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ASSESSMENT OF RIVERBANK STABILITY IN PERAK RIVER INDUCED BY UNSUSTAINABLE SAND MINING ACTIVITIES

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UNIVERSITI SAINS MALAYSIA

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By

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LIST OF ABBREVIATIONS

DID	Department of Drainage
WLF	Water Level Fluctuation
R1	Resistivity Line 1
R2	Resistivity Line 2
R3	Resistivity Line 3
R4	Resistivity Line 4
R5	Resistivity Line 5
ADCP	Acoustic Doppler Current Profiler
GIS	Geographic Information System
LiDAR	Light Detection and Ranging
TGR	Three Gorges Reservoir

ABSTRAK

Selama bertahun-tahun, kedua-dua jalan dan bangunan telah dibina menggunakan agregat seperti pasir dan kerikil. Kerana pertumbuhan besar yang telah berlaku dalam beberapa dekad kebelakangan ini, pasir sungai telah meningkat dalam permintaan sebagai bahan binaan selama beberapa tahun yang lalu. Oleh itu, aktiviti perlombongan pasir telah meningkat dengan pesat. Tanpa pemantauan yang baik daripada pihak berkuasa, perlombongan pasir telah menyebabkan banyak masalah seperti hakisan tebing sungai, memusnahkan zon penampan sungai dan banyak lagi. Objektif kajian ini adalah untuk mengenal pasti kestabilan tebing sungai semasa aliran rendah dan aliran tinggi serta faktor-faktor yang menyebabkan tebing sungai mengalami hakisan. Dengan menggunakan ujian kerintangan ia boleh membantu menentukan sama ada kawasan kajian mempunyai tanah yang mencukupi, dan peralatan boleh mengukur profil bawah permukaan sehingga 80 meter di bawah permukaan tanah. Lebih tinggi kerintangan bermakna sifat tanah adalah lebih stabil. Jika dibandingkan dengan keadaan dengan aliran tinggi, keadaan aliran rendah telah terbukti mempunyai kestabilan tebing sungai yang unggul. Dapatan ini adalah berdasarkan dapatan kajian. Keadaan aliran tinggi mempunyai kadar alir yang lebih tinggi berbanding dengan keadaan aliran rendah, yang secara beransur-ansur menjana hakisan tebing sungai. Di samping itu, kajian ini berjaya menentukan bahawa perubahan paras air, perubahan kualiti tanah, dan perlombongan pasir merupakan faktor utama yang menyumbang kepada hakisan tebing sungai. Dapatan positif muncul daripada pentadbiran tinjauan dan pemeriksaan seterusnya terhadap data yang dikumpul. Penggunaan strategi ini akan membolehkan mengurangkan kesan kerosakan yang disebabkan oleh aktiviti perlombongan pasir, seterusnya memelihara sungai.

ABSTRACT

For many years, both roads and buildings have been built using aggregates like sand and gravel. Because of the enormous growth that has occurred in recent decades, river sand has increased in demand as a building material during the past several years. Therefore, sand mining activities had been increasing rapidly. Without good monitoring from authorities, sand mining had caused many problems such as riverbank erosion, destroy river buffer zone and many more. The objective of this research is to identify riverbank stability during low flow and high flow and factors that causing riverbank to erosion. By using resistivity test it can help determine if the study region has adequate soil, and the equipment can measure the subsurface profile up to 80 metres below the ground surface. The higher the resistivity means the soil properties are more stable. When compared to conditions with a high flow, low flow conditions have been shown to have superior riverbank stability. These findings are based on the findings of study. Conditions of high flow have a greater flowrate as compared to conditions of low flow, which are gradually generating riverbank erosion. In addition, this study was successful in determining that changes in water level, changes in soil qualities, and sand mining are the primary factors that contribute to riverbank erosion. Positive findings emerged from the administration of the surveys and the subsequent examination of the data that was gathered. The utilisation of this strategy will allow for the mitigation of the damaging effects that are caused by sand mining activities, hence preserving the river.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Sand and gravel have been used for many years as aggregates in the construction of both roads and structures. River sand has become more in demand as a building material over the course of the last few years as a direct result of the tremendous growth that has taken place in recent decades. There are two different types of sources from which sand and gravel can be obtained. The first type of resource is made up of aggregate deposits in the rivers, while the second type of resource is made up of land. The quantity of land-based resources that can be extracted from quarries is limited. In light of this, river aggregate is an extremely important factor in the development of the region (Kim, 2005). In addition, the quality of river sand is superior to that of sea sand since concrete made with sea sand has a slightly lower, albeit still adequate, compressive strength when compared to concrete made with river sand (Ratnayake et al., 2014). River sand has a grain size that is coarser than other types of sand, a surface roughness that is around average, and fewer impurities than other types of sand. Even though certain grains of sea sand are so small that they resemble powder, this form of the sand is never employed.

