database; overlapping papers were counted as one), as the others were considered irrelevant. There are peak publications between 2011-2015 with 14 publications, followed by ten publications between 2006-2010, 16 between 2016-2020, two between 2001-2005, and a single publication between 1995-2000. Only two publications were recorded from 2021 and 2022 (Figure 18). This trend indicates that the researcher's interest in the biodiversity of Tasik Chini is growing as this lake was gazetted as the first Biosphere Reserve for Malaysia in 2009, highlighting the richness and abundance of biodiversity in this area (UNESCO, 2015).

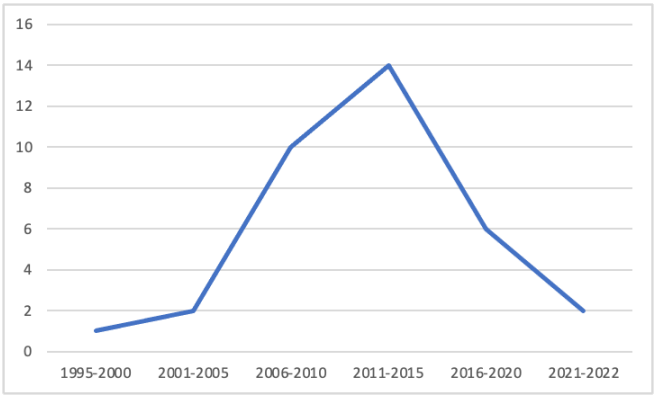


Figure 24: Number of publications found according to five years range

Out of 35, eight were classified under the "management" theme, 11 for "diversity," seven for "ecology," and the remaining nine publications were not included in any category due to inaccessible manuscripts (Figure 19). Within the management category, four manuscripts conducted an assessment of the biodiversity: fireflies (Roslan and Sulaiman, 2015a) and Tasik Chini itself (Roslan and Sulaiman, 2015b); Habibah et al., 2013b; Habibah et al., 2013c; as the potential ecotourism centre on the base of UNESCO gazettement. Two publications discuss sustainable consumption and practices among local and indigenous people in this area (Omar et al., 2011; Habibah, Hamzah and Musrifah, 2010). The remaining papers review the mapping of *Nelumbo nucifera* in Tasik Chini. In terms of ecological publications, the fish community has been studied by Hashim et al., (2015) and Mansour et al., (2016), bat behavioural ecology has been described by Atiqah et al., (2015) and Ahmad Bakri et al., (2021), remaining two records on tropical rainforest community (Ismail et al., 2011) and leaf micromorphology on fern species (Nurnida et al., 2015). The diversity category has been reported on fishes, insects, amphibia, and plants. Seeing the trend of publications related to diversity, only small number of species have been identified. Surprisingly, there is no official record of the overall diversity of reptiles and mammals in Tasik Chini except for a single species of small mammals. This indicates the prolonged biodiversity database in Tasik Chini due to the absence of current updates on the amount of wildlife in this area.

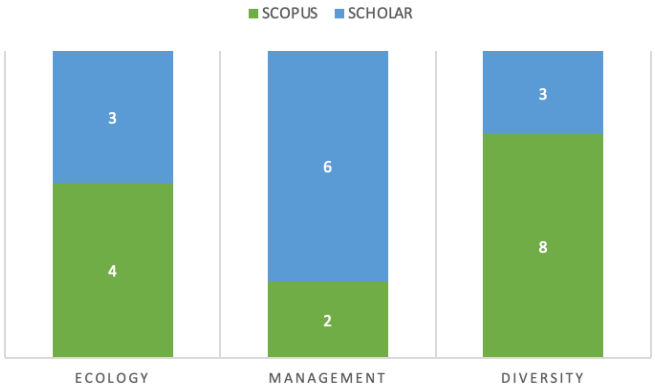


Figure 25: List of publications found in Scopus and Scholar database by using the Keyword "Tasik Chini"

The trend of publication based on the "Plant" and "Animal" categories is presented in Figure 20. A total of 12 publications related to 'Plant' have also been recorded. These include two studies on lotus (Faidi et al., 2018; Mansour et al., 2016), two on ficus (Chew et al., 2018; Muhammad Azmil and Wan Juliana, 2013), and four specifies on aquatic plants (Chew et al., 2011; Juliana et al., 2010; Siti Munirah and Chew, 2010; Zakaria et al., 2021), one on fern (Nurnida et al., 2015) and four described on general vegetation especially trees in Tasik Chini (Nurhanim and Wan, 2018; Ismail et al., 2015; Norwahidah, 2009; Norsiah, 2004). A total of 600 species were recorded, and 20 plant species were recognised as endemic in Tasik Chini (Nurhanim and Wan, 2018). There are two species namely, *Cyathocalyx pahangensis* and *Eniconsanthum fuscum* from *Annonaceae*, classified as common species in Tasik Chini but categorised as endemic species by Turner (1995). *Enicosanthum fuscum* is recorded as an endemic species in Perak and Pahang, while *Cyathocaly pahangensis* is an endemic species found only in Pahang, Terengganu, and Johor (Nurhanim and Wan, 2018). Chew et al., (2011) successfully recorded 172 aquatic plants in Tasik Chini, comprising of 29 species from 22 families.

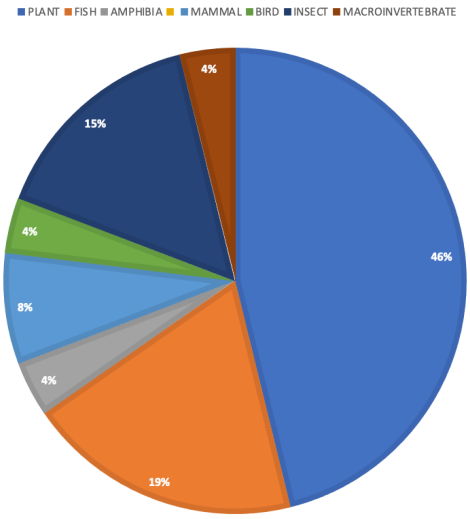


Figure 26: Number of publications retrieved by Organism-Based

Table 7: Unpublished and anecdotal reports of biodiversity in Tasik Chini

Taxa	No of Species	Reference	Notes
Phytoplankton	91	Sharip et al. (2010)	
Aquatic Herbaceous Plants	37	Sharip et al. (2010)	
Freshwater Swamp and Swamp Forest Floral Species	25	Sharip et al. (2010)	
Lowland Forest Plant Species	323	Sharip et al. (2010)	
Amphibians	27	Norhayati, A (undated)	Poster
Aquatic Plants	172		
Small Mammals	22	Toriman et al. (2015)	
Nycticebus coucang	-	Toriman et al. (2015)	Endangered
Manis javanica	-	Toriman et al. (2015)	Critically Endangered
Hylobates lar	-	Toriman et al. (2015) & JICA (2011)	Endangered
Panthera tigris jacksonni	-	Toriman et al. (2015) & JICA (2011)	Critically Endangered
Elephas maximus	-	Toriman et al. (2015) & JICA (2011)	Endangered
Tapirus indicus	-	Toriman et al. (2015) & JICA (2011)	Endangered
Helarctos malayanus	-	Toriman et al. (2015) & JICA (2011)	Vulnerable

For animal categories, further division was made, macroinvertebrate, fish, insect, mammal, reptile, amphibia, and bird. Specifically, five publications described the fish community in Tasik Chini and four reports on insects, while each recorded a single manuscript for benthic macroinvertebrate, mammal, amphibia, and birds. Within publications related to fish, ecological and diversity aspects of fish in Tasik Chini have been covered by Hashim et al., (2015) and Kutty et al., (2018), and specific species being studied include *Hemibagrus nemurus* (Hashim et al., 2018) and *Barbonymus schwanenfeldii* reported by Mansour et al., (2016). Kutty et al., (2009) successfully recorded 24 fish species in Tasik Chini. Insect publication covers diversity and management aspect which involves dung beetle (Aruchunnan et al., 2015; 2016), *ichneumonid* wasps (Idris et al., 2009), and fireflies (Roslan and Sulaiman, 2015). Idris et al., (2009) claimed there are 502 insect individuals consisting of eight orders and 46 families. The first family is *Hymenopterans* (298 individuals and 11 families include *ichneumonids*, *evaniid*, and *vespid* wasps). The second family is *Blattaria* (two families); the remaining family are *Cleridae*, *Anthribidae*, and *Odonata* (nine species). *Scotophilus kuhlii* is the only mammal studied in Tasik Chini on the activity pattern and behavioural ecology (Atiqah et al., 2015; Ahmad Bakri et al., 2021). Bird diversity in Tasik Chini was reported by Zubaid et al., (2009), while *Hylarana erythraea* represents amphibians studied in Tasik Chini specifically on diversity based on genetic variation (Zainuddin et al., 2010). In addition, we managed to gather data from unpublished reports and anecdotal reports, as well as hardcopy printed books and posters covering the flora and fauna of Tasik Chini, as shown in Table 7 and Figure 21.

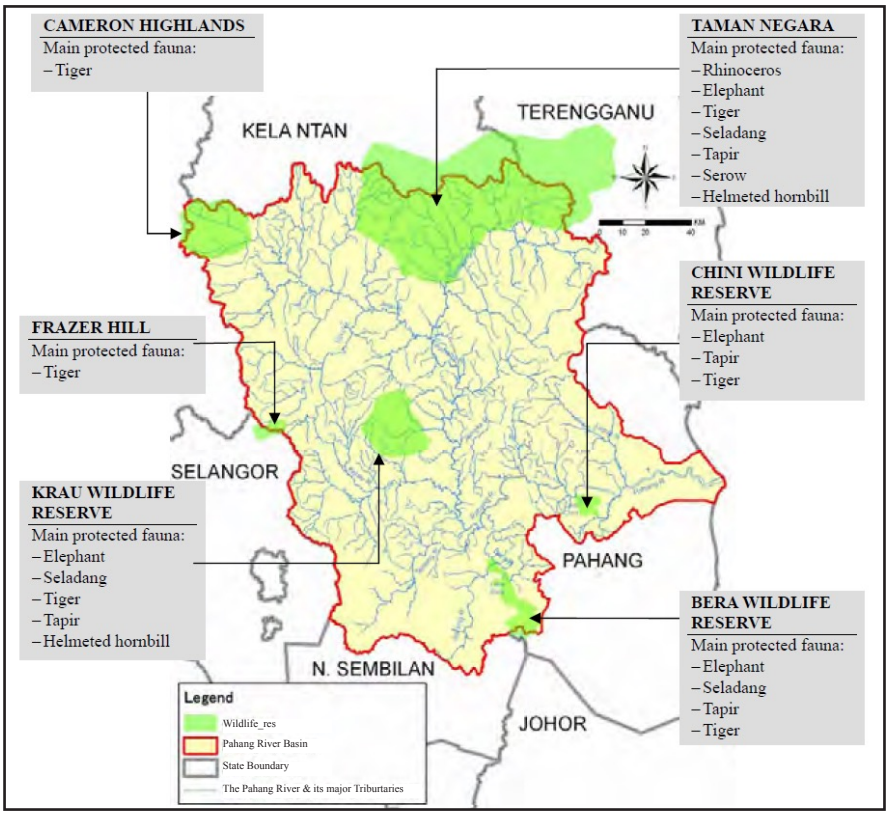
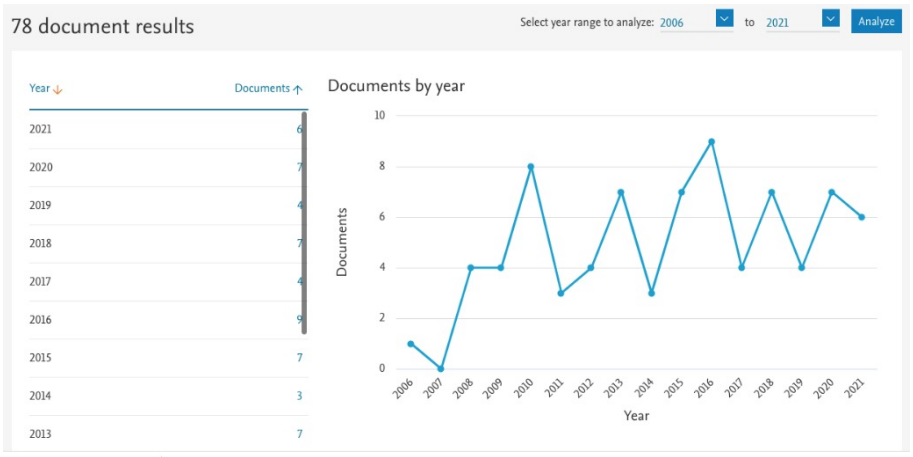


Figure 27: Wildlife Protection Areas surrounding Pahang River Basin (source: Japan International Cooperation Agency and Department of Irrigation and Drainage Malaysia, 2011)

The results of this desktop-based study focussing on documentation of the biological diversity of Tasik Chini show a decreasing trend since the MAB gazettement in 2009. The survey on diversity, ecology, and management is needed to enhance the conservation efforts for Tasik Chini restoration. Relatively, the scientific research and publications coverage for Tasik Chini is lower than Tasik Kenyir Terengganu, which has 153 publications and shows an upward trend as per Figure 22.

a)



b)

Figure 28: Comparative analysis of scientific publications between Tasik Chini (a) and Tasik Kenyir (b)

Exploratory Visit

We conducted an exploratory visit to Tasik Chini to gather data primarily on ethnozoology amongst Orang Asli Jakun and a visual encounter survey of wildlife in the area. The survey and interview session was conducted among 40 randomly chosen respondents from a few villages around Tasik Chini. The questionnaire was divided into two parts; where the first part consists of sociodemographics of the respondents (age, gender, marital status, and occupation), and the second part is the questions related to wildlife consumption where the document was written in Malay as it can help the understanding while conducting the survey. The interviews were conducted using a semi-structured questionnaire with the help of some visual aid to assist the respondents from any confusion, especially regarding the local name and the species name (Figure 23).

Figure 29: Interview session with Orang Asli Jakun in Tasik Chini

A total of 40 randomly chosen respondents participated in this survey and interview session. Out of 40 respondents, six are from Kampung Melai, 19 are from Kampung Gumum, nine are from Ulu Gumum, and three are from Kampung Tanjung Puput, whereas in Kampung Cendahan and Kampung Tanjung Sambet, only two and one person involved, respectively. The information related to the sociodemographics of the respondents was collected through the questionnaire, summarised in Table 8. Based on the questionnaire and interviews, 48 species of wildlife have been consumed and utilised by the Orang Asli community in Tasik Chini. The most wildlife consumed was mammals which are 32 species, followed by birds (ten species), reptiles (five species), and one amphibian (Table 9).

Table 8: The sociodemographic characteristics of the respondents

Profile		n	(%)
Gender	Male	23	57.5
	Female	17	42.5
Age	15-20	3	7.5
	21-30	10	25.0
	>30	27	67.5
Marital status	Married	34	85.0
	Single	6	15.0
Occupation	Yes	34	85.0
	No	6	15.0

Table 9: The number of wildlife consumed and utilised by Orang Asli Community in Tasik Chini

No	Class of animals	No of species
1.	Mammals	32
2.	Birds	10
3.	Reptiles	5
4.	Amphibians	1
	Total	48

In the questionnaire, there were 42 species listed, consisting of 32 mammals and ten birds, most of which can be found in Pahang. Out of 42 species listed, about 40 species have been consumed by Orang Asli. None of the respondents recorded consuming or utilising Malayan gaur (*Bos gaurus*) and Buff-rumped woodpecker (*Meiglyptes tristis*). While conducting the survey, the respondents were also interviewed and reported six species of wildlife (one mammal, five reptiles) have been consumed and utilised by Orang Asli community.

According to the questionnaire, the class of animals consumed by Jakun tribe are mammals. Based on the frequency of consumption presented in Figure 23, the highest wildlife consumptions were wild boar by 37 respondents, followed by long-tailed macaque (*Macaca fascicularis*), pig-tailed macaque (*Macaca nemestrina*), Malayan porcupine (*Hystrix brachyura*), common palm civet (*Paradoxurus hermaphroditus*) and white-handed gibbon (*Hylobates lar*). The least number of wildlife consumed were siamang, white-thighed surili, and straw-headed bulbul. However, most of the listed animals were previously consumed but not recently, as they stated, as most wildlife are harder to find and declining in population due to habitat destruction. Previously, Orang Asli used to consume large mammals such as Asian elephants, tigers, Malayan tapir, and sun bears but unfortunately, these endangered species were no longer found in Tasik Chini. According to them, habitat destruction, logging, and mining activities are the main reasons for the declining wildlife in the area.

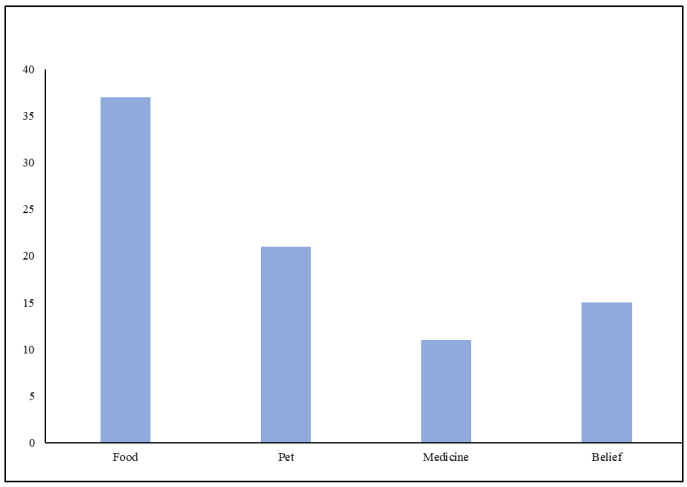


Figure 30: The rate of purpose wildlife consumption and utilisation by the Orang Asli community in Tasik Chini

For Orang Asli, wildlife is not just a source of food but also used as a pet, medicine, and belief. Based on 48 species recorded, most of the wildlife recorded mainly were utilised as a source of food and some for medicine by the older generation. The rest of the wildlife species are taken care of as pets and used as wildlife following their belief in lifestyle (Figure 24). For the record, Orang Asli in Semenanjung Malaysia can hunt and consume ten wildlife species (Table 10) under section 51, *(Act 716)*, 2010. Based on the interviews, some respondents also explained the importance of wildlife in medicine. According to some respondents, the Malayan porcupine (*Hystrix brachyura*) is one of the most profitable mammals. They used to trade the species due to the perceived benefits of the bile in traditional medicine.

Table 10: List of wildlife as food for Orang Asli (Section 51, *(Act 716)*, 2010)

Scientific Name	Common Name
Sus scrofa	Boar
Cervus unicolor equinos	Rusa
Tragulus spp.	Barking Deer
Macaca nemestrina	Pig-tailed macaque
***Presbytis cristata* (*Trachypithecus cristatus*)**	Silvered leaf monkey
***Presbytis obscura* (*Trachypithecus obscurus*)**	Dusky leaf monkey
Hystrix brachyura	Malayan Porcupine
Atherurus macrourus	Asiatic brush-tailed porcupine
Amaurornis phoenicurus	White-breasted waterhen
Chalcophaps indica	Asian Emerald Dove

In addition, the bile of sun bear, Sunda pangolin, and Malayan porcupine is the most highly demanded part to be sold as Jakun people believe that the bile has benefits in terms of medicinal value. Besides, the Malayan tiger and muntjac are also utilised by the Jakun people as they assume that the meat of the mammals can help increase body strength and maintain energy levels. Jakun people revealed that a few species of birds have medicinal values, i.e, the Oriental Pied Hornbill and Junglefowl. The meat of hornbill and Junglefowl must be boiled and cooked to treat certain diseases, especially asthma sufferers. However, the meat of wild boar, the most consumed wildlife, is only consumed by an adult as they believe it can help warm the human body but not by children because they can get stomach pain through meat consumption. The population of *S. scrofa* can be considered high in Tasik Chini as most of the Jakun still consumes it today, similar to the Semoq Beri community in Maran, Pahang (Abdul-Latiff et al., 2021).

The consumption and utilisation of primates among the Jakun tribe can be considered diverse as nine primates were recorded, and most were used as food sources. One respondent revealed that siamang used to be kept as a pet, including the pig-tailed macaque (Picture 8), white-handed gibbon, and Sunda slow loris. The consumption of primates by Jakun people is almost similar to the Temuan tribe, as stated by Fatin et al., (2021), where *M. nemestrina*, *M. fascicularis*, and *H. lar* have often used as entertainment and pet. Abdul-Latiff et al., (2021) and Najmuddin et al., (2021) also reported that the pig-tailed macaque is only used as a pet for the Semoq Beri community, similar to the Jakun tribe in Tasik Chini.

