IMPACT OF SAND MINING ON SG. PERAK RIVER MORPHOLOGY USING GEOGRAPHICAL INFORMATION SYSTEM

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SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2022

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By

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This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfillment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS)

(CIVIL ENGINEERING)

School of Civil Engineering
Universiti Sains Malaysia

July 2022

Appendix A8

UNIVERSITI SAINS MALAYSIA

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2021/2022

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title:

Impact of Sand Mining on Sg. Perak River Morphology Using Geographical Information System

Name of Student: Nurain Soleha Binti Kamaruddin

I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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Date : 10/08/2022

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Date : 10/08/2022

Approved by:

(Signature of Examiner)

Date : 10/8/2022

ACKNOWLEDGEMENT

"In the name of Allah, the Most Gracious, the Most Compassionate."

Alhamdulillah, first of all, I would like to thank Allah S.W.T for giving me the strength and idea to complete this thesis. I would also like to extend sincere appreciation to my supervisor, Associate Professor Mastura Binti Azmi, for his guidance, concern, encouragement, advice, effort, and also criticism of me for being able to complete this thesis as required.

I also thank my co-supervisor, Dr. Zul Azmi Bin Mokhtar, who always gives an opinion and criticism while doing this research. Many thanks to Mr. Zabidi for his assistance in data collection and laboratory. I am also grateful to Universiti Sains Malaysia for providing a research grant for this study.

I would express a deep sense of gratitude to my parents for all the sacrifices, family members and friends for being very understanding and supportive in one way or another all the while.

ABSTRAK

Perlombongan pasir di sungai telah menjadi amalan berleluasa, khususnya di negeri Perak, dan boleh mengakibatkan kemusnahan aset awam serta kesan atau peningkatan tekanan ke atas sumber kehidupan komersial dan bukan komersial yang bergantung kepada tempat ini. Kajian ini dijalankan untuk menganggar kesan-kesan perlombongan pasir terhadap morfologi Sungai Perak pada masa kini berdasarkan kerja lapangan di tapak dan analisis spatial. Acoustic Doppler Current Profiler (ADCP) telah digunakan untuk menunjukkan profil sungai dalam penyiasatan ini. ADCP dapat memprofilkan keratan rentas sungai yang luas dengan cara yang pantas, meningkatkan ketepatan data dalam kajian pengangkutan sedimen dan mengukur jumlah luahan keratan rentas tertentu. Pengambilan sedimen Van Veen Grabber dan Helley-Smith mengumpulkan sampel tanah dasar dan menentukan pengangkutan sedimen. Kaedah ini digunakan untuk menentukan kesesuaian jenis pasir yang ada dan fluks pengangkutan sedimen pada skala kecil. Tinjauan dan analisis data yang dikumpul menunjukkan bahawa 80% daripada sampel Grab adalah pasir berkualiti baik. Pada tahun 2020, dasar sungai Pendiat terhakis antara 28.51 m dan 36.57 m, manakala pasir dimendapkan antara 11.49 m dan 72.76 m. Hanya tiga tempat di Teluk Kepayang menunjukkan hakisan antara 8.26 hingga 58.81 meter. Data selebihnya menunjukkan penambahan tebing sungai dalam julat 14.03-m-hingga-72.53-m. Pulau Pendiat diramalkan berkembang 1 hingga 9% sebulan, tetapi pulau PG Teluk Kepayang akan menyusut 5% menjelang Mac 2020. Tebing pasir Pendiat ialah 0.3577 ha hingga 1.8833 ha, manakala Teluk Kepayang ialah 0.7152 ha kepada 1.1465 ha. Operasi perlombongan pasir kawasan kajian tidak memenuhi garis panduan. Disebabkan oleh pergerakan sedimen yang terhad, kedalaman sungai, aliran air, hakisan tebing sungai, dan pembesaran pulau telah mengganggu sistem hidraulik

berdekatan. Syarikat pasir juga perlu menyediakan profil *bore log* untuk mengira berapa banyak pasir sungai yang boleh diekstrak. Penggunaan pam dan Ponton adalah optimum untuk pengambilan pasir kerana ia mampu mengurangkan hakisan tebing sungai dan mengekalkan kualiti air. Garis panduan dan analisis di tapak ini akan digunakan untuk penilaian reka bentuk dan aktiviti penyingkiran pemantauan sedimen dalam aliran.