In-stream mining is the primary method used to obtain sand in Malaysia. Due to the fact that the mining sites are typically situated along transportation routes, stream sand mining is a common practice (Abidin et al., 2017). The extraction of sand and gravel from the running water of a river is referred to as "instream sand mining," and it is a type of mining. Sand from instream (in-channel) sources typically needs less processing than sand from other sources. For the purpose of instream sand mining, a wide variety of fluvial subsystems, such as bars, point bars, and even active channels, are utilised. After instream sand extraction has been completed, the normal next step is to mine sand from additional alluvial sources (Padmalal et al., 2014).

Sand mining in streams can cause damage to both privately owned and publicly owned properties, and it can also damage aquatic environments. If an excessive amount of sand is taken from a stream channel, the natural equilibrium of the channel may be drastically disrupted. As a result, businesses that mine sand are required to comply with the procedures outlined in state and federal regulations, including those that govern the evaluation and issuance of permits. Before granting a permit, it is customarily necessary to take into account the potential effects of the stream operation on the surrounding area (Meador et al,.1998).

Unsustainable sand mining has a detrimental effect on the ecosystem of rivers by altering the geomorphic structure of the stream and frequently causing channel erosion and degradation (Meador et al,.1998). In areas with a high concentration and frequency of mining activity, a process known as head cutting can occur, which is an upstream progression of channel damage and erosion. Sand mining can have a substantial impact on the instream flow, water chemistry and temperature, bank stability, available cover, and siltation. Head cuts are made when sand is extracted from the ground. Head cuts are a particular kind of knickpoint that are found near the head (or upstream extent) of a channel, as the name suggests. A head cut's starting point, or knickpoint, might be as tiny as an excessively steep riffle zone or as big as a waterfall. The head cut, when not flowing, will resemble a very small cliff or bluff. Head-cut channel erosion has a negative impact on property values, recreational, fishing, and wildlife values, and the extinction and extirpation of stream fauna (Hartfield 1993).

Additionally, rivers constantly modify their course by changing their form and depth in an effort to strike a balance between the water's ability to convey silt and the availability of sediment. This process, known as riverbank erosion, is typically thought of as the long-term wearing down of riverbanks and riverbeds (Islam et al.,2011). The bedform particles, along with riverbank particles, would be detached from their interlocking due to the action of water flow (Abidin et al., 2017). The transportable particles would then begin to move downstream and deposit in a river section's downstream section. If monitoring programmed are not well-managed and practiced, this process will result in severe engineering and environmental problems.

Slope monitoring is a typical acquisition technique that can be used in conjunction with geophysical technologies to resolve engineering and environmental problems. People have become more interested in employing geophysical technologies to solve technical and environmental problems over time (Jongmans D et al, 2007). This seeks to detect and monitor changes in the suspicious area so that appropriate countermeasures can be done. The slope is being monitored at Kg Telus – Teluk Belanja and Pendiat, Perak, Malaysia, using the 2D resistivity method as the monitoring method.

Therefore, the local authority must take a significant role in resolving the river problem brought on by unsustainable sand mining. This is so that the river buffer zone won't gradually be destroyed by unsustainable sand mining, which can make the riverbank unstable. In particular on unstable steep slopes, buffer zones or reserve land are crucial to maintain and help reduce erosion. To determine what occurred in the river area and how to resolve the issue, an inspection and maintenance are required. In the end, it’s difficult to completely restrict sand mining in rivers because it has both benefits and negative effects. It is important for policies to be put in place that specifically addresses sand mining (Tasantab, 2021).