Figure 31: Pig-tailed macaque (*M. nemestrina*) tied with a chain

Based on the interview and questionnaire, the Jakun tribe in Tasik Chini is mostly less dependent on wildlife consumption which causes a decrease in hunting practice. The older generation mainly uses all the documentation regarding wildlife consumption and utilisation, while the new generation is less in applying traditional hunting practices and knowledge (Picture 9). This is due to the exposure to the urban society and habitat destruction that led the Jakun people to change their lifestyles. Besides, the Jakun people in Tasik Chini always rely on the lake as the protein source instead of the forest due to land changes. The decrease in wildlife species due to the increasing anthropogenic activities affected many Orang Asli tribes, such as Semoq Beri and Temuan (Abdul-Latiff et al., 2021; Fatin et al., 2021; Najmuddin et al., 2021).

Figure 32: Types of hunting tools used by Jakun tribe in Pahang: A) snare, B) spears, C) blowpipes

We also documented wildlife in the area during our ethnozoological survey based on a visual encounter survey without trapping. A total of 33 species of *arachnids* were collected in which 28 species belong to the order of *Araneae*; three belong to *Scorpiones*, and one from the *Opiliones* and *Thelyphonida* respectively. Four orders of *arachnids* were discovered in the Tasik Chini area, with the *Araneae* as the most significant number of the *arachnid* species in that area. 11 families from the order *Araneae* were collected from this area, three families from the *Scorpiones* order and one family from both orders of *Opiliones* and *Thelyphonida*. Two interesting findings from this survey were the two spiders from the *Mygalomorph* infraorder. The two interesting spiders found in this study site for the first time were tarantula spiders (*Psednocnemis brachyramosa*) and tube trapdoor spiders (*Damarchus* sp. *Chini*). These findings indicate that the TCB had a good number of *arachnid* species that can serve as good indicators as Tasik Chini is one of the Biosphere reserves. Due to disturbance from human activities in that area, it was observed that some of the interesting species could be found far from the lake area, mainly in the better-forested area, such as the tarantula and the tube trapdoor spider. Only common spider species living in diverse habitats can be found in the disturbed area near the Tasik Chini.

On the other hand, our survey of freshwater fish indicates a total of 18 species from eight families of freshwater fish were recorded during the surveys in Tasik Chini. Family *Cyprinidae* is the most diverse family representing 33.3% of total species recorded, followed by Osphronemidae with 27.8% and Siluriformes with 11.1%. The other five families, including *Anabantidae*, *Channidae*, *Belonidae*, *Zenarchopteridae*, and *Synbranchidae*, only represent 5.6% of the total species recorded from the surveys (Figure 24). Families *Cyprinidae* made up the major proportion of fish fauna in Tasik Chini. *Cyprinidae* is Malaysia's dominant family of freshwater fish in terms of its abundant genera and species (Kamaruddin and Esa, 2009). Species recorded in this study from this family are *Barbodes sellifer*, *Brevibora cheeya*, *Osteochilus spilurus*, *Osteochilus vittatus*, *Puntigrus partipentazona*, and *Rasbora myersi*. All these species are native species and widely distributed in Peninsular Malaysia. These species were assessed as Least Concern species by International Union for Conservation of Nature (IUCN) Red List of Threatened Species except for *B. sellifer*, as there is no information about this species was available, and it was assessed as Not Evaluated (NE).

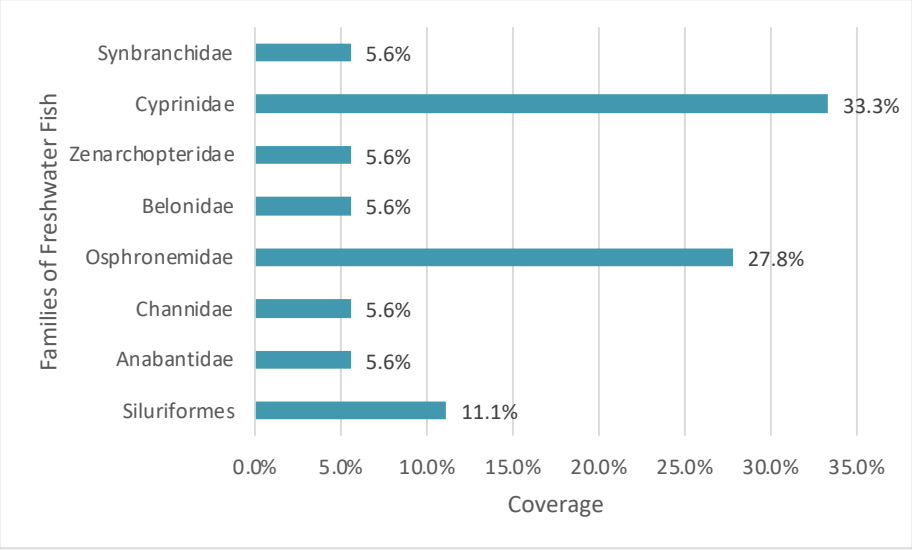


Figure 33: Coverage of fish species by family recorded from the Tasik Chini, Pahang, Malaysia surveys.

Lembaga Kemajuan Pahang Tenggara (1993) previously conducted a study on Tasik Chini and listed 84 species belonging to 22 families. Another study carried out by WIAP (1996) recorded 36 species belonging to 17 families while the latest one by Hashim et al., (2014) recorded 21 species from 8 families. The difference between previous study and the present survey indicated a decreasing trend in freshwater fish families and species in Tasik Chini. The disruption of fish spawning and migration from Pahang River was because of the weir construction at Chini River in 1995 (Hashim et al., 2014). Anthropogenic activities such as logging and mining had increased, negatively impacting Tasik Chini's ecosystems. Tasik Chini's natural habitats have been rapidly deteriorating and causing concerns such as the decline of water quality (Shuhaimi-Othman et al., 2005), reduction in the number of fish (Idris and Kutty, 2005), variation of heavy metal concentration in fish (Ebrahimpour and Mushrifah, 2010) and the status of effluent in Tasik Chini (Islam et al., 2016).

GOVERNANCE DOMAIN

Introduction

This section of the report briefly addresses key aspects for consideration where the governance of Tasik Chini Basin is concerned, taking into account various reports in the media on the state of Tasik Chini and the status of the Tasik Chini MAB Reserve. Sections 4 and 5 of the Academy of Sciences Malaysia (ASM) Act 1994 (ASM Act, 1994) provided the basis for this cursory desktop review, amongst others, to analyse national problems and identify where science, engineering and technology can contribute to their solution.

The concern and opportunity to protect Tasik Chini did not just stem from efforts to have the area designated as an MAB Reserve. Way back in the Third Malaysia Plan, (1976-1980) in Chapter XI, Tasik Chini was listed as an area with potential to be preserved for recreation and tourism (see paragraphs 685-687, pages 223-225), with 12,000 acres identified and earmarked as a Tasik Chini Nature Reserve. The Third Malaysia Plan then recognised the need to effectively conserve ecosystem diversity and it was proposed then that a system of national parks, nature reserves, wildlife sanctuaries and virgin jungle reserves would be established to protect features of Malaysia's landscapes that reflect natural beauty.

The cursory review of problems and issues highlighted in the media as well as in the Penyata Rasmi Dewan Negeri of 2021 and 2022 focused on available reference documents as listed below. As planned strategic consultations to enable the conduct of a brief situational analysis with key stakeholders of the Tasik Chini Basin were not carried out due to the constraints of the COVID-19 pandemic, these documents, as well as mainstream media reports were relied on to determine key concerns, and identify intervention measures for consideration, taking into account the ASM's role as per the provisions of Sections 4 and 5 of the ASM Act 1994. The primary sources that were referred to included the following:

- *Penyata Rasmi: Mesyuarat Pertama Penggal Ke-4 Dewan Negeri Pahang ke-14, 23 hingga 25 Ogos 2021*
- *Penyata Rasmi Mesyuarat Ke-2 Penggal Ke-4 Dewan Negeri Pahang Ke-14, 06 hingga 10 Disember 2021*
- *Penyata Rasmi Mesyuarat Pertama Penggal Ke-5 Dewan Negeri Pahang Ke-14, 28, 29, 30 dan 31 Mac 2022 dan 1 April 2022*
- *Titah DiRaja Ke Bawah DULI YANG MAHA MULIA PEMANGKU RAJA PAHANG, Sempena Pembukaan Penggal Ke-4 Dewan Negeri Pahang Ke-14*
- *Titah DiRaja Ke Bawah DULI YANG MAHA MULIA PEMANGKU RAJA PAHANG, Sempena Pembukaan Penggal Ke-5 Dewan Negeri Pahang Ke-14*
- *Rancangan Kawasan Khas Tasik Chini, Warta Negeri no. 1833, bertarikh 26 November 2018*
- *Rancangan Struktur Negeri Pahang, Warta Negeri no. 297, bertarikh 14 Mac 2019*
- *Garis Panduan Pemuliharaan dan Pembangunan Kawasan Sensitif Alam Sekitar 2017*

Tasik Chini Basin Governance: Context

The perspective of lake basin governance is chosen based on two key factors. Firstly, the term governance, as defined by the United Nations Economic and Social Council Report at the 5th session of the United Nations Committee of Experts on Public Administration in 2006 (Official Records 2006, Supplement No.24 E/2006/44-E/C.16/2006/6), set out a list of definition of basic concepts and terminologies in governance and public administration. The Committee noted that the term 'governance' enlarges and better illustrates what government should be focusing on, though they note that conceptualisation of the terms has not been consistent and various meanings have been attached to it. In the present online United Nations (UN) glossary, hosted by the Department of Economic and Social Affairs, the term governance is taken to mean:

> *"...the exercise of economic, political and administrative authority to manage a country's affairs at all levels, comprising the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences (http://www.unpog.org/page/sub5_3.asp)".*

Secondly, this broader perspective makes room for a better understating of mandates, responsibility, accountability as well as inclusion and engagement, as it sets out the remit from which government can structure interventions working in partnership with all stakeholders. It does centre the focus on government, as it should be, given that they wield the mandate to ensure that affairs are conducted and managed, and will need to provide the necessary room for all stakeholders with respect to their interests, legal rights, and differences. It goes beyond mere administration and management of government matters, as well as conforming to processes and procedures, it also ground means and measures to achieve results that benefits stakeholders (both human and environmental).

Governing lake basins according to specific purposes couched in existing legal mandates require a greater understanding of multiple needs of different users, both human and environmental; opportunities that can be leveraged on, as well as benefits that can be gained. Understanding key processes that influence the basin geological, ecological, and hydrological nature and characteristics helps underpin and unify different approaches grounded on the end game of sustainability, which contributes to human and environmental health, and globally, to planetary health.

This requires an agreed understanding and context as to what constitutes Tasik Chini Lake Basin, i.e., what it is and what it encompasses. There isn't a specific definition or use of the term for Tasik Chini Basin, yet there is an opportunity to develop a term that can be properly understood and used by multiple stakeholders.

There is a definition for lakes, as stated in the Garis Panduan Pemuliharaan dan Pembangunan Kawasan Sensitif Alam Sekitar 2017 (hereinafter referred to as "Garis Panduan KSAS 2017"), as stated in Bahasa Melayu (this quote has not been translated for fear of it being inaccurate):

> *"...Kawasan tasik (semula jadi / buatan) didefinisikan sebagai satu kawasan permukaan bumi yang ditakungi air seluas 1 hektar atau lebih dengan pelbagai kedalaman yang secara umumnya mengandungi nutrien yang mampu membiakkan hidupan air untuk faedah sosio-ekonomi dan rekreasi masyarakat setempat".*

Reference is made to the study undertaken in the preparation of and later forming part of the RKK Tasik Chini 2018 document, gazetted in 2018 (Gazette no. 1833). For the governance desktop review purposes, the outlined area in the RKK Tasik Chini 2018 is taken to represent TCB. Taking off from the RKK Tasik Chini 2018, using the findings therein that sets out the state and condition as well as opportunity for the RKK Tasik Chini 2018 area (read as TCB), the focus has been made on determining mandates to facilitate governance interventions needed for TCB to continue providing ecosystem services that benefit both human and environment, particularly Tasik Chini Man and Biosphere Reserve (hereinafter referred to as "TCBR").

The approach towards informed governance must be based on understanding the state of the basin, as well as its potential. It also includes understanding the emerging as well as existing threats and where science cannot provide the definitive answer, information that can help structure precautionary measures, based on available inputs from multiple disciplines, becomes a key component in informed decision-making that should be made collectively, as the TCB is made up of multiple components serving multiple purposes, attending to multiple needs, and accommodating a myriad of stakeholders, both man and environment.

Consideration will need to be given to determine existing, planned, and needed interventions to address impacts, mitigate threats, reduce risks as well as strengthen the Basin's adaptive capacity, including its people, to ensure sustainability. This lies entrenched in the spirit of what a biosphere reserve is, as noted by UNESCO (https://en.unesco.org/node/314143):

> *"...Biosphere reserves are 'learning places for sustainable development'. They are sites for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity. They are places that provide local solutions to global challenges".*

The initially proposed study process for the governance domain, as shown in Figure 25, was subsequently modified. This was due to the limitations during the COVID-19 pandemic, as engagement with key stakeholders could not be carried out to enable a situational analysis post the gazettal of the RKK Tasik Chini 2018 and the incidences that led to public outcry in 2019 right through to 2021. As a result, the RKK Tasik Chini 2018 became the main source in determining the basin boundary for the governance review and identification of issues and threats.

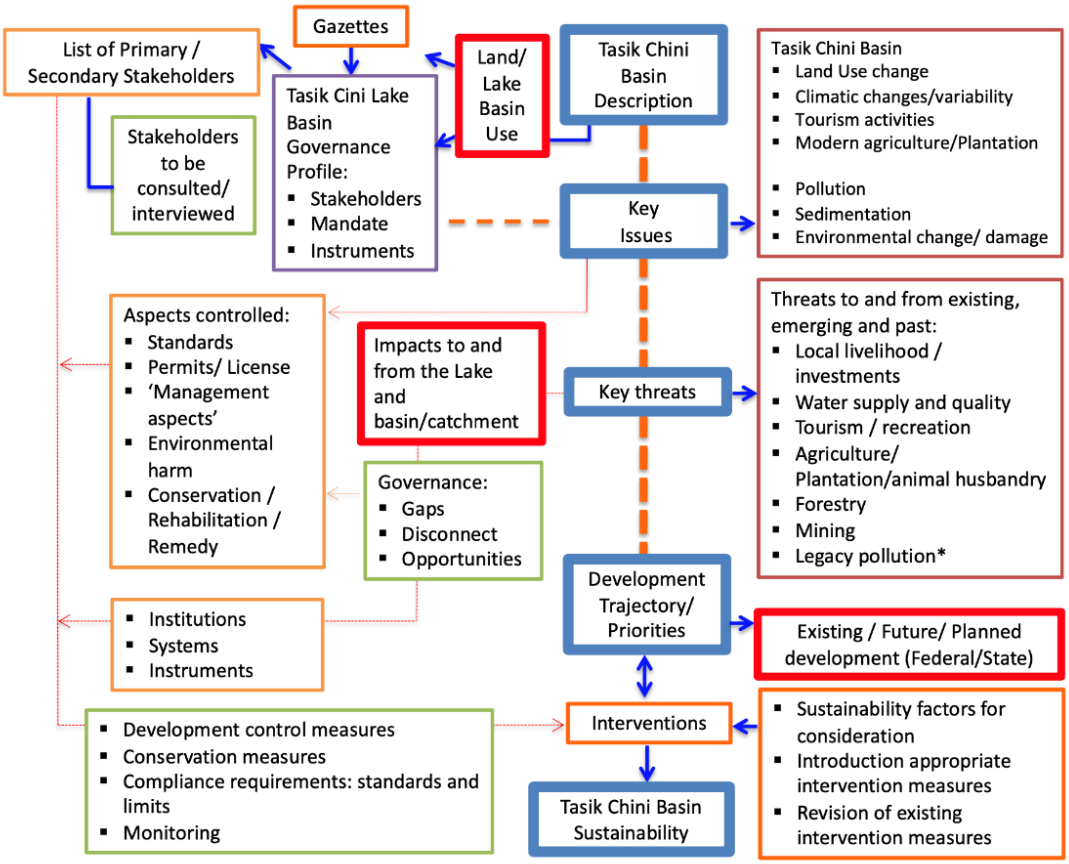


Figure 34: Tasik Chini Basin Governance Domain Study Process

Main Areas of Concern

The RKK Tasik Chini 2018 area spanning 55,586.12 hectares was used and taken to represent the TCB boundary. Based on the RKK Tasik Chini 2018, the TCB sits within the District of Pekan, District of Maran, and District of Rompin Pahang, and within the district, there are multiple mukims, including 11 in the District of Pekan; Mukim Pekan, Mukim Langgar, Mukim Penyor, Mukim Lepar, Mukim Pulau Manis, Mukim Temai, Mukim Pahang Tua, Mukim Pulau Rusa, Mukim Ganchong, Mukim Kuala Pahang and Mukim Bebar. Cusped in the TCB is the TCBR, the Tasik Chini Lake (12 *laut*) which, based on extensive media reporting in 2019 of the impacts from mining activities, has become the centre of focus of government intervention (see list of newspaper and media reports as listed in the Bibliography).

The Tasik Chini catchment area was gazetted in 1989, Gazette no. 1113, spanning 5,065 hectares, as a protected area for public purposes (pursuant to section 62 of the National Land Code 1965). The gazetted area sits within the purview of the Pahang State Forestry Department. Tasik Chini was designated as a MAB Reserve by the UNESCO in 2009, spanning 6,951.44 hectares, with three primary purposes, conservation, development, and logistical support (RKK Tasik Chini, 2018; UNESCO, 2021). The TCBR area encompass 12 lakes, parts of the river basin and a steep hill, Bukit Chini, that stands at 641 metres.

The RKK Tasik Chini 2018 divides the area into three zones (Table 11). The first is the Core Zone, spanning 9,224.19 hectares. Within it sits Tasik Chini, the Orang Asli villages (Kampung Cendahan, Kampung Tanjung Puput, Kampung Melai, Kampung Gumum and Ulu Gumum), forest, mining, and agricultural areas. The Buffer Zone spans 12,008.23 hectares. The area encompasses agricultural areas, forest reserves, and mining areas. The third zone is the Transition Zone, spanning 34,388.35 hectares, with agricultural areas making up 50.20% of the land area and forest areas at 42.19%. The rest of the area encompasses villages and FELDA settlements.

Table 11: Zoning of the TCB based on RKK Tasik Chini 2018

Zone	Area (ha)
Core Zone	9567.12
Buffer Zone	12008.23
Transition Zone	34010.77
Total TCB Area	55586.12

It is important to note here that 62.94% of the RKK Tasik Chini area is owned by State, which includes forest areas, mining areas and water bodies. The remaining 36.54% are owned by government-linked companies (GLCs)/ Agencies/Institutions, and private (corporate) ownerships at 0.52%. As of 2018, the RKK Tasik Chini 2018 states that there were eight areas with mining licences issued, which in total span 664.35 hectares, with a portion sitting within the gazetted Tasik Chini area. Mining activities have gone on in the Tasik Chini area way back since the 1960s, pre-dating the designation of the TCBR. The RKK Tasik Chini 2018 notes that this is the biggest development-conservation conflict.

Tasik Chini Lake, based on the Garis Panduan KSAS 2017, falls within the category of an environmentally sensitive area, which is defined as (the definition in Bahasa Melayu is used as is and not translated for fear of being inaccurate):

> *"...Kawasan Sensitif Alam Sekitar (KSAS) adalah suatu kawasan khas yang sangat sensitif kepada sebarang bentuk perubahan kepada ekosistemnya akibat proses alam semula jadi atau aktiviti di dalam atau di sekitarnya, sama ada secara langsung atau tidak langsung, di mana tahap kesensitifannya ditentukan berasaskan pengintegrasian cirian unsur-unsur fungsi risiko bencana, nilai sokongan hidup serta nilai khazanah dan warisan Kawasan tersebut".*

The many years of development culminating in the 2019 uproar has shown that Tasik Chini Lake is highly sensitive to surrounding development and changes to its ecosystems, which affects not only the environment but also the life support system of the lake. However, there is a need to put into context the present state of the TCB and the need to ensure the conservation of the TCBR. The RKK Tasik Chini 2018 highlighted several areas of concerns stemming from the legacy of existing developments standing at odds with the expectation of maintaining a Man and Biosphere Reserve.