ABSTRACT

Mining sand resources from rivers is now prevalent practice, particularly in the state of Perak, and may result in the destruction of public assets as well as repercussions or increased stress on commercial and noncommercial living resources that rely on these places. This study was conducted to estimate the effect of sand mining effect on current Sg. Perak morphology based on on-site fieldwork and spatial analysis. The Acoustic Doppler Current Profiler (ADCP) was utilized to project the river profile in this investigation. The ADCP could swiftly profile vast river cross-sections, enhance data accuracy in sediment transport studies and measure the total discharge of a specific cross-section. The Van Veen Grabber and Helley Smith sediment samplers gather bed soil samples and determine sediment transport. These methods are used to determine the appropriateness of available sand material and the flux of sediment transport on a small scale. The surveys and analysis of the collected data showed that 80% of the grab samples were good-quality sand. In 2020, Pendiat's riverbed eroded between 28.51 m and 36.57 m, while sand was deposited between 11.49 m and 72.76 m. Only three places on Teluk Kepayang indicate erosion ranging from 8.26 to 58.81 meters. The rest data indicate the addition of a riverbank within the range 14.03-m-to-72.53-m. Pendiat's islands are predicted to grow 1 to 9% per month, but Teluk Kepayang's PG island would shrink 5% by March 2020. Pendiat's sandbank is 0.3577 ha to 1.8833 ha, whereas Teluk Kepayang's is 0.7152 ha to 1.1465 ha. The study area's sand mining operations do not meet guidelines. Due to limited sediment movement, river depth, water flow, riverbank erosion, and island enlargement altered the adjacent hydraulic system. The sand company must also provide a bore log profile to calculate how much river sand can be extracted. The pump and Pontoon approach is optimal for sand dredging since it reduces riverbank

erosion and maintains water quality. These guidelines and on-site analysis will be used for design evaluation and sediment monitoring removal activities in streams.

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADCP	Acoustic Doppler Current Profiler
AMD	Acid Mine Drainage
BS 1990	British Standard 1990
GEE	Google Earth Engine
GIS	Geographic Information System
GPP	Gross Primary Productivity
IRBM	Integrated River Basin Management
LAI	Leaf Area Index
LAP	Lembaga Air Perak
LULC	Land Use and Land Cover
PSD	Particle Size Distribution
SRS	Satellite Remote Sensing
TNB	Tenaga Nasional Berhad
USCS	Unified Soil Classification System

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Illegal sand mining in Sg. Perak has been controversial for over a decade. Presently, there are 13 sand mining companies along the Sg. Perak in Perak Tengah District, which has caused deterioration of river water quality, bank erosion, riverbed degradation, and buffer zone encroachment, which is mainly due to the excessive sand extraction along river stretches (Perunding Pinang Sdn Bhd, 2021). The formation of islands is a natural process and does not pose a threat. However, due to the excessive mining activities and intrusion into the riverbed, these islands' morphology has been changed, ranging in area from a few sq meters to more than 10,000 sq m^2 (Sree et al., 2013). Forming and changing the river's course increase the threat of floods, putting a risk settlement nearby. Goswami et al. (1999) studied river channel changes of the Subansiri (a northern tributary of the Brahmaputra River) in Assam, India, using topographic sheets and satellite data.

This study aims to present the results of ArcGIS and ERDAS IMAGINE software to analyze the historical pattern of local river morphology with different periods. The area covered in this study are 11.8 km of SG. Perak Tengah District from upstream of Sg. Perak near Pendiat, Bota and Teluk Kepayang in Perak Tengah District. River morphology is explained in channel patterns and channel forms and is decided by factors that are interrelated to each other such as discharge, water surface slope, water velocity, and depth and width of channel and river. Van Veen Grabber and Helley Smith sediment samplers are used to collect bed soil samples and determine the grain size distribution (Shazril & Ibrahim, 2013). These two methods could estimate the suitability of available sand material and the soil gradation from the Uniformity Coefficient (Cu) and Coefficient of Gradation (Cc) value (CE 340, 2015). Then, soil classification is determined from the grain size distribution curve of soil sample gain from sieve analysis (coarse-grained soils) and hydrometer analysis (fined-grained soils). In this study, 13 locations of the river within the case study area were chosen to analyze soil gradation.

1.2 Problem Statement

Rapid sand mining activities could have a negative influence on the ecosystem. Environmental issues arise when the extraction rate of sand, gravel, and other materials is higher than the rate at which these materials are produced naturally. The extent of the impact is determined mainly by the extraction magnitudes concerning bedload sediment supply and movement through the reach. Without a clear regulatory framework, unregulated and unmonitored sand mining has aggravated environmental issues (Ismail et al., 2019). . Moreover, there are eight JPS pumphouse and two Water Treatment Plants along the Sg. Perak district, which cannot serve their purpose as the water level has dropped severely due to the accumulation of river-based material (Perunding Pinang Sdn Bhd, 2021).

Excessive removal of sand may significantly distort the natural equilibrium of a river system. Therefore, by conducting this research, a new method or technique which is more flexible and consistent can be implemented by the local authorities in Malaysia. The amount of minable river sand could be determined depending on the condition of the sites. In this study, parameters such as a cross-section of the river, replenishment period, the quality of the sand, and soil type are determined by using modern equipment and tools, which will produce more consistent results. Therefore, every site will have a different amount of river sand that can be extracted. Moreover, the negative impact of river sand mining, such as the river's imbalance and the sediment transport rate, can be reduced.

1.3 Objective of Research

The objectives of this research are listed below:

1. To determine the parameter used for morphology study, including Acoustic Doppler Current Profiler (ADCP) and soil classification via sedimentation practice.
2. To analyze the historical pattern of local river morphology with with a 6-year intervals image.
3. To assess the current Sg. Perak morphology based on the River Sand Mining Guideline (Amendment 2020).