1.2 Problem Statement

One of the major global public issues, at least in some nations, is riverbank erosion. Long-term effects on human life are caused by riverbank erosion. The riverbank zone in the basin offers areas for habitation as well as consumer products and production inputs (Miyazawa et al., 2008). Therefore, riverbank erosion causes loss of household revenue sources in addition to population displacement. One of the main factors that causing riverbank erosion is unsustainable sand mining or extraction of sand at the river area. The irresponsible act resulted in erosion of riverbank, thereby jeopardizing the riverbank's stability. Unsustainable sand mining activities such as taking sand near the riverbank area are affecting the stability of riverbank which is slowly destroying the buffer zone.

In addition, it has been demonstrated that the removal of sand can change the shape, decrease flow velocities, and increase flow turbulence in the areas surrounding mining pits, which can occasionally result in extremely unfavourable outcomes. It has been hypothesised, for instance, that the detrimental impacts of sand mining may be responsible for what appears to be an increase in the overall rate of bank erosion (Hackney et al., 2020). Therefore, an analysis needs to be done to end up with a conclusion about this problem.

Finally, there are many factors that can contribute to riverbank erosion, including bend curvature and specific stream power as well as riparian vegetation and even the mining of sand and gravel (McMahon et al., 2017). That's why determining the riverbank stability and determining what factors cause riverbank erosion are the main goals of this study.

1.3 Objectives

The objectives of this research are listed below:

I. To identify the stability of riverbank during high flow and low flow of Sungai Perak.

II. To identify factors contributing to riverbank erosion at Kg Tepus-Teluk Belanja and Pendiat, Perak.

1.4 Scope of Study

The purpose of the proposed study is to determine whether or not there is sand mining potential in the surrounding area by conducting a preliminary evaluation utilising resistivity equipment based on the features of the subsurface of the area. In addition, RES2DINV software will be used to process the raw data after it has been converted and saved in an extension of the.DAT format. This software will use a least-squares inversion scheme to determine the correct resistivity value, which will ensure that the calculated apparent resistivity values are in agreement with the values that were measured.

1.5 Dissertation Outline

This study consists of five chapters, each of which is titled as follows, introduction, literature review, methods, results and discussion, and conclusion. The history of the study, a description of the problem, the objectives, the scope, and the dissertation of the work were all covered in the first chapter of this research project.

The second chapter is the literature review, and it covers topics such as riverbank erosion, the impact of sand mining, the environmental impact of sand mining, and sustainable sand mining. These topics are discussed in relation to research articles or reviews that were completed in earlier research.

This study's methodology is discussed in Chapter 3, which explains the general flow approach that was applied, such as resistivity and software analysis procedures such the RES2DINV. Additionally, this chapter includes a glossary of terms related to the methodology.

Chapter 4 will go through the data and examine so that significant trends, patterns, and reasons for this project can be found. The result from resistivity result shows the condition of riverbank whether is stable or not.

In conclusion, Chapter 5 summarises the overall success of this project in relation to the aims that it set out to accomplish. Those individuals who are interested in making future improvements to this study might utilise the suggestions and recommendations as a reference.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Sand and gravel derived from rivers are among the most common types of aggregate used in building construction in developing countries. The need for aggregates on a national scale is strongly impacted by the mining of sediment, which frequently takes place directly in river channels. However, if it is not properly managed, instream mining can cause considerable harm to the river and the biota associated with it, in addition to the land surrounding, and it can also cause conflict with others who utilise the river for other purposes. A lack of understanding of the economic and environmental geology of river sand and gravel mining in underdeveloped countries has made it difficult to affect current regulations. Instream sand and gravel mining has been given a code of practise that regulators can use to assess and reconcile the conflicting claims made by the extraction of sand and gravel and the environmental situation (Harrison et al.,2005).