The TCB, by way of legacy, had the development of resources earmarked since the 1960s, with a record of a court case reporting a dispute relating to the payment of tribute in relation to a sub-lease of a mining lease at Tasik Chini. The case Southern Mining & Trading Sdn. Bhd. V. United Mining (Singapore) Co. Pte. Ltd, [1975] 2 MLJ 84, was heard before the Federal Court in 1975, and the lease in question dates to 1964. This raises concerns about the rights to develop resources versus the right to protect resources. The right to develop, for example plantation, forestry, and mining, can be said to have stemmed from decisions made prior to the designation of the TCBR. Over the years, a plethora of literature has since sounded warnings as to the impacts that have and can be wrought on the Tasik Chini lake and the people who call the area as home. This was noted in the RKK Tasik Chini 2018.

The main concern is matching the projected and planned development, physical and socio-economic development, with the present state and condition of the TCB ecosystems. Based on the RKK Tasik Chini 2018, this will require extensive studies to flag vulnerable and fragile areas, species, and systems (both ecological and physical systems). The studies will need to determine the present state and ability of the TCB ecosystem to support the existing and planned development and recover from impacts on the ecosystem, whilst ensuring the conservation of TCBR.

There is also a need to address matters pertaining to legacy pollution and look at the existing remedial measures to determine whether it is sufficient to ensure that the TCB ecosystem remains healthy. At the same time, studies will also need to be conducted to determine the impact on community health and well-being.

What is clear from the RKK Tasik Chini 2018 is the opportunity, more so the post COVID-19 pandemic that crippled the economy, to realign planned development trajectories with sustainable development aspirations. Strict control measures will need to consider approved development and land use, with the expectation to ensure the sustainability of TCBR. For mining areas, interventions will need to consider a phasing out approach, and introducing targeted measures to rehabilitate sterile areas to ensure that impacts are controlled and managed and that these areas are converted into uses that benefit the basin.

Managing Expectations

The 2020 UNESCO Statutory Framework of the World Network of Biosphere Reserves (hereinafter referred to as the "2020 Statutory Framework") and 2021 UNESCO Technical Guidelines for Biosphere Reserves (hereinafter referred to as the "2021 Technical Guidelines") set out specific provisions that should be met to ensure any designated area remains as a MAB site, post the ten-year reviews. The general criteria, as stipulated in Article 4 of the 2020 Statutory Framework states:

"Article 4. Criteria

General criteria for an area to be qualified for designation as a biosphere reserve:

1. It should encompass a mosaic of ecological systems representative of major biogeographic regions, including a gradation of human interventions.

2. It should be of significance for biological diversity conservation.

3. It should provide an opportunity to explore and demonstrate approaches to sustainable development on a regional scale.

4. It should have an appropriate size to serve the three functions of biosphere reserves, as set out in Article 3.

5. It should include these functions, through appropriate zonation, recognizing:

(a) a legally constituted core area or areas devoted to long-term protection, according to the conservation objectives of the biosphere reserve, and of sufficient size to meet these objectives;

(b) a buffer zone or zones clearly identified and surrounding or contiguous to the core area or areas, where only activities compatible with the conservation objectives can take place;

(c) an outer transition area where sustainable resource management practices are promoted and developed.

6. Organisational arrangements should be provided for the involvement and participation of a suitable range of inter alia public authorities, local communities and private interests in the design and carrying out the functions of a biosphere reserve.

7. In addition, provisions should be made for:

(a) mechanisms to manage human use and activities in the buffer zone or zones;

(b) a management policy or plan for the area as a biosphere reserve;

(c) a designated authority or mechanism to implement this policy or plan;

(d) programmes for research, monitoring, education and training".

Articles 71-77 of the 2021 Technical Guidelines requires a dedicated area to be legally protected where nature conservation is made a priority and a management instrument (legal instrument) to be adopted to determine permitted and non-permitted activities as well as control measures for the core area and buffer zones. At the time of this cursory review, the Tasik Chini catchment area is protected under Section 62 of the National Land Code 1965. Still, it is not gazetted for purposes related to the MAB. The provision that requires the legally protected area to set out protection measures that ensure nature conservation is a priority will need to be carefully looked at, as the

development in the area could have pre-dated the designation of the MAB. In this case, there is a need to introduce measures that will allow existing approved development or land use activities to incorporate sustainable measures that will enable it to transition to sustainable practices.
Article 80 of the 2021 Technical Guidelines also recommends that some regions of the Core Areas, human activities should not be permitted save for scientific research, monitoring, and low-impact education, this may run counter to the traditional use of these areas by the Orang Asli communities that have privileges under the Aboriginal Peoples Act 1954. There is a need to leverage Article 109 of the 2021 Technical Guidelines and introduce elements of flexibility to accommodate existing and legacy land use and stakeholder rights as well as interests.

The RKK Tasik Chini 2018 took into consideration these requirements and has reported therein various control measures within the proposed zones that make up the Tasik Chini Man and Biosphere area as well as the surrounding areas beyond the proposed MAB area. It was gazetted in 2018 and considered measures that can help address planned and proposed physical developments. The RKK document also states the institutional set-up that is pending establishment and the recent gazettement of the Pahang State Parks enactment can be seen as a positive step forward to formalising the establishment of the required institutional set-up as per the UNESCO requirement.

The most important aspect for consideration here is that there is a need to reconcile pre-existing development and land use prior to the designation of the MAB and find an appropriate balance that will allow these land use or activities to transition to sustainable uses or practices. The gazettal of the TCBR or MAB area will need to take into consideration also the status of lands already alienated for private or individual, or specific purposes, and the required steps to help existing permitted activities (development) to transition towards practices that minimise impacts to ecosystem health of the lake basin and shifts towards sustainability. This will require extensive scientific input to determine the risks and threats, ensuing impacts and scientific measures required to help minimise or negate the negative impacts. ASM is well-positioned to support the interfacing of scientific intervention measures with planned and ongoing governance measures.

Governance Measures in Play

Since the 2019 media reports, the Pahang State Government has taken measures to address the concerns as well as the impacts that have arisen. During the Dewan Negeri sitting in August, His Royal Highness the Regent of Pahang, in his speech during the opening session on the 23 August 2021, decreed that protected areas such as Tasik Chini must continue to be protected and development activities must be carried out with minimum impact. The need to protect the environment was further reiterated in His Royal Highness the Regent of Pahang's speech during the opening session of the Pahang state Assembly on 28 March 2022.

The State Government, as reported by the Chief Minister of Pahang during the Dewan session, submitted its Periodic Review report on the Tasik Chini Man and Biosphere Reserve in December 2020, and UNESCO has requested the government to provide additional information for the review. The Chief Minister during the question time also stated that forest areas would be further gazetted to boost the conservation efforts for Tasik Chini. Concerns were also raised on the issues of water supply and electricity supply, including the problem related to the use of solar power, pertaining to costs and maintenance. The Dewan session also highlighted reading of the draft enactments on the incorporation of a Pahang States Park and a Biodiversity Council that will be used as vehicles to support conservation in Pahang.

At the second sitting of the Dewan Negeri, from the 6 to 10 December, the matter pertaining to the water supply was raised, the Dewan was informed that Off River Storage Systems were being developed in Chini and is at 35% of completion. The Chief Minister also briefed the Dewan that a Special Committee on Tasik Chini Rehabilitation (Jawatankuasa Khas Tindakan Pemulihan Tasik Chini) has put in place and coordinated various measures, which includes expanding the TCBR area from 6,922.96 hectares to 9,147.18 hectares, with the gazettal of a Permanent Forest Reserve [in the Mukim of Penyor] (via gazette notification dated 5 August 2021).

It was also reported that the Forest Department of Pahang has taken initiatives, along with the Fisheries Department of Pahang, Wildlife Department, Forest Research Institute Malaysia (FRIM) and several universities to help replant degraded areas to avoid the discharge of effluents into the lake. The TCBR will remain a State Forest Park, and no

further development will be allowed in the area. It was also reported to the Dewan that measures are underway to repair and improve facilities and infrastructures at the TCBR to facilitate better access and operations of existing facilities such as the resort at the lake. It was reported in the *Penyata Rasmi Dewan Negeri Pahang*, 30 March 2022, that the Pahang Forestry Department have begun efforts to plant 200,000 trees in Tasik Chini. It was also reported to the Dewan Negeri on the 31 March 2022 that RM6.45million has been put aside for forest conservation, particularly for the Tasik Chini area.

Based on the *Rancangan Struktur Negeri Pahang 2050 (RSNP 2050)*, Tasik Chini is recorded as an environmentally sensitive area (ESA), where development control measures are stricter and all activities are subjected to environmental impact assessment pursuant to the provision of the Environmental Quality Act 1974. Tasik Chini, as noted in the RSNP 2050, is listed under ESA for geological heritage and ESA for Biosphere Reserve. This is echoed by the RKK Tasik Chini 2018.

The focus for spatial strategic development is on developing tourism based on lake ecology and geological heritage. The focus is also given to ensuring that the cultural heritage of the Orang Asli community is protected and conserved and made part of the strategic plans for ecotourism to ensure that they can benefit from the related economic activities. This includes making provisions to facilitate the establishment of homestays and supporting the promotion of related tourism products such as traditional and indigenous crafts, which Kampung Gumum has been picked to showcase this.

Specific areas in the RKK Tasik Chini 2018 area have been identified as an ESA sites and areas for biodiversity conservation. Twelve zones for development have been delineated, with planning blocks identified, whereby any future physical development will require approval from the relevant District Council. The RKK Tasik Chini 2018 also notes a proposal to set up a dedicated State Park Board/Council, where a management Body for Tasik Chini Man and Biosphere Reserve will be given a role to manage the TCBR. What is unclear is the legal mandate from which the proposed bodies will be formed.

TCBR will also form part of the Great Walk, which showcases the history and heritage of Pahang. Emphasis is also made on preparing an Ecotourism Management Plan for Tasik Chini, together with a Spatial Management Plan couched with the Special Area Plan for TCBR (TCBR SAP). The RSNP 2050 also states that the TCBR SAP will make provisions to address issues related to carrying capacity and minimisation of ecological impacts, and plans are underway to conduct a study on the carrying capacity of Tasik Chini.

The Federal Government, through the East Coast Economic Region Development Council in their ECER Master Plan 2.0 2018-2025, have earmarked Pekan, particularly Tasik Chini Biosphere Reserve, as a destination for ecotourism. The focus is on developing sustainable ecotourism, leveraging the Tasik Chini Man and Biosphere Reserve Management Plan prepared in 2013. This has been reflected in the RSNP 2050 and the RKK 2018.

The Pahang State Government has also published in the gazette two enactments, the Pahang Biodiversity Enactment 2021 and the Pahang State Parks Corporation Enactment 2021, in November 2021. The Pahang Biodiversity Enactment 2021 sets out provisions for the establishment of the Pahang Biodiversity Council and Pahang Biodiversity Centre. The functions of the Pahang Biodiversity Council include advising the State Government on matters relating to the conservation and sustainable use of biological resources (section 13a); promote the establishment and strengthen the management of biological resources (section 13b); coordinating activities related to conservation research and sustainable use of biological resources and biodiversity (section 13d).

The function and powers of Pahang Biodiversity Centre, amongst other things, include the provision of accurate information or data on the status, magnitude, distribution, usage, and value of biodiversity (section 15(1)(a)); determination of policies and guidelines for scientific research or experiment; formulation of programmes for systematic surveys of biodiversity and the collection and analysis of data thereto (section 15(1)(d); identificationof priorities for research on biodiversity (section 15(1)(e). It also requires anyone seeking to access biodiversity found on State Land; any reserve, customary lands, or any other site over which indigenous communities exercise,communities-based rights; and any other areas that include rivers, tributaries, waterways, or areas covered by water, marine parks or territorial water; to obtain a license from the Council (section 28).

The Pahang State Parks Corporation Enactment 2021 focuses on, amongst others, the identification, introduction and promotion of the natural environment, resources and biodiversity (section 16a); development, conservation and preservation of the history, culture and flora and fauna (section 16b); advice to the State Authority on matters relating to general policy on the preservation, utilisation, control and management of natural environments, resources, and biodiversity (section 16e) in the State Park. The power to declare an area as a State Park falls with the remit of the State Authority.

These two enactments have great bearing on the status of TCBR, as the Pahang Biodiversity Enactment 2021 now has jurisdiction over it in matters pertaining to access to biodiversity resources, whilst the Pahang State Parks Corporation Enactment 2021 provides the platform to structure the management authority for TCBR. The National Forestry Act 1984 also has a bearing on the TCB and TCBR along with a host of statutory instruments, such as the Aboriginal Peoples Act 1954, the National Land Code 1965, the Environmental Quality Act 1974, the Town and Country Planning Act 1976, the Local Government Act 1976, Pahang State Mineral Enactment 2001, and the Pahang Mineral Regulations 2005.

Capitalising on Opportunities and Some Considerations

Governing TCB as a Basin will not only help Pahang State Government balance the development and conservation needs towards sustainability of the area, but it can also be used to translate the Sustainable Development Goals (SDGs) 2030. Determining the state and condition of TCB and the threats and risks associated with its state and condition as well as its potential impacts to the carrying capacity is key. Based on the areas of focus in the RKK Tasik Chini 2018, there are at least 10 SDGs that can be linked to TCB governance, as shown in Table 12.

Table 12: List of SDGs that can be linked to TCB governance interventions

Goal	Target
GOAL 1 - End poverty in all its forms everywhere.	**SDG Target 1.4:** By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.
GOAL 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture.	**SDG Target 2.4:** By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding, and other disasters and that progressively improve land and soil quality
GOAL 6 - Ensure availability and sustainable management of water and sanitation for all.	**SDG Target 6.3:** By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally **SDG Target 6.6:** By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
GOAL 8 - Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all.	**SDG Target 8.4:** Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

Goal	Target
GOAL 11 - Make cities and human settlements inclusive, safe, resilient, and sustainable.	**SDG Target 11.4:** Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
GOAL 12 - Ensure sustainable consumption and production patterns.	**SDG Target 12.2:** By 2030, achieve the sustainable management and efficient use of natural resources.
GOAL 13 - Take urgent action to combat climate change and its impacts.	**SDG Target 13.1.:** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.
GOAL 15 - Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.	**SDG Target 15.1:** By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains, and drylands, in line with obligations under international agreements. **SDG Target 15.2:** By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally. **SDG Target 15.5:** Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species. **SDG Target 15.6:** Ensure fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources. **SDG Target 15.7:** Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products. **SDG Target 15.8:** By 2020, introduce measures to prevent the introduction and significantly reduce the impact of Invasive Alien Species on land and water ecosystems and control or eradicate the priority species. **SDG Target 15.9:** By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts. **SDG Target 15.a:** Mobilise and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems. **SDG Target 15.b:** Mobilise significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.

Goal	Target
GOAL 16 - Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.	**SDG Target 16.3:** Promote the rule of law at the national and international levels and ensure equal access to justice for all. **SDG Target 16.7:** Ensure responsive, inclusive, participatory and representative decision-making at all levels.
GOAL 17 - Strengthen the means of implementation and revitalize the global partnership for sustainable development.	**SDG Target 17.14:** Enhance policy coherence for sustainable development.

The Pahang State Government can use this opportunity to help realise the aspirations contained in various policy instruments, which, when stitched together can help frame strategies for targeted interventions that lead to the sustainability of the TCB. The number of policies that can help provide the direction, both Federal and State policies, will need to be studied and reconciled to form a narrative that will benefit the TCB and her people. The policies include:

<u>Federal policies:</u>

- Twelfth Malaysia Plan, 2021-2025
- National Policy on the Environment 2002
- Shared Prosperity Vision 2030
- National Development Policy
- National Policy on Climate Change 2009
- National Water Resources Policy 2012
- Malaysia Policy on Foresting 2021
- National Policy on Biological Diversity 2016-2025
- National Mineral Policy 2 2009
- National Policy on Green Technology 2009
- Green Technology Master Plan 2017-2030
- National Cleanliness Policy 2020-2030
- National Policy on Solid Waste Management 2016
- *Rancangan Fizikal Negara Keempat (RFN4)*
- *Dasar Perindustrian Negara*
- National Fourth Industrial Revolution (4IR) Policy
- *Dasar Perbandaran Negara 2*
- National Policy on STIE 2020-2030
- *Dasar Pembangunan Luar Bandar (DPLB)*
- National Housing Policy 2018-2025
- National Agrofood Policy 2021-2030
- *Dasar Pertanian Negara Ketiga (DPN3)*
- National Food Security Policy Action Plan 2021-2025
- The National Sustainable Consumption Production Blueprint 2016-2030

<u>State policies:</u>

- *Rancangan Struktur Negeri 2035*
- *Rancangan Tempatan Daerah Pekan, Rompin, and Maran*
- *Rancangan Kawasan Khas Tasik Chini 2018 (RKK Tasik Chini 2018)*

These policies touch on multiple aspects that contribute to measures instituted by the Federal government towards ensuring planetary health. This is in line with the spirit of the Man and Biosphere Reserve; acting locally to help globally. There is also an opportunity to merge the reporting requirements for the TCBR to UNESCO and Pahang State Sustainability reporting, upscaling indicators not just to suit the purposes of UNESCO but serve the country's interest to monitor its measures and actions to help realise the aspirations for sustainable development. Perhaps, here, there can be an alignment of the various indicators to measure the state and performance of the TCBR and SDG2030.

The options to shift the focus from just TCBR to TCB bring forward seven key points for consideration to facilitate a shift in how TCB is governed, focusing on a system that fosters a collective approach. The considerations are subject matter based, with suggestions as to the mandate and mandate holders that can help bring it to fruition.

Gazettal and Management of TCBR

It is proposed that the TCBR area is gazetted as a State Park, as proposed in the ECERDC, 2010 Strategic Implementation Plan and noted in the RKK Tasik Chini 2018, under section 62 of the National Land Code 1965, and placed under the management of the Pahang State Parks Corporation, as per the Pahang State Parks Corporation Enactment 2021 ("SPCE 2021"). Section 16 of the SPCE 2021 can be leveraged and read in conjunction with other statutory instruments such as the National Forestry Act 1984, the Aboriginal Peoples Act 1954, the Environmental Quality Act 1974, the Town and Country Planning Act 1976, the Local Government Act 1976, Pahang State Mineral Enactment 2001, and the Pahang Mineral Regulations 2005. A dedicated Committee to assist the State Park Corporation can be established (section 19) to facilitate a science-governance interface, ensuring informed decision-making.

Gazettal of Lake Catchment Area

Another option is to gazette and declare the TCB area as a lake catchment, under the Pahang Resources Enactment 2007, Section 6, which states that the State Authority may, when it considers it necessary or expedient to protect or conserve any water resource, declare any lake or any part thereof or its surroundings to be a catchment area. This can be used to delineate the actual lake basin catchment boundary and protect it under Section 6 as a prohibited area, in which the Order gazetted can specify the types of activities permitted or any other details as deemed necessary by the State. Section 7 provides for regulations being instituted to prevent pollution, contamination, and siltation. Section 8 provides the power to the Director to inform by notice to the owner or occupier of the land or premises within the catchment area of Section 6 to prevent pollution, contamination or siltation or prohibit such persons from carrying out activities within a period stipulated in the notice. Non-compliance would attract a fine not exceeding RM200,000 or imprisonment not exceeding two years, and a subsequent offence will lead to a fine not exceeding RM200,000 or imprisonment not exceeding five years. The fines or imprisonment does not preclude the Director from making the cost of repair a recoverable debt due to the State.

Complementary and Concerted Governance

The TCBR cannot be managed in isolation from the Basin it sits in. The RKK Tasik Chini 2018 area provides a boundary and zonation set up that will facilitate cohesiveness, aligning existing and planned development trajectories, grounding it on principles of sustainable development. There is a need to look at the governance of the basin in its entirety, and develop a clear profile of what's ongoing, planned and forecasted, which in turn will allow for a comprehensive mapping of mandates and stakeholders. This is necessary to see where the match and mismatch are and determine the coverage of existing mandates needed to mainstream sustainability. It is not about integration, as mandates and interests held by different mandated stakeholders stem from specific legal instruments (Federal or State), which are purposive in nature. Instead, it focuses on concertedness, allowing each mandate holder the opportunity to form a collective bound by a united goal or purpose. This leads to an opportunity for the Districts of Pekan, Maran and Rompin to develop a policy geared towards sustainability suited to the needs of the district and the existing or planned development.