1.4 Scope Of Work

The scope of work for the proposed study focuses on physical modeling, which is subjected to changes in slope at bed and island formation using ArcGIS and ERDAS Software. Site investigation and field inspection are used for data and information gathering and interpretation. In addition, equipment such as Acoustic Doppler Current Profiler, Van Veen Grabber, and Helley-Smith Sediment Sampler will be used in determining the cross-section and the flow of the study river and the quantity of river sand. Particle size distribution graphs are plotted to measure the distribution of sand and gravel along the study area. Then, a proper guideline on river sand mining is proposed by comparing with the real situation on site.

1.5 Thesis Outline

This thesis has five chapters and the brief outlines of this thesis are as follows.

i. Chapter 1 gives an introduction about the sand mining activity in Malaysia. This chapter also includes the problem statement,objectives, scope of study and the thesis outline.
ii. Chapter 2 discussed about the literature review of the properties to determine morphology of river with the support of several case study, and also review the impact of sand mining toward the sediment pattern and flow at river.
iii. Chapter 3 describes the methodologies that have been used in this research. The detail research methods are explained including field work survey, laboratory procedure and remote sensing analysis.
iv. Chapter 4 discusses the analysis of data collection and a solution on reducing the impact of sand mining.
v. Chapter 5 presents the conclusions and recommendations for future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Excessive sand removal can significantly alter a stream channel's natural equilibrium. The extraction volumes determine the magnitude of the impact concerning the supply and transport of bed load sediment through the reach (Ismail et al., 2019). People have transformed rivers and floodplains into a significant source of sand and gravel for construction in this era of rapid development (Devi et.al., 2015). Sand and gravel are parts of the ground that can be taken out. They are formed underground by the erosion of mountain rocks carried by rivers. Sand and gravel mining is one of the activities that has a positive impact on the local economy and are important resources for developing countries' efforts to grow their economies (Kori et al., 2012).

However, uncontrolled and unmanaged sand mining has occurred without a clear policy framework, exacerbating environmental problems. High sand prices have spurred the mining of sand from fragile and distant places, creating significant harm to road infrastructure owing to huge loads transported on deteriorating rural roads. Politics has complicated the situation even more. Furthermore, the necessities of the rural poor who profit from river sand mining must be considered. (Harrison et al., 2005). There is a study on stretches of the Brahmaputra River, Ganga River, Kosi River, and Gandak River that was used to demonstrate the use of remote sensing and GIS for identifying river bank lines, erosion, deposition, and quantifying the changes that occurred (Sree et al., 2013).

2.2 Geological Parameter

The geological, geomorphological, hydrological, and fluvial features of morphometric parameters have been emphasized from linear, areal, and relief perspectives. Most morphometric features show geomorphological and geological influences on river basin characteristics (Mahala, 2019). Geographical parameters such as grain size distribution, soil categorization, and remote sensing analysis are discussed in this study.

2.2.1 Particle Size Distribution Curve

In geomorphological research, geologists utilize particle size distribution curves extensively to analyze sedimentation and alluvial processes; civil engineers evaluate materials used for foundations, road fills, and other building objectives. The particle-size distribution curve depicts the range of particle sizes present in the soil and the kind of particle distribution. Particle size is defined on a logarithmic scale such that two soils with the same degree of homogeneity are represented by curves of the same shape regardless of their placements on the particle size distribution plot. Figure 2.1 shows examples of particle size distribution curves. From the particle size distribution curve, the particle size that corresponded to any given number on the "percentage smaller" scale was read. D10 represents the size such that 10% of the particles are smaller than that size. The definitions of other sizes, like D30 and D60, are comparable. The size D10 is described as an adequate size (Craig, 2004). The higher the value of the coefficient of homogeneity the broader the range of particles.The general slope and shape of the distribution curve may be represented utilizing the coefficient of uniformity (Cu) and the coefficient of curvature (Cz), defined as follows:

$$Cu = \frac{D_{60}}{D_{10}} \tag{2.1}$$

$$Cz = \frac{D^2{}_{30}}{D_{60}D_{10}} \tag{2.2}$$

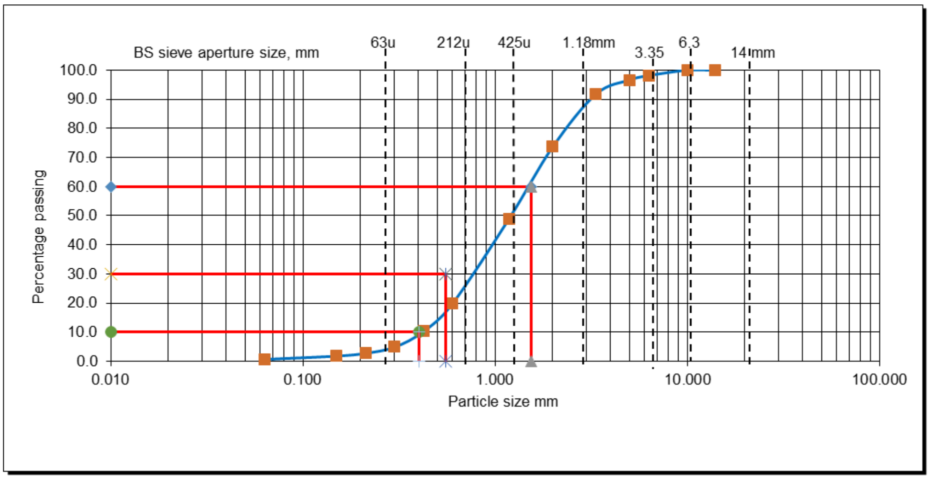

Figure 2.1: Typical particle size distribution graph

2.2.2 Soil Classification

The general features of soils, which are infinitely variable, can be succinctly expressed using classification systems without the need for specific descriptions. According to their engineering behavior, groups and subgroups of many soils with comparable qualities can be categorized. Most soil categorization systems created for engineering reasons are based on specific index characteristics like particle-size distribution and plasticity.

Table 2.1 shows the lists the words and letters used in the UK. Typically, 35% fines are considered the dividing line between coarse and fine soils (particles smaller than 0.06 mm). Based on the plasticity chart in Figure 2.2, the liquid and plastic limits are utilized to categorize fine soils. The plasticity index and liquid limit are the axes of the plasticity chart (R.F. Craig, 2004).

Therefore, a chart point indicates a particular soil's plasticity qualities. There are numerous options for schemes. Each was developed for a specific purpose. For instance, the construction of airport buildings initially applied the Unified Soil Classification System (USCS). Still, the American Association of State Highway and Transportation Officials (AASHTO) devised one scheme that classifies soils according to their utility on roads and highways (Budhu, 2010). The definitions of sand and gravel in the British Standard classification system (BS 1990), which is a modification of the Unified System and also based on the Casagrande classification, are slightly different. Instead of using the straightforward "low" and "high" divisions used in Unified and the original Casagrande system, the fine-grained soils of British Standard are divided into five plasticity ranges (Carter and Bentley, 2016).

Table 2.1: The letter symbol represents the soil group (Craig's, 2004)

Main terms	Group	Qualifying terms	Sub-group
GRAVEL	G	Well graded	W
SAND	G	Poorly Graded	P
		Uniform	Pu
		Gap graded	Pg
FINE SOIL,FINES	F	Of low plasticity(wl< 35)	L
SILT (M-SOIL)	M	Of intermediate plasticity (wL:35-50)	I
CLAY	C	Of high plasticity (wL :70-90)	H
		Of very high plasticity (wL: 70-90)	V
		Of extreme high plasticity (wL >90)	E
		Of upper plasticity range (wL> 35)	U
PEAT	Pt	Organic (may be a suffix to any group)	O

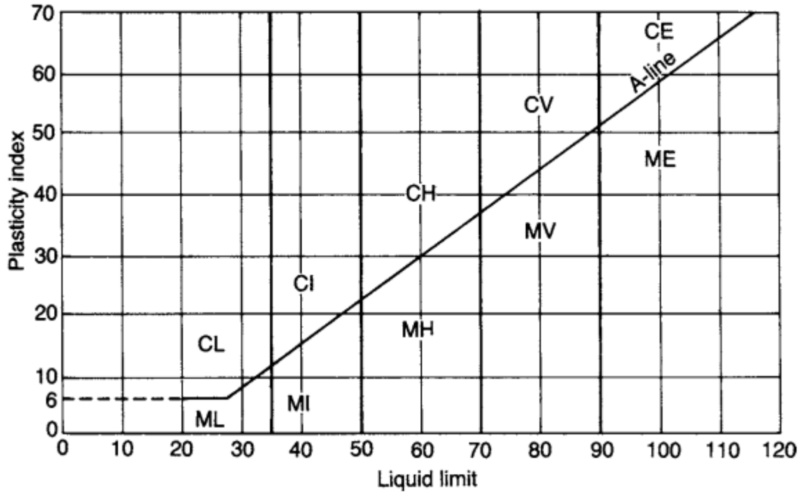

Figure 2.2: Plasticity chart: British system (BS 5930: 1999).

2.2.3 Remote Sensing and Geographic Information System (GIS)

Remote sensing and Geographic Information System (GIS) are cost and time efficient technologies that may be utilized to enable large-scale mangrove mapping, change monitoring, and fragmentation analysis. For the years 2000–2019, the Iskandar Malaysia region has seen significant loss and fragmentation of mangroves, and Kanniah et al. (2021) investigate how these changes have affected mangrove Leaf Area Index (LAI)and Gross Primary and Productivity (GPP) values.

As cited on Sree et al. (2013), Bardhan (1993) used satellite photos to investigate the Barak River's channel dynamics. Moreover, Naik et al. (1999) evaluated the degradation of Kaziranga National Park using remote sensing data. Furthermore, Goswami et al. (1999) investigated river channel alterations of the Subansiri (a northern tributary of the Brahmaputra River) in Assam, India, utilizing information from topographic sheets and satellite data. Research on the Brahmaputra River in India emphasizes the need for satellite remote sensing for monitoring and dynamic evaluation of fluvial ecosystem changes that aid ecosystem restoration planning.