2.2 Riverbank Erosion

One of the natural calamities that compels people who once lived near riverbanks to move away from their homes is riverbank erosion. Many of individuals who are affected by erosion not only lose their homes, means of livelihood, and assets, but they also lose their previous identities. As a consequence of this, they frequently struggle to identify who they were in the past (Das, 2010). On a worldwide scale, flooding and riverbank erosion are exceedingly common occurrences that can't be avoided. In contrast to these two types of natural disasters, the loss of land caused by flooding is temporary, whereas the loss of land caused by erosion of riverbanks is permanent and has an effect on the economy that lasts for a long period of time. It is nearly impossible to reconstruct residential or commercial property that has been destroyed by riverbank erosion once it has reached that point. This upsetting experience calls for appropriate control in order to lessen the likelihood of conflict between the dynamics of rivers and human settlements.

2.3 Method of Monitoring

2.3.1 Geographic Information System (GIS)

The use of Geographic Information Systems (GISs), which are well-known for being able to analyse spatial data in an efficient and effective manner, has tremendously facilitated the study of natural hazards, particularly with regard to studies on slope instability. The GIS framework used in this study, used a digital elevation model (DEM) to obtain topographic information about the site; high-resolution aerial images are used to examine the collapsed regions; and, finally, the dimensions of the simulated collapsed regions are validated against high-resolution aerial images.

2.3.2 Light Detection and Ranging (LiDAR)

As a result of the advent of airborne laser altimetry (LIDAR), it is now possible to accurately measure the position and elevation of banks, and to derive volumetric erosion rates over annual timescales, as a result of the high positional and vertical accuracies (generally decimeters scale) and ability to filter vegetation (Thoma et al., 2005). A near-infrared laser is utilised in topographic LIDAR in order to estimate distances on land. This is absolutely necessary for the vast majority of mining, roadwork, and civil engineering projects, all of which require accurate distance measurement on the land.

2.4 2.3 Impact of Riverbank Erosion

2.4.1 Social Impact

2.4.1(a) Homelessness

Homelessness or the problem of settlement is one of the most significant effects of riverbank erosion because as a result of flooding, people become homeless and move from the affected area to another area. This is a fairly prevalent problem in the delta region of Sunderban, where residents move around a lot due to river erosion. One of the clearest examples of this issue is the Sunderban's Iswari pur delta (Tripathy et al., 2019).

2.4.2 Economy Impact

2.4.2(a) Loss of productive Land

The fact that people whose lives are disrupted by riverbank erosion lose their farmland as a direct consequence of the phenomenon is one of the primary contributors to the economic issues that plague the basin area. During the monsoon months in India's state of West Bengal, this problem manifests itself every year in the lower Ganga River basin (Tripathy et al., 2019).

2.4.2(b) Loss of occupation

Due to the fact that their place of employment was washed away by the river during the flood, many people were forced to find other employment. They have lost their land, goods, and people as a result of their inability to find work, increasing the likelihood that they will fall into poverty.

2.4.3 Human Intervention and Erosion

River bank erosion is not going to be a serious issue so long as there are no human settlements in the vicinity of the river. However, this natural hazard has the potential to become a catastrophe if riparian buffers aren't maintained and human settlements are constructed too close to the banks of rivers that are eroding (Das et al., 2014). In addition, human activity along the river's length disrupts the river's dynamic equilibrium, resulting in a greater rate of bank erosion. Human actions, including as deforestation, gravel mining, the construction of dams and bridges, artificial cut-offs, bank revetment, and other land use adjustments, can alter the natural dynamics of rivers (Kondolf, 1997). When it comes to modifying the flow patterns of rivers, the acts of humans have a much greater impact than natural occurrences like floods, droughts, and landslides (Yamani et al., 2011).

2.5 Riverbank Stability

The width-adjustment reaction of a channel after incision is typically associated with the process of bank retreat. To understand how bank retreat occurs, one must look at conceptual models that depict how erosion of the bank toe and surrounding channel bed has increased the bank's height and angle, resulting in mass failure (Osman and Thorne, 1988). The process of bank retreat is frequently associated with a channel's response to incision in terms of its ability to change its width. The conceptual models of bank retreat show how bank failure occurs when erosion of the bank toe and the adjacent channel bed has increased the bank's height and angle to the point where gravity forces exceed the shear strength of the bank material, resulting in mass failure. This happens when the bank's height and angle reach a critical threshold. The importance of soil strength for maintaining slope and bank stability has been proven by a large number of previous research (Parker et al., 2008).