Inclusivity in Governance

The Basin cannot just be governed by the mandated stakeholders, as all parties with an interest in the area, present and future, are stakeholders in the sustainable future of the Basin. Stakeholder engagement, not just consultation, is critical to informed decision-making, as responsibility and accountability will now be spread beyond the government domain. It is no longer the government determining and directing. This will require platforms that will allow for two-way communication, both formal and informal, so that as far as possible everyone is in the know and no one can say they were excluded. The state of the TCB should be everyone's concern. Information will need to be available, accessible, and tailored to suit different types of users and uses, and platforms communicating this information should be user-friendly.As it is two ways, it can be used to push for citizen policing. The Office of the Chief Minister could perhaps spearhead this effort.

Leveraging on Analytics

Conserving the TCBR will require a basin approach. This, in turn, requires analytics and intelligence and science will take into account the best available knowledge approach, where knowledge gaps are covered by complementary knowledge systems drawing from indigenous and local knowledge and expertise. The analytics will help address gaps, risks, and threats; provide real-time information necessary for real-time decision-making; allow for a better understanding of trends and drivers, including the anticipated and unanticipated; and it should draw from multi-disciplinary research and data sharing. ASM could perhaps form a consortium to facilitate the stitching together of multiple disciplines to form a cohesive scientific/knowledge input, methods, and techniques to contribute to the analytics. The platforms and data architecture should be seamless to allow different applications to 'speak' to each other, and data can be ingested, processed, analysed, and presented in real time. This will also allow for comprehensive monitoring and reporting.

Recovery, Rehabilitation and Restoration plan

Analytics can support framing a recovery, rehabilitation, and restoration plan (3RP) for environmentally sensitive areas within the TCB. This will help ensure the natural and cultural legacy that has been passed from generation to generation is protected and that the health of the TCB ecosystem is maintained. One example of a 3RP would be a specific plan for mining areas to help minimise and mitigate the impacts of pollution and transition the sterile mining areas into a productive areas that can contribute to the socioeconomic development of the surrounding area and provide a means to help balance the health of the TCB ecosystem. It is proposed that the office of the Chief Minister spearheads this.

Investing in Sustainable Futures

Shifting towards mainstreaming sustainability will require the mobilisation of financial and capital resources that need not only stream from government coffers. Through inclusive engagements, investments can be drawn from non-government stakeholders, such as from the private sector, endowments, or even crowd funding initiatives. It is proposed that the *Bahagian Perancang Ekonomi Negeri Pahang* (*BPEN*) spearheads this.

Continuing Legacies

The narrative as to why the TCBR is important to the present and future is needed to allow for appreciation of what is there and why it's there. It is a slice of the Earth's history, a living lab where humans and nature intersect. It holds the memories and legacies from the past, the richness of the biodiversity and beauty of the landscape that has created value in the present, that hopefully will carry through to the future. The narrative has to be compelling enough, to bring a sense of belonging, of wanting to be part of the story to be created and experienced today and in the future. This can only be done by weaving together the scientific narrative with the indigenous and local knowledge, traditions, and practices, creating an experience of Tasik Chini, not just its beauty but the stories and memories it holds. It is proposed that the office of the Chief Minister spearheads this.

These proposed considerations can be supported by ASM as the ASM Act 1994 allows the ASM to support the Pahang State government particularly in the scientific and technological aspects. ASM has a wide range of experts such as fellows and networks with various institutions that can be leveraged, particularly in conducting the situational analysis (profiling of risks, threats, challenges, constraints, options, and opportunities, amongst other things), and determining the necessary scientific interventions and measures to strengthen governance systems.

CONSTRAINTS

The Task Force faced several challenges as follows:

i. MCO and current SOPs for COVID-19 prevention
ii. Flood disasters and heavy rainfall from November 2021 until January 2022
iii. Inaccessible documents and reports from certain agencies limit our perspectives on TCB and TCBR
iv. Coordinated discussions and execution of the planning by Task Force members coming from different agencies and philosophies
v. The high workload on teaching and research in the university for academic staff that are part of this Task Force
vi. Overworked and exhausted from the current online working environment

CONCLUSION

Various gaps in the knowledge need further evaluation and validation for Tasik Chini Basin that can be included and improved in the Phase 2 study. Overall, Tasik Chini Basin is currently not in a pristine condition and requires immediate rehabilitation and restoration program to conserve the ecosystems and fulfil our SDG2030 commitment.

KEY TAKEAWAYS

Socioeconomic Domain

Synergistic participation of all stakeholders

- Integrated management of TCB must include all stakeholders, including Orang Asli, by using international, national, state, and local agendas as the main blueprint.

Rigorous monitoring, regulation, and enforcement

- This element should serve as the main agenda for the rehabilitation of TCBR.

Synergistic participation of all stakeholders

- Integrated management of TCB must include all stakeholders, including Orang Asli, by using international, national, state, and local agendas as the main blueprint.

Integrity and sustainability of TCBR for local communities

- The functionality and integrity of the ecosystems of TCB and TCBR must be preserved for the purpose of conservation, as well as serving as sustainable resources for local communities.

Physical Domain

Soil Rehabilitation

- Improvement of compacted soil affected by mining operations is necessary if the reforestation program takes place successfully. Soil rehabilitation has started by planting cover crops to improve soil properties. Cover crops can establish quickly and protect the surface soil against raindrop impact and erosion.
- Overland flow from mining and agricultural areas can be intercepted by constructing an adequate number of sediment ponds.
- Construction of a perimeter bund in the mining area can hold overland flow and minimise sediment loading into the lake

Restoration of Lake Hydrological Regime

- The weir that was constructed to regulate the lake water level for navigation purposes has greatly modified the flow regime and increased the lake water level, especially during rainy seasons. This has unintentionally caused severe disruption on the *N. nucifera*'s habitat. Hydrological and hydraulic modelling is necessary to determine the appropriate weir design with the aim of bringing back the habitat of *N. nucifera* (water lily).
- Lake eutrophication due to high loading of nutrient from plantation and local communities must be regulated to ensure high quality of lake water that can support flora and fauna habitat.
- The land-use impact on water quality was not adequately measured. The lack of storm sampling might have underestimated loading of suspended sediment and other pollutant.

Changing the forest status from production to protection forest

- The existing secondary forest in the Lake Chini Basin is generally classified as a poor forest with low yield. A full protection of the secondary forest may have much higher benefits in terms of biodiversity conservation, ecosystem services, and eco-tourism.

Biological Domain

Ecosystem Rehabilitation

- Improvement of biodiversity that provides crucial ecosystem function, services, and stability

Ecosystem Management

- Management of TCB must be inclusive with a co-management approach with all the stakeholders by integration of Blue Economy, Low Carbon initiatives, and 8R-Nature-centric-Blue Ocean (8R-NCBE) philosophy (**Respect** marine and coastal environment, **Rethink** the value of marine and coastal resources, **Reduce** wastage, Reuse marine resources to reduce wastage, **Recycle** waste, **Restore** biological aquatic plants and animals; **Repurpose** biodiversity for higher-value use; and **Revitalise** marine and coastal resources) Position Paper on Blue Economy: Unlocking the Value of the Oceans (ASM, 2022)

Ecosystem Governance

- The governance of the TCB ecosystem must be transparent with active local participation by practising consensus rules in decision-making to restore and rehabilitate TCB.
- The management agencies must be accountable, responsive, and efficient in governing the ecosystem in TCB.

Governance Domain

Gazettal and management of TCBR

- Gazette as a State Park, under section 62 of the National Land Code 1965 managed by the Pahang State Parks Corporation, as per the Pahang State Parks Corporation Enactment 2021.

Gazettal of lake catchment area

- Pahang Water Resources Enactment 2007, Section 6, states that the State Authority may, when it considers it necessary or expedient to protect or conserve any water resource, declare any lake or any part thereof or its surroundings to be a catchment area.

Complementary and concerted governance

- Focus on concertedness, allowing each mandate holder the opportunity to form a collective bound by a united goal or purpose. This leads to an opportunity for the Districts of Pekan, Maran and Rompin to develop a policy geared towards sustainability.

Inclusivity in governance

- Stakeholder engagement, not just consultation, is critical to informed decision-making as responsibility and accountability will now be spread beyond the government domain. It is no longer the government determining and directing, this encourage citizen 'policing'.

Leveraging on analytics

- Analytics, intelligence, and science take into account the best available knowledge approach, where knowledge gaps are covered by complementary knowledge systems drawing from indigenous and local knowledge and expertise.

Recovery, rehabilitation, and restoration

- Analytics to support the framing of a recovery, rehabilitation and restoration plan (3RP) for environmentally sensitive areas within the TCB.

Investing in sustainable futures

- Mainstreaming sustainability will require the mobilisation of financial and capital resources that need not only stream from government coffers, e.g., private sector funding, endowments, or crowdfunding.

Continuing legacies

- The narrative as to why the TCBR is important to the present and future is needed to allow for appreciation of what is there and why it's there. It is a slice of the Earth's history, a living lab where humans and nature intersect. It holds the memories and legacies from the past, the richness of the biodiversity and the beauty of the landscape that has created value in the present, that will hopefully carry through to the future. The narrative has to be compelling to bring a sense of belonging, of wanting to be part of the story to be created and experienced today and in the future. This can only be done by weaving together the scientific narrative with the indigenous and local knowledge, traditions, and practices, creating an experience of Tasik Chini, not just for its beauty but the stories and memories it holds.

BIBLIOGRAPHY

Abdullah, M. T., Mohammad, A., Zalipah, M. N., & Lola, M. S. (Eds.). (2019). Greater Kenyir Landscapes: Social Development and Environmental Sustainability: From Ridge to Reef. Springer Nature.

Abdullah, M. T., Adnan, N. A., Zakaria, A. A., Ahmad, N. I. I. & Ruslan, A. (Eds). (2019). Tasik Kenyir Stunning Beauty and it's biodiversity. UMT Publisher.

Abdullah, M. T., Bartholomew, C. V., & Mohammad, A. (Eds.). (2021). Resource Use and Sustainability of Orang Asli: Indigenous Communities in Peninsular Malaysia. Springer Nature.

Abdul Hamid, Z. (2018, May 21). Tasik Chini a dead lake? *New Straits Times*. https://www.nst.com.my/opinion/columnists/2018/05/371520/tasik-chini-dead-lake

Abdul Hamid, Z. (2021, June 17). Climate change and biodiversity loss must be tackled together. *New Straits Times*. https://www.nst.com.my/opinion/columnists/2021/06/699448/climate-change-and-biodiversity-loss-must-be-tackled-together

Abdul Malek, R. (2021, June 15). Kerajaan negeri komited pulihkan Tasik Chini. *Harian Metro*. https://www.hmetro.com.my/mutakhir/2021/06/718087/kerajaan-negeri-komited-pulihkan-tasik-chini

Abdullah, M. F., & Abd Aziz, M. A. F. (2016, October 16). "Jaga" Chini. *Harian Metro*. https://www.hmetro.com.my/mutakhir/2016/10/174389/jaga-chini

Adilah, A. N., & Nadia, H. N. (2020). Water quality status and heavy metal contains in selected rivers at Tasik Chini due to increasing land use activities. In IOP Conference Series: Materials Science and Engineering (Vol. 712, No. 1, p. 012022). IOP Publishing.

Ahmad-Bakri, F. A., Abd-Rahman, N. A., Ahmad, Z. A. M., Maryati, M., & Abu-Bakar, M. F. (2021, April). Activity pattern of Scotophilus kuhlii at agriculture and urban landscape area in Tasik Chini and Universiti Kebangsaan Malaysia. In IOP Conference Series: Earth and Environmental Science (Vol. 736, No. 1, p. 012005). IOP Publishing.

Ahmad, H. (2010). Tourism Sector Of Tasik Chini Biosphere Reserve. https://www.academia.edu/489510/TOURISM_SECTOR_OF_TASIK_CHINI_BIOSPHERE_RESERVE

Ahmad, H., & Idris, M. (2012). Mempakej Pelancongan Tasik Chini Sebagai Rizab Biosfera. Journal of Social Sciences and Humanities, 7(1), 119–131. https://www.semanticscholar.org/paper/Mempakej-Pelancongan-Tasik-Chini-Sebagai-Rizab-Ahmad-Idris/b04e0db5a715c5cfe3e27f1f543806a0e2697fa1

Ahmad, H., Idris, M., Ekhwan, M., Jusoh, H., & Ahmad, N. (2012). The learning culture of a mobility program for sustainability of Tasik Chini biosphere reserve. Procedia - Social and Behavioral Sciences, 59, 33–41. https://doi.org/10.1016/j.sbspro.2012.09.242

Ahmad, H., Idris, M., Jusoh, H., & Er, A. C. (2013). Place-Making of Ecotourism in Tasik Chini : From Exploratory to the Place-Making of Ecotourism in Tasik Chini : From Exploratory to the Contemporary Biosphere Reserve. Asian Social Science, 9(6). https://doi.org/10.5539/ass.v9n6p84

Ahmad, H., Idris, M., Jusoh, H., Toriman, M. E., Buang, A., Jusoff, K., Mohd Fuad, M. J., Er, A. C., Azima, A. M., & Habibah, A. (2012). Assessing Natural Capitals for Sustainable Ecotourism in Tasik Chini Biosphere Reserve. Advances in Natural and Applied Sciences, 6(1), 1–9. https://www.researchgate.net/publication/286957505_Assessing_natural_capitals_for_sustainable_ecotourism_in_Tasik_Chini_Biosphere_Reserve

Ahmad, H., Jusoh, H., Choy, E. A., & Idris, M. (2020). Unpacking The Experience Of The Biosphere Reserve Tourism From The Academic Tourists ' Perspectives : A Case Of Tasik Chini. *Journal Of Tourism, Hospitality And Environment Management*, 5(21), 163–183. https://doi.org/10.35631/JTHEM.5210010.Abstract

Ahmad, S. (2021, June 20). Nasib Tasik Chini, UNESCO Paris beri tempoh hingga 2022. *Harian Metro*. https://www.hmetro.com.my/mutakhir/2021/06/720391/nasib-tasik-chini-unesco-paris-beri-tempoh-hingga-2022

Ainon Hamzah & Yanti Hattasrul. 2008. Water Quality and Bacterial Study in Tasik Chini, Pahang. https://www.semanticscholar.org/paper/Water-Quality-and-Bacterial-Study-in-Tasik-Chini%2C-Hamzah-Hattasrul/b0f3e89de0764a072e27c90bf9fd3ed8ee6a90c2

Alagesh, T.N. (2021a). ECERDC set to focus on west Pahang as new growth centre. (The East Coast Economic Region Development Council). *New Straits Times*, 5 August. https://www.nst.com.my/news/nation/2021/08/715390/ecerdc-set-focus-west-pahang-new-growth-centre.

Alagesh. T.N. (2021b). RM20 million to restore Tasik Chini after mining aftermath. *New Straits Times*, 25 June. https://www.nst.com.my/news/nation/2021/06/702267/rm20-million-restore-tasik-chini-after-mining-aftermath#:~:text=Menteri%20Besar%20Datuk%20Seri%20Wan,restore%20the%20abandoned%20mining%20sites.

Alagesh, T. N. (2017, March 13). Tasik Chini ecosystem under threat? *New Straits Times*. https://www.nst.com.my/news/2017/03/220353/tasik-chini-ecosystem-under-threat

Alagesh, T. N. (2020a, June 23). Once the jewel of Chini, Tasik Chini now all but forgotten. *New Straits Times*. *New Straits Times*. https://www.nst.com.my/news/nation/2020/06/602717/once-jewel-chini-tasik-chini-now-all-forgotten

Alagesh, T. N. (2020b, June 24). Tasik Chini set for major rehabilitation work. *New Straits Times*. https://www.nst.com.my/news/nation/2020/06/602978/tasik-chini-set-major-rehabilitation-work

Alagesh, T. N. (2021, June 14). Brighter days await Tasik Chini as Pahang Regent orders for expansion of forest reserve. *New Straits Times*. https://www.nst.com.my/news/nation/2021/06/698665/brighter-days-await-tasik-chini-pahang-regent-orders-expansion-forest

Albert Albee. 1973. Orang Asli Anecdotal Reflections. https://link.springer.com/chapter/10.1007/978-3-030-64961-6_2

Albert Albee. 2017. A Journey of Incremental Steps for the Orang Asli. https://link.springer.com/chapter/10.1007/978-3-030-64961-6_1

Aldrich, D.P. Building Resilience: Social Capital in Post-Disaster Recovery; University of Chicago Press: Chicago,IL, USA, 2012; ISBN 0–226–01287–5.

Aldrie Amir, A. (2021, June 16). Reminder of crucial need to protect our forests, lakes. *New Straits Times*. https://www.nst.com.my/opinion/columnists/2021/06/699122/reminder-crucial-need-protect-our-forests-lakes

Amran, I. R., & Jamin, R. M. (2021). Kajian Pencemaran Air Terhadap Komuniti Orang Asli. Universiti Malaysia Terengganu Journal of Undergraduate Research, 3(2), 119–128. https://doi.org/http://doi.org/10.46754/umtjur.2021.04.0012

Anon. 2019a. Act now to save Tasik Chini. *New Straits Times*, 22 February. https://www.nst.com.my/opinion/leaders/2019/02/462821/nst-leader-act-now-save-tasik-chini.

Anon. 2019b. Masa depan Tasik Chini makin kelam. *BH Berita Harian*, 20 February. https://www.bharian.com.my/berita/nasional/2019/02/533206/masa-depan-tasik-chini-makin-kelam.

Anon. 2021a. MB Pahang harus membatalkan perlombongan berhampiran Tasik Chini untuk memelihara tasik, menggesa kumpulan persekitaran. *New Straits Times*, 8 June. https://www.nst.com.my/news/nation/2021/06/697003/pahang-mb-should-cancel-mining-near-tasik-chini-preserve-lake-urges.

Anon. 2021b. NGO sangkal dakwaan Tasik Chini sudah dipulihara. *Malaysiakini*, 10 June. https://www.malaysiakini.com/news/578488.

Anon. 2021c. Perak's Gunung Kanthan in danger of being reduced to rubble. *The Malaysian Insight*, 6 July. https://www.themalaysianinsight.com/s/325594.

Anuar, M. K. (2020, February 18). Tasik Chini an impending disaster. Aliran. https://aliran.com/web-specials/tasik-chini-an-impending-disaster/

Arafat, M.Y., M. S. Islam, M. I. Ali, Z. Ab. Wahid (2016) Status and Contamination Level of Water Quality in Lake Chini, Malaysia. *The National Conference for Postgraduate Research 2016*, Universiti Malaysia Pahang

Aruchunnan, G., Ng, Y. F., Hazmi, I. R., & Wee, S. L. (2016). Dung Beetles (Coleoptera: Scarabaeoidea) From Tasik Chini Biosphere Reserve, Pahang. Serangga, 21(1).

Aruchunnan, G., Foo, N. Y., Ling, W. S., & Hazmi, I. R. (2015). Diversity and abundance of dung beetles attracted to different ages of cow dung at Tasik Chini Biosphere Reserve, Pahang. In AIP Conference Proceedings (Vol. 1678, No. 1, p. 020005). AIP Publishing LLC.

ASEAN Committee on Disaster Management. (2019). Dam Management in Malaysia – Flood Risk Management Case Visit. 8 July 2019. https://www.iges.or.jp/sites/default/files/inline-files/03_DID%20Dam%20Management_1.pdf

Asrol, A. 2021a. Kembalikan kegemilangan Tasik Chini. *Berita Harian*, 14 June. https://origin.bharian.com.my/berita/wilayah/2021/06/827644/kembalikan-kegemilangan-tasik-chini.

Asrol, A. 2021b. Nafi lombong Tasik Chini dalam hutan simpan. *Berita Harian*, 12 June. https://www.bharian.com.my/berita/nasional/2021/06/826944/nafi-lombong-tasik-chini-dalam-hutan-simpan.

Asrol, A. 2021c. Pahang, PPTC konsisten pulihara kelestarian Tasik Chini. *Berita Harian*, 12 Jun. https://www.bharian.com.my/berita/nasional/2021/06/827170/pahang-pptc-konsisten-pulihara-kelestarian-tasik-chini.

Atiqah, N., Akbar, Z., Syafrinna, Ubaidah, N., & Foo, N. Y. (2015, September). Comparison of the ranging behavior of Scotophilus kuhlii (Lesser Asiatic Yellow Bat) in agricultural and urban landscape. In AIP Conference Proceedings (Vol. 1678, No. 1, p. 020026). AIP Publishing LLC.