The study of river morphology using remote sensing data is a recent innovation that has only been used in India for the last 20 to 25 years. Using satellite images, Murthy (1990) investigated the Brahmaputra River flood plain. Hussain (1992) used satellite images to conduct morphological research on the Brahmaputra River. The Space Application Centre in Ahmedabad used satellite photos to undertake erosion studies on Majuli Island and Kaziranga

National Park. Singh (2003) also used satellite data to conduct a spatiotemporal morphological investigation of the length of the Brahmaputra River.

2.2.4 Acoustic Doppler Current Profile

ADCP is a part of the most critical parameters and instruments used to measure the amount of sand to be retrieved. The function is to measure data collection, which has been highlighted in the discussion and explanation of this paper. As a result, suitable methods for managing sand mining operations, recovering and improving the quality of Sg. Perak and Bota Kiri have been finalized (Ismail et al., 2019). .

The ADCP device analyses errors and velocity fluctuations within the measuring volume and estimates velocity without utilizing an echo under typical measurement conditions. A space-averaging approach was employed to construct reliable maps of flow field characteristics to eliminate uncertainty from individual profile measurements (such as depth-averaged velocity, friction velocity, and surface-bottom velocity angle). To account for the trade-off between map resolution and reliability, ADCP helps alter ensemble duration, averaging window length, and map interpolation mesh size (Guerrero and Lambert,2011).

Although this may not be possible for sediment that has not been well sorted and when utilizing the standard frequencies of regular ADCPs, the indetermination of the actual PSD may be somewhat resolved using a multi-frequency technique. Another method is obtaining a stable calibration between the backscattering strength and the concentration of a select group of PSD-forming fractions. This technique depends on the ADCP's frequency's insufficient sensitivity to the actual spectrum of suspended particle sizes (Guerrero et al.,2016).

2.3 Sediment Transport in River

The mechanics of sediment transport investigate the principles governing sediment movement in fluids and the processes of erosive, transport, and deposition. An alluvial channel's loose boundary (made of movable material) deforms due to the force of flowing water and the deformed bed. The bed form changes its roughness when it interacts with the flow. Sediment transfer is the bed material (sediment) movement in the flow direction. The critical shear stress(τc) must be surpassed to initiate particle movement. This type of acute shear stress is referred to as an incipient (threshold) motion state, and the flow is identical to that on a rigid boundary. The material's mode of transport is determined by the sediment properties such as its size and shape, density ρs (usually 2650 kg m^3), fall velocity *(w_s)*, bulk density and porosity, and sediment concentration (C) (volumetric, ppm, or mg l^{-1}).

The particle flows in distinct modes along the flow direction when flow parameters (velocity, average shear stress) in an alluvial channel exceed the threshold requirement for the bed material. According to Figure 2.3, some sediment particles roll or slide over the bed irregularly, while others jump or bounce along it. The stuff conveyed in one or both techniques is referred to as a "bed load." Finer particles (with low fall velocities) are entrained in suspension by the fluid turbulence and transported along the channel at rest and transported along the channel at rest.

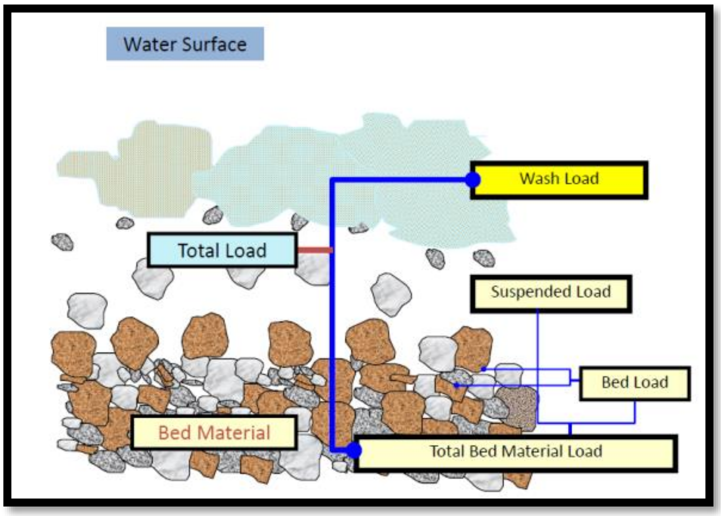

Figure 2.3: Modes of Sediment Transport (DID, 2009)

This method of transportation is known as "suspended load." Finer particles form upland catchment (sizes not present in bed material) are often conveyed in suspension and are identified as "wash load." The term "total load" refers to the combination of bed material and wash load. The sediment transport rate generally increases as a function of flow power. In other words, increasing flow results in more than double sediment transfer. The majority of sediment transfer happens during floods. Two existing sediment transport equations, the Yang and Engelund-Hansen equations, have been recognized as acceptable for calculating the replenishment rate of rivers in Malaysia.