Awang, A. (2021, June 13). Pahang, PPTC konsisten pulihara kelestarian Tasik Chini. *Berita Harian*. https://www.bharian.com.my/berita/nasional/2021/06/827170/pahang-pptc-konsisten-pulihara-kelestarian-tasik-chini

Awang, A. (2021, June 13). Syor Hutan Simpan Chini diwarta Hutan Perlindungan. *Berita Harian*. https://www.bharian.com.my/berita/nasional/2021/06/827370/syor-hutan-simpan-chini-diwarta-hutan-perlindungan

Azmil, A. M., & Juliana, W. W. (2013). Phenological patterns of selected Ficus species in Tasik Chini, Malaysia. Malaysian Applied Biology, 42(2), 89-92.

Barker, P.A., Roberts, N., Lamb, H.F., van der Kaars, S., & Benkaddour, A. (1994). Interpretation of Halocene lake-level change from diatom assemblages in Lake Sidi Ali, Middle Atlas, Morocco. *Journal of Paleolimnology*. 12, 223-234. https://doi.org/10.1007/BF00678022

Basori, M.B.I (2014) Geology and genesis of volcanic-hosted massive sulphide deposits in the Tasik Chini District, Central Peninsular Malaysia. PhD Thesis University of Tasmania.

Bernama. (2014). Najib submits five environment management plans for ECER sustainable development. The Sun Daily. https://www.thesundaily.my/archive/1028339-YRARCH249826

Bernama. (2019, April 29). Tasik Chini gazetted as permanent forest reserve. *New Straits Times*. https://www.nst.com.my/news/nation/2019/04/478005/tasik-chini-gazetted-permanent-forest-reserve

Bernama. (2020, June 26). Pahang govt making efforts to restore Chini Lake. *Astro Awani*. https://www.astroawani.com/berita- malaysia/pahang-govt-making-efforts-restore-chini-lake-248828

Bernama. (2021a, June 11). Pahang govt urged to halt mining activities at Tasik Chini. *Malay Mail*. 11 June, https://www.malaymail.com/news/malaysia/2021/06/11/pahang-govt-urge-to-halt-mining-activities-at-tasik-chini/1981334

Bernama. (2021b, June 13). Make Chini reserve a Protected Forest, says Pahang forestry dept. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2021/06/13/make-chini-reserve-a-protected-forest-says-pahang- forestry-dept/

Briddon, C.L. and McGowan, S. and Metcalfe, S.E. and Panizzo, V. and Lacey, J. and Engels, Stefan and Leng, M. and Mills, K. and Shafiq, M. and Idris, M. (2020) Diatoms in a sediment core from a flood pulse wetland in Malaysia record strong responses to human impacts and hydroclimate over the past 150 years. Geo: Geography and Environment. 7 (1), e00090. ISSN 2054-4049.

Cardoso, A.C., Free, G., Nõges, P., Kaste, Ø., Poikane, S., & Solheim, L. (2009). Lake Management Criteria. In Likens, G.E. (eds.) Encyclopaedia of Inland Waters, p. 310-331. Academic Press.

Carpenter, S. R., Stanley, E. H., & Vander Zanden, M. J. (2011). State of the world's freshwater ecosystems: physical, chemical, and biological changes. Annual review of Environment and Resources, 36, 75-99.

Catford, J. A., Vesk, P. A., Richardson, D. M., & Pyšek, P. (2012). Quantifying levels of biological invasion: towards the objective classification of invaded and invasible ecosystems. Global Change Biology, 18(1), 44-62.

Celcom dan Universiti Kebangsaan Malaysia jalin kerjasama untuk memperkasa Tasik Chini. (2018, August 21). Celcom. https://www.celcom.com.my/about-celcom/media-centre/2018/celcom-dan-universiti-kebangsaan-malaysia-jalin-kerjasama-untuk-memperkasa-tasik-chini

Chan, Y.Q. (2021, June 11). NGO sangkal dakwaan Tasik Chini sudah dipulihara. *Malaysiakini*. https://www.malaysiakini.com/news/578488

Chew, M. Y., & Phon, C. K. A butterfly-attracting common strangling fig (Ficus sundaica) in the Tasik Chini riverine forest in Peninsular Malaysia.

Choong, M. Y. (2012, August 28). Tasik Chini's lost allure. *The Star*. https://www.thestar.com.my/lifestyle/features/2012/08/28/tasik-chinis-lost-allure/

Chow, M.F., Z. Yusop and S. Shirazi (2013) Storm Runoff Quality and Pollutant Loading from Commercial, Residential and Industrial Catchments in the Tropic. Environmental Monitoring and Assessment. 185:8321-8331. doi 10.1007/s10661-013-3175-6. Springer

Crabtree, S. A., & Parker, J. (2014). Report on Ethnographic Work at Tasik Chini (Issue April). https://core.ac.uk/download/pdf/29050786.pdf

Crabtree, S.A. et al. (2016). Death of the Dragon God Lake: Voices from Tasik Chini, Malaysia. *Petaling Jaya: Strategic Information and Research Development Centre & Center for Orang Asli Concerns*.

Crabtree, S. A., Parker, J., Parker, I. C., & Parker, M. C. (2018). Development as eradication : The pillage of the Jakun ' people ' s bank ' of Tasik. *South East Asia Research*, 26(3), 283–298. https://doi.org/10.1177/0967828X18793201

Crabtree, S.A. et al. (2019). 'Behaving like a Jakun!' A case study of conflict, 'othering' and indigenous knowledge in the Orang Asli of Tasik Chini. *Journal of Sociology and Development*, 3(1): 23-45.

Cutter, S. L. (1996). Vulnerability to environmental hazards. *Progress in Human Geography*, 20(4), 529–539. https://doi.org/10.1177/030913259602000407

Dewan Negeri Pahang. (2021a). Penyata Rasmi: Mesyuarat Pertama Penggal Ke-4 Dewan Negeri Pahang ke-14, Ogos 2021.

Dewan Negeri Pahang. (2021b). Penyata Rasmi: Mesyuarat Kedua Penggal Ke-4 Dewan Negeri Pahang ke-14, Disember 2021.

East Economic Region Development Council, & UKM Pakarunding Sdn Bhd. (n.d.). ECER Master Plan 2.0: The Next Leap 2018-2025. https://www.ecerdc.com.my/wp-content/uploads/2020/03/Master-Plan-2.0_BI_rev046-low-res.pdf

Ebrahimpour, M. and Mushrifah I. (2008). Heavy metal concentrations in water and sediments in Tasik Chini, a freshwater lake, Malaysia. Environmental Monitoring Assessment, 141:297–307. DOI 10.1007/s10661-007-9896-7

Elton, C.S., and Miller, R.S. (1954). "The Ecological Survey of Animal Communities: With a Practical System of Classifying Habitats by Structural Characters". *The Journal of Ecology*. 42 (2): 460–496. doi:10.2307/2256872. JSTOR 2256872.

Extensive rehab programme needed to restore Tasik Chini to its former glory. (2019, February 23). *New Straits Times*. https://www.nst.com.my/news/nation/2019/02/462937/extensive-rehab-programme-needed-restore-tasik-chini-its-former-glory

Faidi, M. A., Hasan, M. G., & Shamsuddin, S. A. (2018). Mapping of Lotus Distributions Using Sentinel-2 Satellite Imagery in Tasik Chini. *International Journal of Agriculture, Forestry and Plantation*, 6.

Fatin, Z., Othman, N., Haris, H., Najmuddin, M.F., Md-Zain, B.M. and Abdul-Latiff, M.A.B. (2021). Ethnoprimatological survey among Temuans (Proto-Malay) in Gunung Ledang, Johor, Malaysia. Malayan Nature Journal 73(4): 647-652.

Federal Department of Town and Country Planning. (2010). National Physical Plan-2. Ministry of Housing and Local Government Malaysia. https://www.academia.edu/8576257/NPP_National_Physical_Plan

Flanagan, Barry E., Gregory, Edward W., Hallisey, Elaine J, Heitgerd, Janet L. and Lewis, Brian. *"A Social Vulnerability Index for Disaster Management" Journal of Homeland Security and Emergency Management*, vol. 8, no. 1, 2011, pp. 000010220215477355179 2. https://doi.org/10.2202/1547-7355.1792

FMT Reporters. (2021, June 7). Cancel approval for mining near Tasik Chini, pleads heritage group. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2021/06/07/cancel-approval-for-mining-near-tasik-chini-pleads-heritage-group/

Foo, K.Y. (1983) The Palaeozoic sedimentary rocks of Peninsular Malaysia-stratigraphy and correlation, Proceedings of the workshop on stratigraphic correlation of Thailand and Malaysia 1: Technical papers. *Geological Society of Thailand and Geological Society of Malaysia*, p. 1-19.

Gasim, M.B. Mohd. E. Toriman, Z. Ali Rahman, M. S. Islam and T. C. Chek (2009) Flow characteristics of the Tasik Chini's feeder rivers, Pahang, Malaysia. *Bulletin of the Geological Society of Malaysia*, 55 (2009) 7 – 13, doi: 10.7186/bgsm2009002

Ghazali Kori. (2021). Paradise in limbo. *New Straits Times*, 24 July. https://www.nst.com.my/news/nation/2021/07/711406/paradise-limbo.

Habibah, A., Hamzah, J., & Mushrifah, I. (2010). Sustainable Livelihood of The Community In Tasik Chini Biosphere Reserve : The Local Practice. Journal of Sustainable Development Vol., 3(3). p. 184. http://www.ccsenet.org/journal/index.php/jsd/article/view/6439

Habibah, A., Mushrifah, I., Hamzah, J., Buang, A., Toriman, M. E., Abdullah, S. R. S., Amirah, K. Z. N., Farahin, Z. N., & Er, A. C. (2013a). Biosphere Reserve as a Learning Tourism Destination: Approaches from Tasik Chini. International Journal of Geosciences, 04(10), 1447–1458. https://doi.org/10.4236/ijg.2013.410142

Habibah, A., Er, A. C., Mushrifah, I., Hamzah, J., Sivapalan, S., Buang, A., Toriman, M. E., & Sharifah Mastura, S. A. (2013b). Revitalizing Ecotourism for a Sustainable Tasik Chini Biosphere Reserve. Asian Social Science, 9(14), 70–85. https://doi.org/10.5539/ass.v9n14p70

Habibah, A., Mushrifah, I., Hamzah, J. E. A. C., Er, A. C., Buang, A., Toriman, M. E., & Zaimah, R. (2013c). Place-making of ecotourism in Tasik Chini: From exploratory to the contemporary biosphere reserve. Asian Social Science, 9(6), 84.

Haliza Abdul Rahman. 2021. Audit UNESCO penentu status Tasik Chini. *Sinar harian*, 6 Julai. https://www.sinarharian.com.my/article/148307/KHAS/Pendapat/Audit-UNESCO-penentu-status-Tasik-Chini.

Hashim, M. H., Idris, M., Bakar, Y., & Choong, C. (2018). Genetic relationships of Hemibagrus nemurus in Tasik Chini Biosphere Reserve based on D-loop sequences. Malayan Nature Journal, 70(1), 55-65.

Hashim, M. H., Idris, M., Ismail, A., & Aiman, S. (2015) Fish Community In The Lake Of Tasik Chini Biosphere Reserve, Pekan, Pahang.

Hezri, A. & Chan, H. (2012). Tasik Chini: A Lake at the Edge of Ecological Collapse. Malaysian Asian Public Intellectuals, Regional Project Working Group.

HoLT, Goethals PLM. (2019). Opportunities and Challenges for the Sustainability of Lakes and Reservoirs in Relation to the Sustainable Development Goals (SDGs). Water. 2019; 11(7):1462. https://doi.org/10.3390/w11071462

Husin, N. N. (2008, December 29). Tasik Chini still a popular haunt among tourists. *The Star*. https://www.thestar.com.my/news/community/2008/12/29/tasik-chini-still-a-popular-haunt-among-tourists

Husin, N. N. (2008, February 5). Lure of Tasik Cini Government. *The Star*. https://www.thestar.com.my/news/community/2008/02/05/lure-of-tasik-cini-government

Ida Royani & Rahaya Jamin. (2021). Penyertaan orang Asli dalam aktiviti eko-pelancongan di Tasik Chini, Pahang, Malaysia. https://umtjur.umt.edu.my/wp-content/uploads/sites/141/2021/04/Article-V3N1-12.pdf

Idris, A., Ismail, S., Haron, Y., & Suhana, Y. (2009). Insects of Tasik Chini with special emphasis on Ichneumonid Wasps. Sains Malaysiana, 38.

Idris, M. (2011). Greening Tourism in Malaysia's Environmental Sensitive Site: Case Study on Tasik Chini. https://www.oecd.org/site/eduhecr/47123463.pdf

Ishak, A. R. (2019, February 23). Unbated land clearing, mining mar Tasik Chini environment. *New Straits Times*. https://www.nst.com.my/news/nation/2019/02/462893/unabated-land-clearing-mining-mar-tasik-chini-environment#:~:text=PEKAN%3A At least two illegal,the Tasik Chini Research Centre.

Ishak, A. R., & Alagesh, T. N. (2019, February 22). "Lake may lose Unesco listing." *New Straits Times*. https://www.nst.com.my/news/nation/2019/02/462526/lake-may-lose-unesco-listing

Ismail, A., Alang, W. Z. A. M., Pardi, F., Alwi, I., Wahab, N. A., Ismail, A., & Daud, D. (2015) Community structure of tropical rainforest floor vegetation at different zonation in Tasik Chini Forest Reserve, Pahang.

Jarić, I., Lennox, R. J., Kalinkat, G., Cvijanović, G., & Radinger, J. (2019). Susceptibility of European freshwater fish to climate change: Species profiling based on life history and environmental characteristics. Global change biology, 25(2), 448-458.

Japan International Cooperation Agency & Department of Irrigation & Drainage Malaysia. (2011). The Preparatory Survey for Integrated River Basin Management Incorporating Integrated Flood Management With Adaptation of Climate Change. Final Report. Vol. 3. Pahang River Basin. https://openjicareport.jica.go.jp/pdf/12020327.pdf

Jenny, J-P. et al. (2020). Scientist's Warning to Humanity: Rapid Degradation of the World's Largest Lakes. Journal of Great Lakes Research, 46: 686-702.

Jerry Choong. 2021. Tasik Chini Unesco status under review, faces risk of delisting amid pollution. *MalayMail*, 3 July. https://www.malaymail.com/news/malaysia/2021/07/03/report-tasik-chini-unesco-status-under-review-faces-risk-of-delisting-amid/1986826.

Juliana, W. A., Nizam, M. S., Khatijah, H. H., Torman, M. E., Idris, M., Norafida, N. A., & Nurhanim, M. N. (2010). The biodiversity and ecology of aquatic plants at Tasik Chini, Pahang, Malaysia. Research Journal of Biological Science, 5(10), 692-698.

Kamarudin, M.K.A, M. E. Toriman, M. Idris, H. Juahir, A. Azid, M. B. Gasim, R. Umar, A. Endut, M. Mokhtar, S. I. Khalit, A. Ismail, N. H. Mat Yaakob and M. A. Rwoo (2016). Environmental Management on Natural Lake Using Sediment and Hydrology Hydraulic Models. Malaysian Journal of Applied Sciences, 1(2): 9-26

Kementerian Tenaga Dan Sumber Asli. (2021). Kenyataan Media: Kementerian Tenaga Dan Sumber Asli Menyokong Usaha Pemuliharaan Tapak Biosfera Tasik Chini. https://www.jmg.gov.my/images/jmg/news/newspaper/2021/Kenyataan_Media_Kementerian_Tenaga_Dan_Sumber_Asli_Menyokong_Usaha_Pemuliharaan_Tapak_Biosfera_Tasik_Chini.pdf

Khoo, S. (2007, May 8). Groups working together to rehabilitate Lake Chini ' s surroundings. *The Star*. https://www.thestar.com.my/news/community/2007/05/08/groups-working-together-to-rehabilitate-lake-chinis-surroundings

Khoo, S. (2008, December 15). Pahang wants to revive Tasik Chini. *The Star*. https://www.thestar.com.my/news/nation/2008/12/15/pahang-wants-to-revive-tasik-chini

Khoo, S. (2012, August 14). Pahang govt pledges to preserve lake's ecology. *The Star*. https://www.thestar.com.my/news/nation/2012/08/14/pahang-govt-pledges-to-preserve-lakes-ecology

Kong, L. (2008, December 16). Make the polluters pay, says group. *The Star*. https://enviro2.doe.gov.my/ekmc/newspaper/165162/

Kurnia, A. (2010). "Tasik Chini Biosphere Reserve in Regional Sustainable Development: Contribution of Tasik Chini Biosphere Reserve in Developing Local Community Economy." http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_YoungAwards_2010_MalaysiaFinalReport_e.pdf

Kutty, A. A., Othman, M. S., Ghasim, M. B., & Dugat, S. (2009). Fish diversity at lake Chini, Pahang, Malaysia. Sains Malaysiana, 38(5), 625-630.

Lake Chini could be gazetted as state park, says Pahang exco. (2020, November 7). *Malay Mail*. https://www.malaymail.com/news/malaysia/2020/11/07/lake-chini-could-be-gazetted-as-state-park-says-pahang-exco/1920426

Luke, S.H., Barclay, H., Bidin, K., Chey, V.K., Ewers, R.M., Foster, W.A., Nainar, A., Pfeifer, M., Reynolds, G., Turner, E.C., Walsh, R.P.D., Aldridge, D.C., (2017). The effects of catchment and riparian forest quality on stream environmental conditions across a tropical rainforest and oil palm landscape in Malaysian Borneo. Ecohydrology 10, 1–14..

Mamat, M.R. (2020, June 30). Pemandu bot pelancong Tasik Chini hilang pendapatan. *Berita Harian*. https://www.bharian.com.my/berita/wilayah/2020/06/705722/pemandu-bot-pelancong-tasik-chini-hilang-pendapatan

Man et al. (2011). Strategi Tradisional Komuniti Jakun Tasik Chini, Pahang Mengurus Sumber Semulajadi Secara Lestari. https://www.researchgate.net/publication/245586235_Strategi_Tradisional_Komuniti_Jakun__Tasik_Chini_Pahang_Mengurus_Sumber_Semulajadi_Secara_Lestari.

Mana, S.C.A. & N. T. Fatt (2017) Arsenic speciation using ultra high-performance liquid chromatography and inductively coupled plasma optical emission spectrometry in water and sediments samples, Geology, Ecology, and Landscapes, 1:2, 121-132, DOI: 10.1080/24749508.2017.1332855

Mansour, O., Idris, M., & Das, S. K. (2016, November). Effect of different types of commercial feed meal on the growth forms of Barbonymus schwanenfeldii (Lampam) in Chini Lake, Malaysia. In AIP Conference Proceedings (Vol. 1784, No. 1, p. 060044). AIP Publishing LLC.

Marimuthu, S. B., & ZakariahZakariah, A. A. (2020). The Sufficiency of Malaysia ' s Environmental Laws for the Protection of the Tasik Chini UNESCO Biosphere Environmental Damage at Tasik Chini and its Consequences. *Australian Journal of Asian Law*, 21(1), 25–37. https://ssrn.com/abstract=3748938

Metcalfe, I., (1980), Upper Carboniferous conodont faunas of the Panching limestone, Pahang, West Malaysia: Paleontology, v. 23, p. 297-314.

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: wetlands and water synthesis. World Resources Institute, Washington, DC

Mineral and Geoscience Department of Malaysia (2020) Malaysian Mining Industry 2020. Department of Mineral and GeoScience Department of Malaysia.

Ministry of Natural Resources And Environment Conservation and Environmental Management Division. (2009). Malaysia: Tasik Chini. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_BR_Malaysia_TasikChini_EN.pdf

Mir, S. I., Gasim, M. B., Rahim, S. A., & Toriman, M. E. (2010). Tasik Chini catchment, Pahang, Malaysia. Geological Society of Malaysia, 56, 1-7. https://doi.org/10.7186/bgsm56201001

Mohamad Shofi Md Isa. (2021). Golden Prosperous harap kebenaran melombong di Tasik Chini. *Utusan*, 20 June. https://www.utusan.com.my/terkini/2021/06/golden-prosperous-harap-kebenaran-melombong-di-tasik-chini/.

Mohd Izam, N. A., Azman, S. N., Jonit, E., Sallehoddin, S. M. H., Khairul, D. C., Zainul Abidin, M. K., & Farinordin, F. A. (2021). Freshwater ecosystem: A short review of threats and mitigations in Malaysia. *Gading Journal of Science and Technology*, 4(1), 109-117.

Mohd Zalani Md Atan. (2021). Demi Tasik Chini! Masyarakat Orang Asli sambut gembira titah istana. *AstroAwani*, 15 June. https://www.astroawani.com/berita-malaysia/demi-tasik-chini-masyarakat-orang-asli-sambut-gembira-titah-istana-303307.

Mokhtar, K (2011) Quantification and modelling of sediment loading in oil palm catchment. Master Thesis, Faculty of Civil Engineering, Universiti Teknologi Malaysia

Muhammad Barzani Gasim. (2008). Water Quality of Several Feeder Rivers between Two Seasons in Tasik Chini, Pahang. https://www.researchgate.net/publication/289971678_Water_Quality_of_Several_Feeder_Rivers_between_Two_Seasons_in_Tasik_Chini_Pahang

Muhammad Barzani Gasim. 2010. Assessment of land use and land cover changes in the Tasik Chini Catchment area, Pahang, Malaysia using the GIS. https://www.researchgate.net/publication/287683275_Assessment_of_land_use_and_land_cover_changes_in_the_Tasik_Chini_Catchment_area_Pahang_Malaysia_using_the_GIS

Musa, S. (2014, February 6). Restoring Tasik Chini To Its Pristine Condition | UKM News Portal. https://www.ukm.my/news/archive/tahun-2014/february-2014/restoring-tasik-chini-to-its-pristine-condition/

Najmuddin, M.F., Afiqah, M.A., Fatin, Z., Othman, N., Haris, H., Md-Zain, B.M. and Abdul-Latiff, M.A.B. (2021). Ethnoprimatological survey among Semoq Beri (Senoi) in Maran, Pahang, Malaysia. *Malayan Nature Journal*, 73(4): 641-646.

Nakagawa, Y.; Shaw, R. Social Capital: A Missing Link to Disaster Recovery. Int. J. Mass Emergencies Disasters, (2004), 22, 5–34.

Nasrudin Subhi, Rozita Ibrahim, Mushrifah Idris, & Mohd. Suhaimi Mohamad. (2018). Tasik Chini Nadi Kehidupan Orang Asli Jakun, Bangi: Penerbit UKM.

National Land Code, (1965). http://extwprlegs1.fao.org/docs/pdf/mal5145.pdf

Negeri Pahang. (2020). Warta Kerajaan (Issue 26, pp. 129–157). http://ptg.pahang.gov.my/images/muat_turun/warta54.pdf

New Straits Times. (2016, October 16). Tasik Chini's eco-sustainability. *News Straits Times*. https://www.nst.com.my/news/2016/10/180812/tasik-chinis-eco-sustainability

Nimisha K et al., (2019). The chemical form and spatial variation of metals from sediment of Jemberau mining region of Tasik Chini, Malaysia. https://www.semanticscholar.org/paper/The-chemical-form-and-spatial-variation-of-metals-Krishnankutty-Idris/837a299f86b4890fe877a1d607d99485e4ecf298

No end in sight for Tasik Chini's mining activities. (2021, June 7). *New Straits Times*. https://www.nst.com.my/news/nation/2021/06/696701/no-end-sight-tasik-chinis-mining-activities

Norsiah, B. (2004). Tree species composition and diversity of riverine forest at Tasik Chini Forest Reserve, Pahang (Doctoral dissertation, MSc thesis, Universiti Kebangsaan Malaysia, Bangi.

Norwahidah, Z. A., & Wan Juliana, W. A. (2009). Comparative study on tree species composition, diversity and biomass of riverine and adjacent forested area in Tasik Chini Forest Reserve. Sumber Asli Tasik Chini. Ekspedisi Saintifik. Universiti Kebangsaan Malaysia, Bangi.

Noor Atiqah Sulaiman. 2021. Tasik Chini: KASA sokong tindakan Pahang. *Berita Harian*, 12 June. https://www.bharian.com.my/berita/nasional/2021/06/827226/tasik-chini-kasa-sokong-tindakan-pahang.

Nor Salwani Mat Arsad. T. t.h. IIImpak Pembangunan Pelancongan kepada Masyarakat Setempat di Pengkalan Gawi, Tasik Kenyir. https://www.academia.edu/24644895/Impak_Pembangunan_Pelancongan_kepada_Masyarakat_Setempat_di_Pengkalan_Gawi_Tasik_Kenyir

Norazwani. 2021. Hidupkan kembali keindahan Tasik Chini. *Sinar harian*, 17 Jun. https://www.sinarharian.com.my/article/144658/EDISI/Hidupkan-kembali-keindahan-Tasik-Chini.

Norris, F.H.; Stevens, S.P.; Pfe erbaum, B.; Wyche, K.F.; Pfe erbaum, R.L. Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. Am. J. Community Psychol. 2008, 41,127–150.

Novoa, A., Kaplan, H., Wilson, J.R.U., Richardson, D.M. (2016). Resolving a prickly situation: Involving stakeholders in invasive cactus management in South Africa. Environ Manage 57(5): 998-1008. 10.1007/s00267-015-0645-3

NST Leader, Act now to save Tasik Chini. (2019, February 22). New Straits Times. https://www.nst.com.my/opinion/leaders/2019/02/462821/nst-leader-act-now-save-tasik-chini

Nurhanim, M. N., & Wan, J. (2018). Determination of plant species rarity status in a tropical forest as a conservation approach at UNESCO Biosphere Reserve in Malaysia. Sains Malaysiana, 47(8), 1657-1664.

Nurnida, M. K., Noraini, T., Ruzi, A. R., & Idris, S. (2015, September). Leaf micromorphology of four medicinal ferns species in Tasik Chini, Pahang. In AIP Conference Proceedings(Vol. 1678, No. 1, p. 020029). AIP Publishing LLC.

Omar, M., Man, Z., & Yussof, I. (2011). Strategi Tradisional Komuniti Jakun Tasik Chini, Pahang Mengurus Sumber Semulajadi Secara Lestari. e-BANGI, 6(2), 15.

One of only two Malaysian Unesco biosphere reserves "in danger of losing status." (2019, February 22). Coconuts KL. https://coconuts.co/kl/news/report-one-two-malaysian-unesco-biosphere-reserves-danger-losing-status/

Ong Han Sean. 2021. DOE (Pahang Department of environment) says data shows Tasik Chini is clean and not polluted. TheStar, 10 Jun. https://www.thestar.com.my/news/nation/2021/06/10/doe-says-data-shows-tasik-chini-is-clean-and-not-polluted#:~:text=%22Generally%2C%20the%20data%20for%202020,'%20category%2C%22%20it%20said.&text=%22In%20conclusion%2C%20the%20water%20quality,it%2C%22%20said%20Pahang%20DOE.\

Ong, H. S. (2012, August 16). 'Chini not as polluted as claimed.' *The Star*. https://www.thestar.com.my/news/nation/2012/08/16/chini-not-as-polluted-as-claimed

Ong, H. S. (2016, October 16). Tasik Chini on the road to recovery. *The Star*. https://www.thestar.com.my/news/nation/2016/10/16/tasik-chini-on-the-road-to-recovery-lake-once-again-filled-with-famous-lotus-plants-and-aquatic-life

Ong, H. S. (2017, April 19). Preserving a natural asset. *The Star*. https://www.thestar.com.my/metro/community/2017/04/19/preserving-a-natural-asset-lake-in-pahang-becomes-a-topic-of-discussion-at-state-assembly/

Ong, H. S. (2021, June 11). Mining project approval near Tasik Chini go through due processes, says Pahang Land and Mines Office. *The Star*. https://www.thestar.com.my/news/nation/2021/06/11/mining-project-approval-near-tasik-chini-go-through-due-processes-says-pahang-land-and-mines-office

Ong, H. S. (2021, June 14). Pahang Regent recommends halt to mining activities in Tasik Chini area. *The Star*. https://www.thestar.com.my/news/nation/2021/06/14/pahang-regent-recommends-halt-to-mining-activities-in-tasik-chini-area

Othman, N., Haris, H., Fatin, Z., Najmuddin, M. F., Sariyati, N. H., Md-Zain, B. M., & Abdul-Latiff, M. A. B. (2021, April). A review on environmental DNA (eDNA) metabarcoding markers for wildlife monitoring research. In IOP Conference Series: Earth and Environmental Science (Vol. 736, No. 1, p. 012054). IOP Publishing.

Pahang govt making efforts to restore Chini Lake. (2020, June 26). *Bernama*. https://www.astroawani.com/berita-malaysia/pahang-govt-making-efforts-restore-chini-lake-248828

Palansamy, Y. (2021, June 18). Report. More than two years later, area covering Tasik Chini yet to be gazetted as forest reserve. *Malay Mail*. https://malaysia.news.yahoo.com/report-more-two-years-later-021815806.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAEPKe7dE4_vsM8FPKEhDn0y8KCjBOyrmisc1eVZODVy3lPeQFOsIu3FDTZdes5VZy1NO7ucRhU91sBDK6YRRqsyS_flY6INCROg8bN6i2nXNmmoYMpm-EIAKH-gm3THO-RimV0h8J86591ldtkzn6Ec5eAeCly7YmbPDoe--5amQ

PLANMalaysia@Pahang.(2018). Rancangan Kawasan Khas Tasik Chini. Preserving And Conserving Tasik Chini. (2016, October 15). *New Straits Times*. https://www.frim.gov.my/v1/fin/file/MY_899_20161015_N_NST_LN_pg20,21_2c38b7.pdf

Preserving Tasik Chini. (2012, January 29). *The Star*. https://www.thestar.com.my/news/education/2012/01/29/preserving-tasik-chini

Pusat Penyelidikan Tasik Chini. (2013). Laporan Tahunan 2013 Pusat Penyelidikan Tasik Chini. https://www.ukm.my/fst/wp-content/uploads/2015/12/pptc.pdf

Putnam, R.D. (2000). Bowling alone: The Collapse and Revival of American Community. New York, NY, USA: Simon & Schuster, ISBN 978-0-684-83283-8.

Rafidi, R. (2019, November 6). Enhancing water quality monitoring for Tasik Chini. *New Straits Times*. https://www.nst.com.my/education/2019/11/536190/enhancing-water-quality-monitoring-tasik-chini

Rahim, R. (2012, August 13). Tasik Chini under threat. *The Star*.

Ramly, N. S. (2017, July 17). Perbadanan khas pantau pembangunan Tasik Chini. *BH Online*. https://www.bharian.com.my/berita/wilayah/2017/07/302964/perbadanan-khas-pantau-pembangunan-tasik-chini.

Rareez Azman. (2020). Chini Memilih: Masa depan Tasik Chini semakin muram?. *Astro Awani*, 30 June. https://www.astroawani.com/berita-malaysia/chini-memilih-masa-depan-tasik-chini-semakin-muram-249297.

Reed, M.S., Dougill, A.J. & Taylor, M.J. (2007). Integrating local and scientific knowledge for adaptation to land degradation: Kalahari rangeland management options. Land Degrad. Dev. 18: 249-268. https://doi.org/10.1002/ldr.777

Rendana, M., Rahim, S. A., Idris, W. M. R., Lihan, T., & Rahman, Z. A. (2017). Soil erosion assessment in Tasik Chini Catchment using remote sensing and GIS techniques. Sains Malaysiana, 46(4), 529-535

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T., & Cooke, S. J. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. Biological Reviews, 94(3), 849-873.

Roslan, N., & Sulaiman, N. (2015a). Assessment of environmental factors that affect the fireflies for ecotourism in Unesco Tasik Chini biosphere reserve. In AIP Conference Proceedings, 1678 (1), 20025. AIP Publishing LLC.

Roslan, N., & Sulaiman, N. (2015b) Assessment Of Unesco Tasik Chini Biosphere Reserve, As A Potential New Site For Entotourism.

Sadeka, S., Suhaimi, M., & Kabir, S. (2020). Disaster experiences and preparedness of the Orang Asli Families in Tasik Chini of Malaysia : A conceptual framework towards building disaster resilient community. Progress in Disaster Science, 6. https://doi.org/10.1016/j.pdisas.2020.100070

Samadi Ahmad. (2021). Nasib Tasik Chini, UNESCO Paris beri tempoh hingga 2022. *MyMetro*, 20 July. https://www.hmetro.com.my/mutakhir/2021/06/720391/nasib-tasik-chini-unesco-paris-beri-tempoh-hingga-2022.

Seftyono, C. (2011). Pengetahuan Ekologi Tradisional Masyarakat Orang Asli Jakun dalam Menilai Ekosistem Servis di Tasik Chini, Malaysia. *Jurnal Ilmu Sosial Dan Ilmu Politik*, 15(1), 55–67. https://jurnal.ugm.ac.id/jsp/article/view/10925

Sharifah Mahsinah Abdullah. (2021). Villagers upset with soil erosion from logging activity. *New Straits Times*, 3 April. https://www.nst.com.my/news/nation/2021/04/679316/villagers-upset-soil-erosion-logging-activity#:~:text=%22Villagers%20also%20suspected%20the%20logging,said%20the%20father%20of%20three.

Sharip, Z., & Jusoh, J. (2010). Integrated lake basin management and its importance for Lake Chini and other lakes in Malaysia. Lakes & Reservoirs: Research and Management, 15(1), 41–51. https://doi.org/10.1111/j.1440-1770.2010.00421.x

Sharip, Z., Majizat, A., & Suratman, S. (2018). Socio-economic and Institutional Assessment of Malaysia ' s First Biosphere Reserve : Chini Lake. Lakes & Reserv., 1–13. https://doi.org/10.1111/lre.12217

Singh, S., Pratibha, Singh, V., Kumar, S. (2022). Assessment of Water Resources in Development of Rajasthan. In: Yadav, S., Negm, A.M., Yadava, R.N. (eds). Wastewater Assessment, Treatment, Reuse and Development in India. Earth and Environmental Sciences Library. Springer, Cham. https://doi.org/10.1007/978-3-030-95786-5_13

Siti-Munirah, M. Y., & Chew, M. Y. (2010). Cabombaceae, a new family record for Peninsular Malaysia. Malayan Nature Journal, 62(3), 241-248.

Soosai, V., & Sivalingam, A. (2011). Tasik Chini – A National Heritage in Peril. Transparency International- Malaysia, 22(2). http://transparency.org.my/images/posts/jJ751VRmxGc886VXX5K5zeHfPidhaPnS01BmIfz9.pdf

Study: Half of our 90 lakes need urgent rehabilitation. (2008, December 18). *The Star*. https://www.thestar.com.my/news/nation/2008/12/18/study-half-of-our-90-lakes-need-urgent-rehabilitation

Shuhaimi-Othman, M., Mushrifa, I., Lim, E. C., Ahmad, A., & Lim, E. C. (2008). Seasonal influences on water quality and heavy metals concentrations on Tasik Chini, Peninsular Malaysia. In Proceedings of Taal 2007: The 12th World Lake Conference, 300, 303.

Sujaul, M., G. Muhammad Barzani, B.S. Ismail, A.R. Sahibin and T. Mohd Ekhwan (2012) Estimation of the Rate of Soil Erosion in the Tasik Chini Catchment, Malaysia Using the RUSLE Model Integrated with the GIS. Australian Journal of Basic and Applied Sciences, 6(12): 286-296, 2012. ISSN 1991-8178

Sulaiman, W.N. A. et al. (2010). Identification of Flood Source Areas in Pahang River Basin, Peninsular Malaysia. https://www.researchgate.net/publication/289781545_Identification_of_Flood_Source_Areas_in_Pahang_River_Basin_Peninsular_Malaysia

Sumaiya Sadeka et al. (2020). Disaster experiences and preparedness of the Orang Asli Families in Tasik Chini of Malaysia: A conceptual framework towards building disaster resilient community.

Tasik Chini can still be saved, says expert. (2009, July 7). *The Star*. https://www.thestar.com.my/news/nation/2009/07/07/tasik-chini-can-still-be-saved-says-expert

Tasik Chini gazetted as permanent forest reserve. (2019, April 10). *New Straits Times*. https://www.nst.com.my/news/nation/2019/04/478005/tasik-chini-gazetted-permanent-forest-reserve

Tasik Chini's eco-sustainability. (2016, October 17). *New Straits Times*. https://www.nst.com.my/news/2016/10/180812/tasik-chinis-eco-sustainability

Toriman, M. E., Jamil, N. R. B., Idris, M., Mastura, S. S., Ahmad, H., Er, A. C., & Elfithri, R. (2012). Identification and mapping of lotus (Nelumbo nucifera) distribution in a shallow lake using satte; ite imagery and geographical information system (GIS). JEAS-Journal of Engineering & Applied Sciences, 7(4), 300-305.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences of the United States of America, 100(14), 8074–8079. https://doi.org/10.1073/pnas.1231335100

Tussupova, Kamshat, Anchita, Peder Hjorth, and Mojtaba Moravej. (2020). "Drying Lakes: A Review on the Applied Restoration Strategies and Health Conditions in Contiguous Areas" Water 12, no. 3: 749. https://doi.org/10.3390/w12030749.

Unit Komunikasi dan Media Pahang. (2021). Pptc Konsisten Memelihara Kelestarian Alam Sekitar Tasik Chini. https://www.pahang.gov.my/pahang/resources/PDF/Berita/2021/Jun/(13hb)_PPTC_KONSISTEN_MEMELIHARA_KELESTARIAN_ALAM_SEKITAR_TASIK_CHINI.pdf

UNESCO. (2009). United Nations Proclaims 22 New Biosphere Reserves. Retrieve from http://blogs.nationalgeographic.com/blogs/news/chiefeditor/2009/05/united-nations-proclaims-22-ne.html

UNESCO. (2014). Man and Biosphere Programme For 26th Meeting Of International Coordinating Council (Issue 26). http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/___SC/pdf/MAB_national_report_Malaysia_MABICC26_en.pdf

UNESCO. (2016). Man and Biosphere Programme, Country Report: Malaysia. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/images/MAB_20National_Report__Malaysia.pdf

UNESCO. (n.d.). The Man and the Biosphere (MAB) Programme of UNESCO and its World Network of Biosphere Reserves (WNBR): contribution to global transformation towards sustainable and resilient societies. Retrieved June 30, 2021, from https://sustainabledevelopment.un.org/content/ documents/18137ECOSOC_MAB_report.pdf

UNESCO. (2015). Man and Biosphere Programme for the 27th Meeting Of International Coordinating Council (Issue 27). http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/__SC/pdf/MAB_national_report_Malaysia_MABICC27_en.pdf

van der Helm, Pb.A. (2021). Sri Gumum , Orang Asli, Tasik Chini, Malaysia, accessed website: 6 February 2021,. ppw.kuleuven. be/apps/research/petervanderhelm/srigumum/doc/history.html

White, G.F. (1975). Assessment of Research on Natural Hazards. The MIT Press environmental studies series; MIT Press:IISBN 0-262-08083-4.

WHO (1999). Arsenic in drinking water. Fact sheet No. 210. Geneva: World Health Organisation.
The Star. (2008, December 16). Why only ask for help now? https://www.thestar.com.my/opinion/letters/2008/12/16/why-only-ask-for-help-now

Wilkinson, C. L., Yeo, D. C., Tan, H. H., Fikri, A. H., & Ewers, R. M. (2018). Land-use change is associated with a significant loss of freshwater fish species and functional richness in Sabah, Malaysia. Biological Conservation, 222, 164-171.

WWF Malaysia. (2012). WWF Statement on Tasik Chini. https://www.wwf.org.my/?14660/Statement-on-Tasik-Chini

Yusoff, F. M., Shariff, M., & Gopinath, N. (2006). Diversity of Malaysian aquatic ecosystems and resources. Aquatic Ecosystem Health & Management, 9(2), 119-135.

Yusop, Z. (2010). Water sustainability: Wisdom in the headwater. Professorial Inaugural Lecture Series no 35. Penerbit UTM Press. ISBN 978-983-52-07518.

Zainudin, R., Nor, S. M., Ahmad, N., Md-Zain, B. M., & Rahman, M. A. (2010). Genetic structure of Hylarana erythraea (Amphibia: Anura: Ranidae) from Malaysia. Zoological Studies, 49(5), 688-702.

Zakaria, Maisarah S., Amri, C., Nurul C. A., Talip, Noraini, Juhari, A., Aiman A., Rahman, A., Ruzi, M., Zohari, Fitri, A., Shahari, & Rozilawati. (2021). Leaf anatomy and micromorphology of potential medicinal weed (Ruellia repens L.) from Tasik Chini, Pahang. In: International eConference of Science and Biosphere Reserve (IECSBR) 2021, 3rd - 4th March 2021, Selangor. (Unpublished)

Zamhari, A. (2017, March 3). Fuziah urges Putrajaya to rescue "dying" Tasik Chini. *Malaysia Kini*. https://www.malaysiakini.com/news/374398

Zanisah Man & En Ne Yeaoh. (2019). Penyertaan orang Asli dalam aktiviti eko-pelancongan di Tasik Chini, Pahang, Malaysia. https://ejournal.ukm.my/gmjss/article/view/29073.