2.3.1 Yang Equation

The stream power idea is employed in developing a new transport relationship for huge rivers. Yang (1973) estimated the total sand transport rate as the product of velocity and slope as excess unit stream power (the unit stream power is defined as the time rate of potential energy dissipation per unit weight of water) (Yen et al., 2017). The minimum energy dissipation rate theory states that a dynamic system's energy dissipation rate is at its lowest when it reaches equilibrium. The system's limitations determine the minimal value. Energy dissipation due to sediment movement may be ignored for a uniform flow (Shazril and Ibrahim, 2013). Yang equation for sand transport is:

$$\log Ct = 5.435 - 0.286 \log \frac{Ws\, d50}{v} - 0.457\, log \frac{U*}{Ws} + \Big\{(1.799 - 0.4909)\, log \frac{Ws\, d50}{v} - 0.314 log \frac{U*}{Ws}\Big)\, x \log\ \Big(\frac{Vso}{Ws} - \frac{VcSo}{Ws}\Big\} \tag{2.3}$$

where,

$$Cv(ppm) = \frac{Ct(ppm)}{Ss}$$

Critical velocity Vc is given by:

$$\frac{Vc}{Ws} = \frac{2.5}{log \frac{U*}{V} - 0.06} + 0.06$$

For,

$$Re *= \frac{U * d50}{V} = 12\ to\ 70$$

$$\frac{Vcr}{Ws} = 2.05\ f\ for\ Re * \geq 70$$

C_t - Total sand concentration (ppm by weight)

W_s - Terminal fall velocity (m/s)

d_{50} - Average particle diameter of granular material (m)

ν - Kinematic viscosity (m2/s)

U_* - Shear velocity (m/s)

VS - Unit stream power (m-kg/kg)/s)

VcS - Critical unit stream power required at incipient motion ((m-kg/kg)/s)

C_v - Sediment concentration by volume (ppm by volume)

2.3.2 Engulend Hansen Equation (1967)

Frank Engelund and Eggert Hansen of the Technical University of Denmark created this equation. Engelund and Hansen (1967) assumed that sediment movement's energy rate should be proportional to the sediment transport rate. This equation is appropriate for a river with a sand bed. This calculation, like Yang's, did not account for wash load when estimating total load and was based on the stream power technique. DID (2009) also suggests using the Engelund and Hansen equation (1967) to assess sediment transport capacity in Malaysian rivers.

Engelund - Hansen Equation (1967) is given by:

$$q_t = 0.05\, \gamma_s\, V^2 \sqrt{\frac{d_{50}}{g\left(\frac{\gamma_s}{\gamma} - 1\right)}}\ \sqrt[3]{\frac{\tau}{(\gamma_s - \gamma) d_{50}}} \tag{2.4}$$

$$Q_t = B\, q_t \tag{2.5}$$

Where:

q_t - total sediment discharge (metric Ton/m sec or kg/ms)

Q_t - total sediment discharge (metric Ton/sec or kg/s)

B - width of channel (m)

R - Hydraulic Radius (m)

ρ_s - density of sediment $\left(\frac{kg}{m^3}\right)$

ρ - density of water $\left(\frac{kg}{m^3}\right)$

γ_s - the specific weight of sediment

γ - the specific weight of water

d_{50} - median particle diameter (mm)

V - average flow velocity $\left(\frac{m}{s}\right)$

τ - shear force acting along the bed $\left(\frac{kg}{m^2}\right)$

g - acceleration due to gravity (9.81 $\frac{m}{s^2}$)

2.4 Impact of Sand Mining

2.4.1 Groundwater Level

The gradient of groundwater flow from the banks of the river is found to be towards the river course. Because of the sand bed in the river courses and its saturated condition, the gradient of groundwater flow is restricted towards the valley portion. Hence, groundwater is available in the wells existing on the banks of the river course for most of the year.

When the sand is mined, the riverbed level comes down. Degradation of riverbed levels will cause an increase in the gradient of groundwater flow from both banks towards the valley portion, thereby causing faster subsurface runoff towards the river course. Because of this, the depth to groundwater level falls on the banks of the river course and causes water scarcity during the summer months (Prasad, 2017).

2.4.2 Turbidity

The main reason for excessive turbidity water in the Kelantan River is a long-term sand mining business along the river. The high quantity of fine sediment and organic particles in the river causes significant turbidity. High turbidity can have an indirect impact on the aquatic ecology. When the turbidity content surpasses the natural range of turbidity and sedimentation in the area, it begins to block the light, reducing the clarity of the water. The decrease in light penetration impacts the ecosystem's primary output. Changes in productivity will then affect the food chain and phytoplankton composition (Yen and Rohasliney, 2013).

Wash-water discharge, storm runoff, and dredging from inappropriate sand and gravel operations can all contribute to increased stream turbidity. Turbidity levels are typically higher around dredging sites or wash-water discharge stations. As one moves downstream, turbidity decreases, but it can be managed by lowering runoff and filtering or containing wash water. Oxygen levels may change if in-stream mining alters stream temperature, dissolution, or water velocity by reducing it or distributing it over shallow areas (Ashraf et al., 2011).

2.4.4 Riparian Habitat, Flora, and Fauna

Beyond the immediate mine sites, instream mining can have far-reaching implications. Many hectares of productive soils, precious wood resources, and wildlife habitats are lost in riparian zones. Degradation of stream habitat decreases fisheries production, biodiversity, and recreational opportunities. As a result, it might negatively affect the quality of the land and its appearance. Factors affecting sediment supply weaken beds and banks, resulting in dramatic channel relocation. Human activities, such as riparian forest loss or instream mining, induce stream banks to become sediment providers, which can have severe consequences for aquatic species (Ashraf et al., 2011).

Changes in sediment supply and channel geometry caused by mining give impact to channel and habitat development processes. Furthermore, habitat sedimentation downstream is caused by the movement of unstable substrates. Mining intensity, particle size, stream velocity, and channel shape all influence the distance affected. Animal populations are reduced when vegetation is completely removed from the soil profile, habitats above and below ground, and the aquatic environment. The channel will continue to expand until the restoration site's sediment intake and outflow.

2.4.5 Changes in Bed Forms

Public and private property may be harmed by sand and gravel mining in stream channels. Gravel mining can degrade bridge piers, expose subsurface pipelines, and abuse water intake units and other river-protection engineering elements. The two primary causes of bed deterioration, also known as channel incision, are head cutting and "hungry" water. In an active channel, excavating a mining pit lowers the stream bed, resulting in a nick point that locally steepens the channel slope and increases flow energy. Therefore, head cutting produces a large amount of stream bed material transported downstream and deposited in the excavated areas. The second form of bed deterioration occurs when mineral extraction increases the flow capacity of the channel (Ashraf et al., 2011).

The galvanized river water from the mining site is known as 'hungry water.' The rage of the hungry water is expressed by eroding additional materials from the stream below the mining site, resulting in bed deterioration downstream. This state will persist until a balance between sediment input and output is restored. Figure 3 shows how sand extraction forms a nick point. The upstream migration of the nick point causes downstream erosion of the bed due to the flow of hungry water that arises from the sediment deposition in the excavation hole (Padmalal & Maya, 2014).

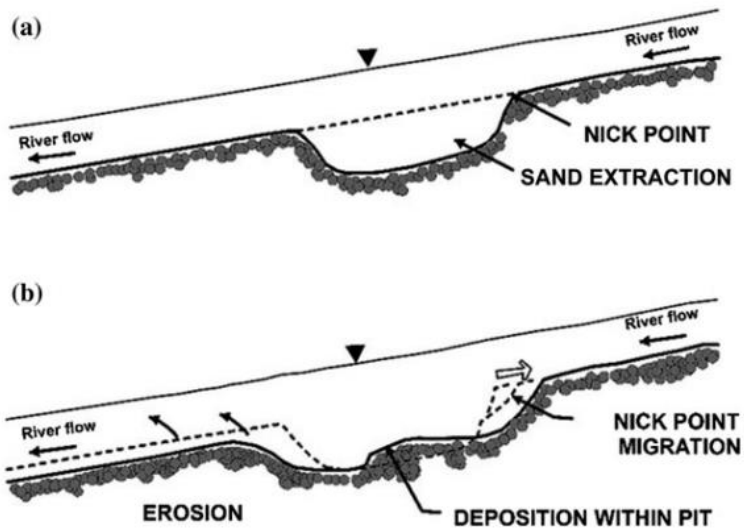

Figure 2.4: Incision produced by instream sand mining (Padmalal and Maya, 2014)

2.4.6 Water Quality

Instream sand mining will influence river water quality because of increased short-term turbidity at the mining site linked to sediment resuspension. Oil spills, leaking from excavation equipment and trucks, and stockpiling and dumping surplus mining materials and organic particulate matter all contribute to the degradation of water quality. Particle concentration rises when riverbed and bank erosion develops near the excavation site and further downstream. Suspended solids have the potential to affect both water users and aquatic ecosystems. If water consumers downstream of the property remove water for residential consumption, the impact is magnified. Suspended particles can considerably raise the cost of water treatment.

Furthermore, mining sand and gravel from alluvial reaches severely affects surface and underground (groundwater) water supplies. Due to covert sand mining operations, the water column contains a high concentration of suspended particulates, causing severe harm to river ecosystems. Sand and gravel mining churns river water indiscriminately, generating delicate organic and inorganic pollution clouds. A high particulate matter load above water limits instream vegetation's respiration and photosynthesis, resulting in slower development and extinction. Degradation of drinking water quality and changes to water flow and quality could lead to an increase in the prevalence of infectious diseases (Padmalal & Maya, 2014).