Zati S., S. S. Schooler, M. R. Hipsey, R. J. Hobbs. (2012). Eutrophication, agriculture and water level control shift aquatic plant communities from floating-leaved to submerged macrophytes in Lake Chini, Malaysia. Biol Invasions, 14:1029–1044. DOI 10.1007/s10530-011-0137-1.

Zati S., A. T. A. Zaki, M. A. H. M. Shapai, S. Suratman and A. J. Shaaban. (2014). Lakes of Malaysia: Water quality, eutrophication and management. Lakes and Reservoirs: Research and Management 2014 19: 130–141.

Zati S., R. Yanagawa, & T. Terasawa. (2016). Eco-hydrodynamic Modelling of Chini Lake: Model Description Environ Model Assess (2016) 21:193–210. DOI 10.1007/s10666-015-9464-4.

Zati, S. and Juhaimi J. (2010). Integrated lake basin management and its importance for Lake Chini and other lakes in Malaysia. https://www.researchgate.net/publication/229901123_Integrated_lake_basin_Management_and_its_importance_for_Lake_Chini_and_other_lakes_in_Malaysia.

Zati S. et al. (2018). Socio-economic and institutional assessment of Malaysia's first biosphere reserve: Chini Lake. https://www.researchgate.net/publication/325364850_Socio-economic_and_institutional_assessment_of_Malaysia's_first_biosphere_reserve_Chini_Lake

Zubaid, A., Lowrence, K., & Harun, M. Y. (2009). Burung sekitar lembangan: Tasik Chini, Pahang. Fakulti Sains dan Teknologi, Universiti Kebangsaan Malaysia.

Zubaid, A.M.A. (2021, July 6). Perak's Gunung Kanthan in danger of being reduced to rubble. *The Malaysian Insight*. https://www.themalaysianinsight.com/s/325594

Zulkifli, A. M. 2021. Perlombongan dan pembalakan ancam ekosistem Tasik Chini. Malaysia Now, 1 July. https://www.malaysianow.com/berita/2021/07/01/perlombongan-dan-pembalakan-ancam-ekosistem-tasik-chini/.

APPENDICES

Appendix 1 - Detailed References of 44 Selected Articles Reviewed Related to Tasik Chini Socio-Economic Matters

Index	Total	References
SCOPUS	**23**	Habibah, A., Mushrifah, I., Hamzah, J., Buang, A. & Toriman M.E. 2012. Crafting the natural capitals for sustainability of ecotourism in Tasik Chini biosphere reserve: The host-guest perspectives. Social Sciences 7(4): 611-619. Habibah, A., Mushrifah, I., Hamzah, J., Buang, A. & Toriman M.E. 2012. Crafting the natural capitals for sustainability of ecotourism in Tasik Chini biosphere reserve: The host-guest perspectives. Social Sciences 7(4): 611-619. Habibah, A., Mushrifah, I.,Hamzah, J., Er, A.C., Buang, A., Toriman, M.E., Selvadurai, S. & Zaimah, R. 2013 Place-making of ecotourism in Tasik Chini: From exploratory to the contemporary biosphere reserve. Asian Social Science 9(6): 84-95. Habibah, A., Er, A.C., Mushrifah, I., Hamzah, J., Sivapalan, S., Buang, A., Toriman, M.E. & Sharifah Mastura, S.A. 2013. Revitalizing ecotourism for a sustainable tasik chini biosphere reserve. Asian Social Science 9(14): 70-85. Parker, J. & Crabtree, S.A. 2015. Part of the solution or part of the problem? Reflections on teaching participatory asset mapping. Community Development Journal 51(3): 367-381. Ruhizan, M.Y., Mazzlida, M.D., Siti, M.D., Fariza, K. & M.Nizam, A.R. 2017. Charting a model of life long learning centre for sustainable living of indigenous community: Voices from the ground. Man in India 97(24): 305-319. Crabtree, S.A., Parker,J., Parker, I.C. & Parker, M.C. 2018. Development as eradication: The pillage of the Jakun 'people's bank' of tasik Chini, Pahang, Malaysia. South East Asia Research 26(3): 283-298. Sadeka, S., Mohamad, M.S.& Sarkar, M.S.K. 2020. Disaster experiences and preparedness of the Orang Asli Families in Tasik Chini of Malaysia: A conceptual framework towards building disaster resilient community. Progress in Disaster Science 6. https://doi.org/10.1016/j.pdisas.2020.100070 Sadeka, S., Mohamad, M.S., Sarkar, M.S.K. & Al-Amin, A.Q. 2020. Conceptual Framework and Linkage Between Social Capital and Disaster Preparedness: A Case of Orang Asli Families in Malaysia. Social Indicators Research 150(2): 479-499. Zakaria, M.S., Nordin, R. & Ruslan, M.S. 2020. IoT Infrastructure for Environmental Monitoring: A Case at Tasik Chini Biosphere Reserve. IEEE Conference on e-Learning, e-Management, and e-Services IC3e2020: 43-48. Habibah, A., Mushrifah, I., Hamzah, J., Toriman, M.E., Buang, A., & Jusoff, K. 2011. The success factors of public consultation in the establishment of a biosphere reserve - evidence from Tasik Chini. World Applied Sciences13 (Sustainable Development Impact from the Socio-Environmental Perspectives): 74-81. Mukrimah, A., Mohd Parid, M., Diana, E., Faten Naseha, T.H. & Lim, H.F. 2018. Economic valuation of Tasik Chini Biosphere Reserve, Pahang, Malaysia. ASM Science Journal 11 (Special Issue 3): 74-78. Habibah A, Hamzah J., & Mushrifah, I. 2010. Sustainable livelihood of the Community in Tasik Chini Biosphere Reserve: the local practices. Journal of Sustainable Development 3(3): 184–196.

Index	Total	References
		Ahmad, A.K & Shuhaimi-Othman, M. 2010. Heavy metal concentration in sediments and fishes from Lake Chini, Pahang, Malaysia. Journal of Biological Sciences 10(2): 93-100. Habibah, A., Mushrifah, I., Hamzah, J., Toriman, M.E., Buang, A., Jusoff, K., Fuad, M., Er, A.C. & Azima, A.M. 2012. Assessing natural capitals for sustainable ecotourism in Tasik Chini Biosphere Reserve in Tasik Chini Biosphere Reserve. Advances in Natural and Applied Sciences 6(1): 1-9. Hamid, H., Samah, A.A. & Norsida, M. 2013. The level of perception toward agriculture land development among orang asli di Pahang, Malaysia. Asian Social Science 9(10): 151-159. Sujaul, I.M., Ismail, B.S., Mohamad, B.G., Mohd, E.T. & Sahibin, A.R. 2010. Assessment of land use and land cover changes in the Tasik Chini Catchment area, Pahang, Malaysia using the GIS'. Advances in Environmental Biology 4(3): 404-413. Sharip, Z. & Jusoh, J. 2010. Integrated lake basin management and its importance for Lake Chini and other lakes in Malaysia. Lakes & Reservoirs: Research and Management 15: 41-51. Sharip, Z., Majizat, A. & Suratman, S. 2018. Socio-economic and institutional assessment of Malaysia's first biosphere reserve: Chini Lake. Lakes & Reservoirs Research & Management 23(2): 104-116. Nimisha, K., Mushrifah, I., Firdaus, M.H. & Yasmin, M. 2019. The chemical form and spatial variation of metals from sediment of Jemberau mining region of Tasik Chini, Malaysia. Environmental Science and Pollution Research 26. https://doi.org/10.1007/s11356-019-05680-3 Wong, C.M., Daud, F., Diana Safraa, S., Raja Mohd Azim, R.H., & Siti Zubaidah, A.R. 2018. Prevalence and modifiable risk factors of non-communicable diseases among Jakun orang asli at Tasik Chini, Pekan, Pahang. International Medical Journal Malaysia 17(3): 3-16. Nakagawa, Y. & Shaw, R. 2004. Social Capital: A Missing Link to Disaster Recovery. International Journal of Mass Emergencies and Disasters 22(1): 5-34. Sulaiman, W.N.A., Heshmatpoor A., & Rosli, M.H. 2010. Identification of Flood Source Areas in Pahang River Basin, Peninsular Malaysia. EnvironmentalAsia 3 (special issue): 73-78. Habibah, A., Mushrifah, I., Toriman, M.E., Hamzah, J., Buang, A. & Norela, A. 2012. The learning culture of a mobility program for sustainability of Tasik Chini biosphere reserve. Procedia - Social and Behavioral Sciences 59: 33–41.
Web of Science	**8**	Ebrahimpour, M. & Mushrifah, I. 2009. Variation and correlations of selected heavy metals in sediment and aquatic plant plants in Tasik Chini, Malaysia. Environmental Geology 57(4): 823-831. Ebrahimpour, M. & Mushrifah, I. 2008. Heavy metal concentration in water and sediments in Tasik Chini, a freshwater lake, Malaysia. Environmental Monitoring and Assessment 141(1-3): 297-307. Ebrahimpour, M. & Mushrifah, I. 2008. Heavy metal concentration (Cd, Cu and Pb) in five aquatic plant species in Tasik Chini, Malaysia. Environmental Geology 54(4):689-698.

Shuhaimi-Othman, M., Mushrifah, I., Lim, E.C. & Ahmad, A. 2008. Trend in metal variation in Tasik Chini, Pahang, Peninsular Malaysia. Environmental Monitoring and Assessment 143(1-3): 345-354.

Flanagan, B.E., Gregory, E.W., Hallisey, E.J, Heitgerd, J.L. & Lewis, B. 2011. A Social Vulnerability Index for Disaster Management. Journal of Homeland Security and Emergency Management 8(1): 1-5.

Norris, F.H., Stevens, S.P., Pfefferbaum, B., Wyche, K.F., & Pfefferbaum, R.L. 2008. Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. Am. J. Community Psychol (41): 127–150.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A. & Schiller, A. 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences of the United States of America 100(14): 8074–8079.

Ho, L.T. & Goethals, P.L.M. 2019. Opportunities and Challenges for the Sustainability of Lakes and Reservoirs in Relation to the Sustainable Development Goals (SDGs). Water 11(7): 1462.

Zanisah Man & Yeoh En Ne. 2019. Penyertaan orang Asli dalam aktiviti eko-pelancongan di Tasik Chini, Pahang, Malaysia. GEOGRAFIA Malaysian Journal of Society and Space 15(4): 50-63.

MyCite **1**

Ahmad, A.K., Mohd, S.O., Mohd, B.G. & Sambau, D. 2009. Fish diversity at Lake Chini, Pahang, Malaysia. Sains Malaysiana 38(5): 625-630.

Non Index **13**

Shuhaimi-Othman, M. & Lim, E.C. 2006. Keadaan neutrofikasi di Tasik Chini, Pahang. Sains Malaysiana 35(2): 29-34.

Omar, M., Man, Z. & Yussof, M. 2011. Strategi tradisional komuniti Jakun Tasik Chini, Pahang mengurus sumber semulajadi secara lestari. Jurnal e-Bangi 6(2): 239-254.

Sulong Mohamad & Mohd Ekhwan Toriman. 2006. Implikasi struktur kunci air ke atas aktiviti pelancongan dan penduduk di sekitar Sungai Chini dan Tasik Chini, Pahang. Jurnal e-Bangi 1(1): 1-13.

Ida, R.A. & Rahaya, M.D.J. 2021. Kajian pencemaran air terhadap komuniti orang asli di Tasik Chini, Pahang. Universiti Malaysia Terengganu Journal of Undergraduate Research 3(2): 119-128.

Parker, J., Crabtree, S.A., Crabtree, M.A. & Crabtree, I.S. 'Behaving like a Jakun!' A case study of conflict, 'othering' and indigenous knowledge in the Orang Asli of Tasik Chini. 2019. Journal of Sociology and Development 3(1):23-45.

Seftyono, C. 2011. Pengetahuan ekologi tradisional masyarakat orang asli jakun dalam menilai ekosistem servis di Tasik Chini, Malaysia. Jurnal Ilmu Sosial Dan Ilmu Politik 15(1): 55–67.

Cutter, S.L. 1996.Vulnerability to environmental hazards. Progress in Human Geography 20(4): 529–539.

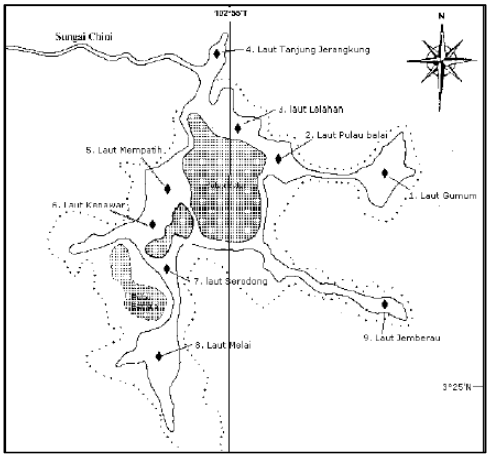
Habibah, A., Mushrifah, I., Hamzah J., Toriman, M.E. & Kurnia, A. Mempakej Pelancongan Tasik Chini Sebagai Rizab Biosfera. 2012. Journal of Social Sciences and Humanities 7(1): 119–131.

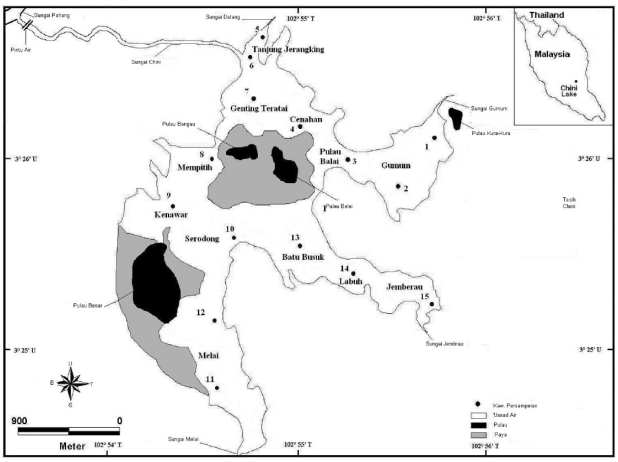
Habibah, A., Hamzah, J., Er, A.C. & Mushrifah, I. 2020. Unpacking The Experience Of The Biosphere Reserve Tourism From The Academic Tourists 'Perspectives : A Case Of Tasik Chini. Journal Of Tourism, Hospitality And Environment Management 5(21): 163–183.

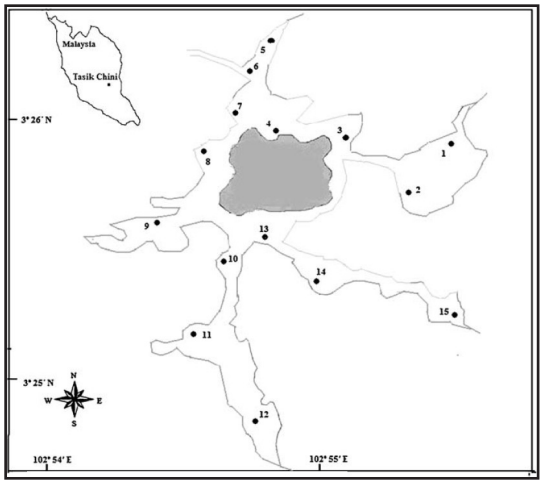
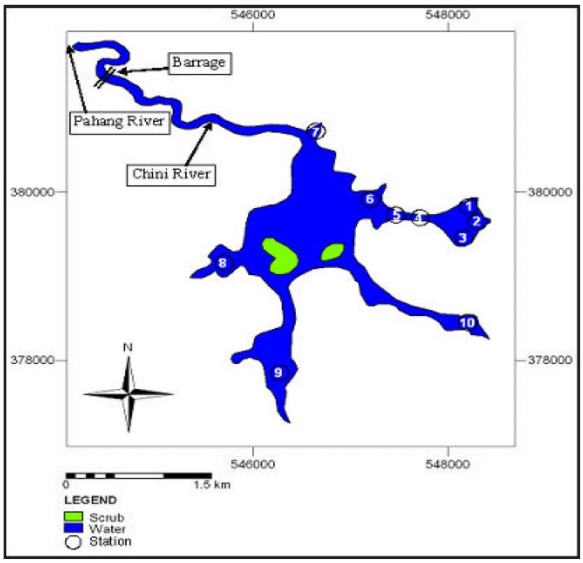
Habibah, A., Mushrifah, I., Hamzah, J., Buang, A., Toriman, M.E., Abdullah, S.R.S., Nur Amirah, K.Z., Nur Farahin, Z. & Er., A.C. 2013. Biosphere Reserve as a Learning Tourism Destination: Approaches from Tasik Chini. International Journal of Geosciences 4(10): 1447–1458.

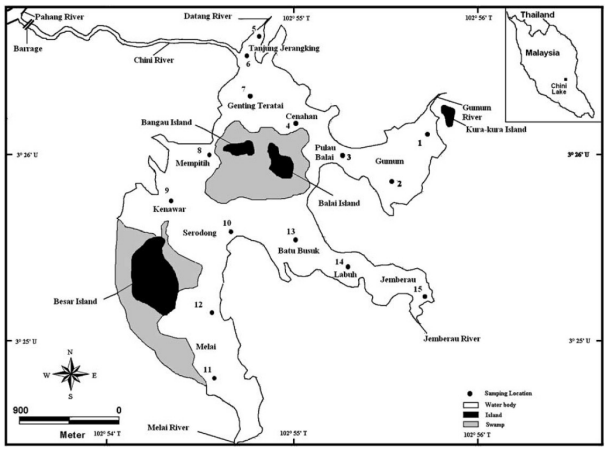
Gasim, M.B., Toriman, M.E., Abas, A., Islam, M.S. & Tan, C.C. 2008. Water Quality of Several Feeder Rivers between Two Seasons in Tasik Chini, Pahang. Sains Malaysiana 37(4): 313-321.

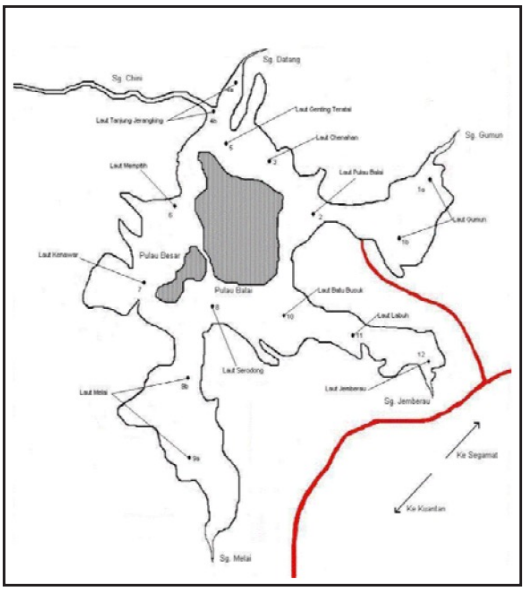
Appendix 2 - Literature Review on Physical Parameter Studied in Tasik Chini

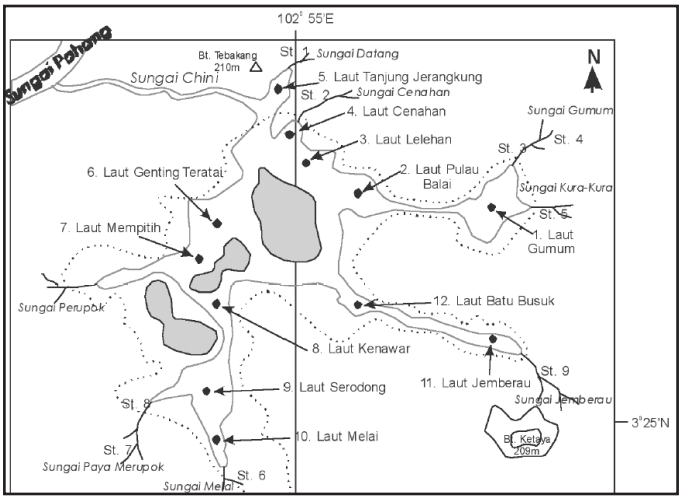
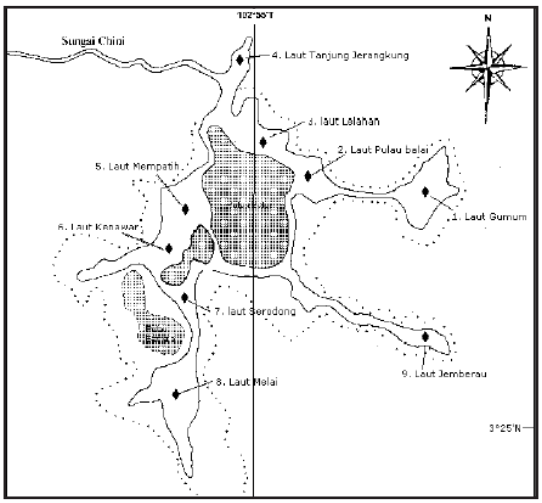
No.	Sample	Description	References
1.	Water	**Parameter Studied:** Pb, Zn, Cu, Cd, Fe, Mn and Al **Number of Samples:** 24 Samples **Findings:** • Water quality classification from Class I to Class III • Pb in water sample is slightly higher, potentially to be polluted by Pb in the future. **Sampling Points:** 	Ahmad Abas Kutty & Lai Mei Hui (2001) Analisis kandungan logam berat di dalam air dan tisu ikan di Tasik Chini. Malaysian Journal of Analytical Sciences, 7(1), 273-279.
2.	Water	**Parameter Studied:** Temperature, Conductivity, Dissolve Oxygen, Turbidity, Total Suspended Solid (TSS), pH, COD, Sulphate, Total Dissolve Solid (TDS), BOD5, Ammoniacal Nitrogen, Orthophosphate, Nitrate, Chlorophyll a. **Number of Samples:** 15 Samples **Findings:** • Analysis showed that Lake Chini water quality was determined by more than one factor. • The results indicated that the biological and chemical (nutrients) components significantly influence the lake water quality. • The biological parameters namely BOD5, COD, chlorophyll a and chemical (nitrate and orthophosphate) are important parameters in Lake Chini. • Primer productivity is very good based on the chlorophyll concentration.	Ahmad AK, Shuhaimi Othman M, Lim EC, & Abd Aziz Z (2013) Analisis Kualiti Air Tasik Chini Menggunakan Pendekatan Multivariat. Sains Malaysiana, 42(5), 587–596.