Water pollution is visible in Meghalaya by the color of the water, which ranges from brownish to reddish-orange in most rivers and streams in the mining area. Acid Mine Drainage (AMD) pollution from mines and spoils, heavy metal leaching, organic enrichment, and sand particle silting are all significant contributors to water quality degradation in that area. (M. Naveen Saviour,2012)

2.4.7 Changes in Sediment Characteristics

Sand mining in alluvial reaches alters the grain size characteristics of river sediments significantly. Because bed materials are a crucial abiotic component of a river ecosystem, changes in bed materials frequently result in changes in river biodiversity. According to a study undertaken in southern India's Manimala and Muvattupuzha rivers, uncontrolled river sand mining has resulted in considerable changes in the grain size spectral image of the in-channel sediments (Padmalal et al., 2010; Anooja et al., 2011).

Bed coarsening caused by removing finer particles from the upstream end of the Manimala River point bars is demonstrated by examining sediments collected from selected Manimala River point bars. The continued mining of sand in the downstream areas causes bed coarsening in the upstream portion of the point bars. Due to selective sedimentation and the elimination of medium to very fine sands from the sediment population, point bars originally composed of sand-sized particles transform into gravelly sand and sandy gravel. Sand particles intentionally extracted from the point bar's upstream end are later deposited in the deep pools formed by sand pit excavation.

Continuous sand mining in rivers aggravates the sediment sorting cycle, resulting in dramatic changes in the textural fabric of naturally produced bars and point bars. Sand particles intentionally taken from the point bar's upstream end are later deposited in the deep pools generated by sand pit excavation. In addition, a lack of sand in the sediment substratum may enhance the hungry water effect (the increased harmful effects of sediment-deficient water) in rivers during high flow times (Padmalal & Maya, 2014).

2.4.8 Climate

Under natural settings, thermodynamic processes on the shore neutralize radioactive mineral emissions, considerably lowering effective radiation perceived in the surrounding environment. Furthermore, ilmenite and silica function as an envelope, helping to reduce natural radiation. The ilmenite extraction procedure revitalizes the emissions from radioactive monazite (sand run through sulfuric acid). This process will raise the local ambient temperature, affecting the microclimate. As a result, the earth's energy budget is impacted, contributing to the phenomenon of global warming (Ashraf et al., 2011).

Elevation of climate change and coastal sand mining- sea-level rise caused by climate change reduces accessible land surface, which is especially crucial on small islands. Coastal sand mining has the same effect which is reduced accessible land surfaces by hastening erosion from the sea. As a result, scientists contend that human impact on coastal lines exacerbates the effects of sea-level rise (Worliczek et al.,2016).

2.4.9 Destruction of Riparian Vegetation

Over the last few decades, indiscriminate sand-bar mining has devastated many migrating birds' resting and breeding habitats. Natural riparian ecosystems have varying amounts of wetness and light, lush flora, and a high level of biodiversity. If indiscriminate sand mining, lowers the water table to the point where it is below the root zone, riparian vegetation along river banks may disappear. Riparian flora and fauna suffer from severe repercussions such as river bank slumping, channel incision, water table lowering, and so on due to direct loss of vegetation along river banks, bank undercutting, and channel incision. (Padmalal & Maya, 2014).

Riparian vegetation is also influenced by large machinery, processing facilities, and gravel stockpiles at or close to the extraction site. Heavy machinery also causes soil compaction, which promotes erosion by reducing soil penetration and boosting overland flow, upsetting the standard hydraulics of the riparian zone during seldom high flow levels. In these circumstances, it may be prevented for water with high nutrient and sediment loads from settling on riparian terraces downwind of the disturbance. Consequently, affect the recruitment of particular species that rely on these events for an extended period of survival on these terraces. In other words, a generation of recruitment may be missed, leaving a void in the population structure for other species, most commonly exotics, to exploit (Ashraf et al., 2011).

Incontinent sand mining in the bar and riparian zones disrupts, disturbs, and destroys vegetation. As a consequence, the water temperature may rise. Removing standing trees and drowned vegetation in the bars reduces the river's load of massive woody waste, which is critical for habitat development and resource supply. (Padmalal & Maya, 2014).

2.4.10 Water Supply Scheme

The water supply systems will be built based on the estimated water requirements, and infiltration arms will be embedded in the river course's sand beds. There are regulations to prevent river sand mining near water supply schemes. On the other hand, any sand mining activities in the lower reaches will almost certainly impact the performance and sustainability of infiltration galleries in the upstream portion. The sand mining activities will cause unevenness and significant depressions in the lower parts of the river channel. However, this will be compensated somewhat, negated during the coming monsoon period due to the transfer of sand from the upper to lower ranges. Also, it may diminish the saturated thickness of the sandy formation available above the infiltration arm required for a water delivery plan to function successfully over time.

Illegal and excessive sand mining in the Karnataka riverbed's Papagani catchment region has resulted in groundwater depletion and environmental degradation in both Andhra Pradesh and Karnataka communities on the river banksLegal sand mining from the Papagani river catchment region in the Kolar district has been going on for about six to seven years in Karnataka. Initially, the Karnataka government granted a few contractors sand mining rights. However, rising illegal and excessive mining has resulted in environmental damage and people's difficulties by diminishing groundwater levels in riverbank settlements. Consequently,