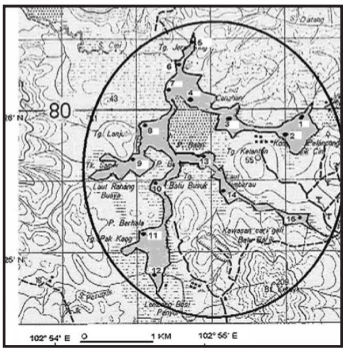
		Sampling Points:  	
3.	Water	**Parameter Studied:** pH, temperature, turbidity, Electrical Conductivity (EC), Suspended Solids (SS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia Nitrogen (NH3-N), Phosphorus (P) **Number of Samples:** 4 Samples (Melai River, Jemberau River, Jerangking River and Gumum River) **Findings:** • Water quality classification in Class II • Activities conducted around Tasik Chini have caused water pollution which involves the release of heavy metals. • Amongst the activities identified as the main cause of water pollution in Tasik Chini are iron mining, agriculture, illegal logging and waste disposal. **Sampling Points:** Station | Coordinate District | Location | Latitude | Longitude Station 1 | Melai River | N 3°24'53.6" | E 102°54'36.0" Station 2 | Jemberau River | N 3°25'18.8" | E 102°55'40.2" Station 3 | Jerangking River | N 3°26'34.2" | E 102°54'49.7" Station 4 | Gumum River | N 3°26'11.6" | E 102°55'43.8"	Nadiatul Adilah AAG & Muhammad Syukri L (2021) Determination of Presence Iron and Manganese in Tasik Chini. IOP Conf. Series: Earth and Environmental Science 682 (2021) 012026.
4.	Water	**Parameter Studied:** Pb, Cu & Cd **Number of Samples:** 15 **Findings:** • The heavy metal concentration in the water is described in the descending order of Pb > Cu > Cd at all sampling sites, except for sampling sites 2 and 3 for copper. • The present results indicate that cadmium and lead have a higher potential for mobilization from the sediment than copper because of their higher concentration at the exchangeable and acid reduction fraction. **Sampling Points:**	Mohammad Ebrahimpour & Idris Mushrifah (2008) Heavy metal concentrations in water and sediments in Tasik Chini, a freshwater lake, Malaysia. Environ. Monit. Assess, 141, 297-307.

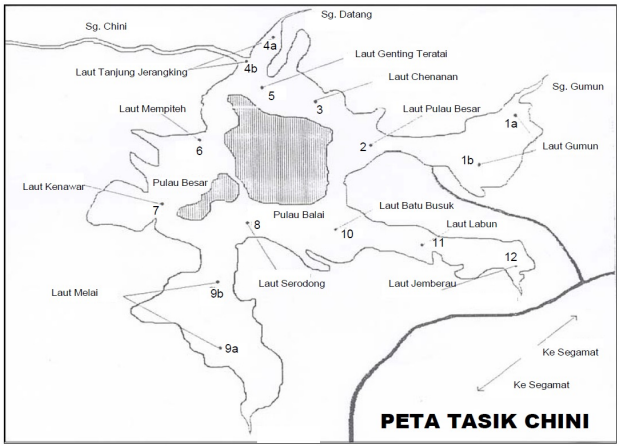
			
5.	Water	**Parameter Studied:** Temperature, conductivity, total suspended solids (TSS), nitrate, sulphate, total dissolved solids (TDS), turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen and phosphate **Number of Samples:** 10 **Findings:** • Temperature was within the normal ranges; conductivity, total suspended solids (TSS), nitrate, sulphate and total dissolved solids (TDS) were categorized under class I, while turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen and phosphate came under class II and pH under class III. • Water quality in Chini Lake varied temporally and spatially; the most affected parameters were pH, TSS, turbidity, DO, ammoniacal nitrogen, phosphate and conductivity. • Based on the Malaysian Water Quality Index (WQI), the water in Chini Lake was classified under class II, meaning it is suitable for recreational activities and safe for body contact. **Sampling Points:** 	M. Sujaul Islam, B.S. Ismail, G. Muhammad Barzani, A.R. Sahibin and T. Mohd Ekhwan (2012) Hydrological Assessment and Water Quality Characteristics of Chini Lake, Pahang, Malaysia. American-Eurasian J. Agric. & Environ. Sci., 12(6), 737-749.

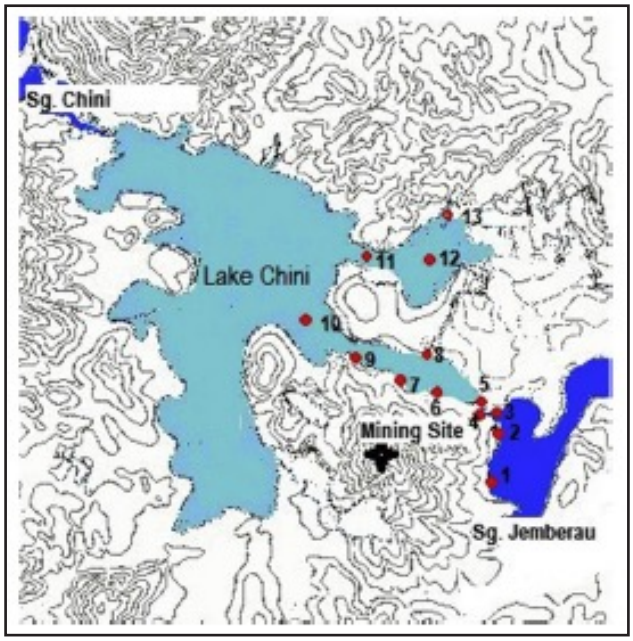
6.	Water	**Parameter Studied:** ron (Fe), aluminium (Al), manganese (Mn), barium (Ba), zinc (Zn), lead (Pb), copper (Cu), cadmium (Cd), nickel (Ni), chromium (Cr) and cobalt (Co) **Number of Samples:** 15 **Findings:** • The present study showed that metal concentrations in Tasik Chini water are still low and in the range of natural background concentration except for Fe and Al. • Generally, metal concentrations of the water were found to decrease in the order of Fe>Al>Mn>Ba>Zn>Pb>Cu>Cd. Metal concentrations in the lake water vary with the season and the location of the sampling stations. • High precipitation during wet season can generate changes to the metal concentrations in the water through the reverse flow of flood • Water from Pahang River results in high concentrations of metals especially Fe and Al. • The revival of abandoned mines contributed to the increase in Ba and Mn concentrations in the lake water bodies. • Stations located in the Tanjung Jerangking and Melai areas were the most affected due to seasonal changes and human activities. • It is proposed that mining activities should be stopped or minimized during the heavy raining season as the incoming flooded water into the lake already pose a high risk of metal influx into the lake. **Sampling Points:**  	M. Shuhaimi-Othman, I. Mushrifah, E.C. Lim & A. Ahmad (2007) Trend in metals variation in Tasik Chini, Pahang, Peninsular Malaysia. Environ Monit Assess, 143, 345–354.
7.	Water	**Parameter Studied:** ron (Fe), aluminium (Al), manganese (Mn), barium (Ba), zinc (Zn), lead (Pb), copper (Cu), cadmium (Cd), nickel (Ni), chromium (Cr) and cobalt (Co) **Number of Samples:** 15 **Findings:** • The highest number of faecal coliform was observed at Laut Gumum and Tanjung Puput. • The sources of faecal pollution were wastes from humans and animals; domestic effluent, which might be due to a lack of improper sanitation systems and also effects of land use from surrounding agricultural areas.The physico-chemical parameters indicated that the lake is categorised as Class 1 and Class 11 based on Malaysia's Interim National Water Quality Standards (INWQS).	Ainon Hamzah & Yanti Hattasrul (2008) Water Quality and Bacterial Study in Tasik Chini, Pahang. Proceedings of Taal2007: The 12th World Lake Conference: 184-189

		• However, from the bacteriological aspect, Tasik Chini is in Class V. • This means the water in Tasik Chini are polluted with total and faecal coliform exceeding the standard count permitted by the Malaysian Department of Environment. **Sampling Points:**  	
8.	Water	**Parameter Studied:** Temperature, conductivity, dissolved oxygen, pH, turbidity, total suspended solid (TSS), total dissolved solid (TDS), NH3-N, NO3-, PO43- and SO42-. **Number of Samples:** 9 **Findings:** • The results of water quality trends clearly show that the majority of water quality parameters were quite high during the wet season compared to the dry season. • Water quality analysis shows that pH, NH3-N, NO3-, PO43-, TDS, TSS and turbidity were lower in the dry season, but DO was higher. • All the parameters were higher during the wet season except DO and conductivity. • Sungai Gumum (St. 3) and Sungai Datang (St. 1) are comparatively more polluted than other rivers. • The pollutants were caused by domestic and agricultural activities from the local people. • Sungai Cenahan (St. 2), Sungai Kura-kura (St. 5), Sungai Melai (St. 6) and Sungai Jemberau (St. 7) were less polluted. • The least polluted river is Sungai Paya Merupuk (St. 8 and 9). • According to INWQS classification, all the feeder rivers were in Class I and IIA. • In the dry season, rainfall was low so discharge from each feeder river was low compared to the wet season. **Sampling Points:**	Muhammad Barzani Gasim, Mohd Ekhwan Hj Torimn., Ahmad Abas,mir Sujaul Islam & Tan Choon Teck (2008) Water Quality of Several Feeder Rivers between Two Seasons in Tasik Chini, Pahang. Sains Malaysiana, 37(4), 313-321.

			
9.	Organism	**Type of Organism:** Fish **Parameters Studied:** Pb, Zn, Cu, Cd, Fe, Mn and Al **Number of Samples:** 5 individuals each species. Total 13 species **Findings:** • All metals studied show low concentrations and below the Malaysia Food Regulation (1985) • Potentially to be polluted by Pb in the future. **Sampling Points:** 	Ahmad Abas Kutty & Lai Mei Hui (2001) Analisis kandungan logam berat di dalam air dan tisu ikan di Tasik Chini. Malaysian Journal of Analytical Sciences, 7(1), 273-279.
10.	Organism	**Type of Organism:** Plant *(D.esculentumand)* **Parameters Studied:** Pb, Fe, Mn, Zn, Cu, and Cr **Number of Samples:** 3 samples **Findings:** • All metals studied were lower except for Cu Sampling Points: n.m.	Hind S.Jasim, Mushrifah Idris, Aminah Abdullah & Kadhum AAH (2014) Effects of Physicochemical Soil Properties on the Heavy Metal Concentrations of *Diplaziumesculentum* (medicinal plant) from the UKM and Tasik Chini, Malaysia. International Journal of ChemTech Research, 6(14), 5519-5527.

11.	Organism	**Type of Organism:** Fish **Parameters Studied:** Cd, Cu & Pb **Number of Samples:** 259 fish individuals (7 species) **Findings:** • Cadmium, Cu, and Pb concentrations varied significantly depending on the type of the tissue and season. • Bone samples of the Osteochilus hasseltii showed the highest concentrations of Pb (6.08 µg/g dw) during September (the dry season), whereas bone samples of the Puntioplites bulu showed the lowest concentrations of Cd (0.08 µg/g dw) during September. • Muscle samples of the P. bulu indicated the highest concentrations of Cu (2.58 µg/g dw) during March (the normal season). • On the other hand, muscle samples of Channa straitus sowed the lowest concentrations of Cd (0.04 µg/g dw) during July (the dry season). • Gills samples of the O. hasseltii showed the highest concentration of Pb (6.56 µg/g dw) during March (the normal season), while gills samples of C. straitus indicated the lowest concentration of Cd (0.06 µg/g dw) during July (the dry season). • **Sampling Points:** n.m.	Mohammad Ebrahimpour & Idris Mushrifah (2009) Seasonal Variation of Cadmium, Copper, and Lead Concentrations in Fish from a Freshwater Lake. Biol Trace Elem Res 138, 190–201.
12.	Organism	**Type of Organism:** 5 species (*Lepironia articulata*, *Pandanus helicopus*, *Scirpus grossus*, *Cabomba furcate*, and *Nelumbo nucifera*) **Parameters Studied:** Cd, Cu & Pb **Number of Samples:** 15 points **Findings:** • The highest concentration of heavy metals among the aquatic plants and plant parts was found in the roots of S. grossus. • The concentrations of Cd in the leaves and stems of submerged aquatic plant, C. furcata, were higher than the concentration of Cd in the leaves and stems of an emergent aquatic plant and floating leaf plant. The concentration of Cu in the stem of C. furcate was greater than that in the leaf, while the concentration of Cd was more in the leaf than in the stem. • The heavy metal contents of the aquatic plants were in descending order of Pb > Cu > Cd. • **Sampling Points:**  	Ebrahimpour M & Mushrifah I (2008) Heavy metal concentrations (Cd, Cu and Pb) in five aquatic plant species in Tasik Chini, Malaysia. Environ. Geol., 54, 689-698.

13.	Sediment	**Parameters Studied:** As, Ba, Co, Cr, Cu, Ni, Pb, Rb, Sr, V, Zn, Zr,, ^{40}K, ^{238}U, ^{232}Th, ^{137}Cs **Number of Samples:** 12 Samples **Findings:** • Eastern part had a higher concentration of metals studied due to human activities, logging, and deforestation. • Higher concentration of radionuclide (^{40}K, ^{238}U, ^{232}Th, ^{137}Cs) in Tasik Chini sediment. **Sampling Points:** 	Amran Ab.Majid, Siti Rahimah Umar, Redzuwan Yahaya, Muhamad Samudi Yasir & Mohd Suhaimi Othman (2008) The Malaysian Journal of Analytical Sciences 12(1), 167-171.
14.	Sediment	**Parameters Studied:** particle size, organic matter content, and soil hydraulic conductivity and three chemical soil properties, such as available nutrients, dissolved nutrients, and heavy metals **Number of Samples:** 20 Samples (4 Stations) **Findings:** • Total flow of nutrients and heavy metals from the Melai sub-catchment into Lake Chini is expected to be low due to the low rate of soil loss. • Low discharge of soluble nutrients and heavy metals due to minor land use activity in the study area showed that Melai River is considered a stable sub-catchment for the present time **Sampling Points:** 	Muhd Barzani Gasim, Sahibin Abd. Rahim, Mohd Ekhwan Toriman, Wan Mohd Razi Idris, Tukimat Lihan, Zulfahmi Ali Rahman, Azman Hashim & Norhadilla Hadib (2013) Flux of nutrients and heavy metals from the Melai River sub-catchment into Lake Chini, Pekan, Pahang, Malaysia. Environ. Earth Sci., 68, 889-897.

15.	Sediment	**Parameters Studied:** Fe, Al, Mn, Zn, Pb, Co, Cd, Cr, As, and Ni **Number of Samples:** 12 samples **Findings:** • The result reveals that Fe, Al, Mn, Zn, and Pb are the primary constituents of sediment contributing to about 98% of the residual fraction. • Co, Cd, Cr, As, and Ni are found in trace metal concentration and are identified to be mainly released from anthropogenic sources nearby. • Although the individual proportion is less than major metals in exchangeable and carbonate fractions, they possess geochemically significant concentrations above the permissible limit. • More than 70–80% of all its total concentration proportion is, hence, found in mobile and bioavailable state. • These possess toxic and have chronic effects to aquatic life and public health even in trace elemental concentration. • Hence, these metals are the most toxic and bioavailable metals causing risk to aquatic and public health. • **Sampling Points:**  	Nimisha Krishnankutty, Mushrifah Idris, Firdaus Mohamad Hamzah & Yasmin Manan (2019) The chemical form and spatial variation of metals from sediment of Jemberau mining region of Tasik Chini, Malaysia. Environmental Science and Pollution Research, 26, 25046–25056.

Discover the urgent truth about the Tasik Chini Basin (TCB) and Tasik Chini Biosphere Reserve (TCBR) in Assessment on the Sustainability of the Tasik Chini Basin and Tasik Chini Biosphere Reserve. Once a pristine natural wonder and beloved sanctuary for both nature enthusiasts and local communities, this treasured Malaysian lake has fallen victim to rapid and alarming anthropogenic changes since the late 1990s.

Deforestation, mining activities, and uncontrolled agriculture have wreaked havoc on the delicate ecosystem, threatening its very survival. Overexploitation of natural resources, coupled with the relentless expansion of human settlements and aggressive socioeconomic pursuits, have resulted in severe water and soil pollution within the TCB and TCBR region.

Triggering a nationwide outcry and heightened ecological awareness, a damning news report on 11th June 2021 exposed the alarming ecological collapse of Tasik Chini. Responding swiftly, The Academy of Sciences Malaysia mobilised the Science, Technology, Innovation Policy and Advisory Committee (STIPAC) to form a specialised task force. Their mission: to assess the sustainability of TCB and TCBR and offer advisory notes to mitigate the crisis.

Meticulously conducting a comprehensive desktop study of published and unpublished manuscripts, combined with immersive field explorations and in-depth stakeholder engagements, the task force unraveled the grim reality. TCB and TCBR are presently teetering on the brink of devastation, their ecosystems highly disturbed and endangered.

However, hope remains, for this report presents a lifeline for the survival of Tasik Chini Basin and the Tasik Chini Biosphere Reserve. Urgent rehabilitation and restoration programs are advocated as crucial intervention measures to prevent a fate similar to that of Tasik Mentiga. Integrated basin management, rigorous monitoring, and stringent regulations must take center stage in the fight to revive these precious ecosystems.

Guided by principles of inclusivity and collaboration, concerted governance becomes paramount in the journey towards recovery, rehabilitation, and restoration. With SDG2030 commitments in mind, every effort must be made to preserve the natural state of TCB and TCBR for generations to come.

Yet, the work has only just begun. As we lay the foundation for Phase 2, deep-oriented management research, data validation, and comprehensive monitoring will further enhance the recovery and restoration efforts of Tasik Chini Basin.

Unveil the stark reality and promising hope encapsulated within this impactful assessment. Join the mission to save Tasik Chini Basin and Tasik Chini Biosphere Reserve from the brink of extinction, as we strive to fulfill our dream and commitment to a sustainable future.

Academy of Sciences Malaysia

Level 20, West Wing, Matrade Tower,
Jalan Sultan Ismail Haji Ahmad Shah,
off Jalan Tuanku Abdul Halim,
50480 Kuala Lumpur, Malaysia

Phone: +6 (03) 6203 0633
Fax : +6 (03) 6203 0634

9 789832 915980