2.5.1 Factors affecting riverbank stability

2.5.1(a) River Water Level Fluctuations

The contour of a river disturbance zone is perpetually subject to change as a result of the active processes of erosion and deposition. During the dry season when the water level is high, more frequent navigation as a result of wider and deeper reservoir water may cause the banks to collapse as a result of sheet, creep, and/or undercutting erosion owing to more intense waves. This may be caused by a combination of factors (Chen et al., 2002).

Physical processes that are both massive and diffuse, such as erosion and deposition, have been researched for the water-level fluctuation zone. Some examples of massive physical processes are rockfalls and landslides (Xu et al., 2008). Our knowledge of the geochemical and biological processes involved with the zone's worsening pollution and damaged ecology is hindered as a result of the fact that the coupled influence of these activities on the water-level fluctuation zone and its reaction to them remains undiscovered. The zone is a geomorphological unit that is completely unique on the world scale as a result of the complex interactions between geomorphological, geological, and biological processes. If these processes are understood, significant insights into the impact of the zone on the natural environment of the TGR and the water quality will be gained. These insights, in turn, may play a role in the creation of new environmental regulations.

2.5.1(b) Mass Failure

Recent years have seen significant advances in the understanding and modelling of the importance of positive and negative pore water pressures, river pressures, and hydrograph characteristics in the analysis of bank stability (Rinaldi et al., 2007).

2.5.1(c) Cantilever Failure

Due to the fact that a cantilever collapse results in the quick widening of the channel and the delivery of a significant amount of sediment into the channel, it is essential to have an understanding of this mechanism from the perspective of river engineering. Experiments demonstrated that the upper section of cohesive riverbanks are gradually weakened when the lower half of the riverbank is eroded by water during the initial stage of a cantilever collapse. This occurs when the cantilever begins to break. After that, tension cracks start to show up at the top of the riverbanks, and failure of the beams follows shortly after that (Patsinghasanee et al., 2017). The grain size and density of the soil, in particular, are the key parameters that influence the rate of fluvial erosion as well as riverbank stability in terms of cantilever riverbank failure. Other characteristics that are important include the grain size of the soil (Samadi et al.,2011).

2.5.1(d) Effects of pore water pressures

Putting these changes into bank process models is one of the most important things that has changed in recent years. Changes in pore water content and pressures are known to be one of the most important factors that affect when and how a bank becomes unstable (Thorne, 1982), and it is one of the most important things that has changed in recent years. At least these four primary effects are caused by pore water: (1) it lessens the shear strength of the bank material; (2) it raises the unit weight of the bank material; (3) it adds a destabilising force when there is water in tension cracks (the force of the water on the sides of the cracks before it gets into the soil material); and (4) it adds more seepage forces, which can either stabilise or destabilise the bank.

2.6 Impact of Sand Mining

Mining for sand has a number of physical repercussions, the most notable of which are a decline in the quality of the water and the instability of the stream bed and bank. In addition, mining can have an effect on the supply of sediment as well as the structure of channels, which can lead to incision of channels and the sedimentation of ecosystems further downstream. Instream mining can also cause channel instability, which can wreak havoc on public infrastructure. Sedimentation is another negative effect of instream mining (bridges, pipelines, and utility lines). The disappearance of infauna, epifauna, and certain benthic fishes, in addition to the transformation of the accessible substrate, have all had an adverse effect on the biological resources. In addition, this process has the potential to damage the vegetation found along rivers, contribute to erosion, taint water supplies, and reduce the species diversity that can be found in ecosystems that are dominated by trees (Byrnes and Hiland, 1995).

2.6.1 Environmental Impact of Sand Mining

Sand deposits are interconnected and adding or removing sand from one region has an effect on all of the other habitats. Numerous issues arise as a result of sand mining. The following is a concise outline of the issues recorded.

2.6.1(a) Riparian habitat, flora and fauna

Costs of in-stream mining can extend well beyond the actual mine sites. Significant timber resources and wildlife habitats in the riparian zones are lost in the process. Fisheries production, biodiversity, and recreational opportunities are all negatively impacted by stream ecological degradation. An eroding channel may have an adverse effect on the land and its aesthetics. To ensure long-term existence, all species require distinct habitat conditions. In many cases, changes in the sediment supply are responsible for the bed and banks becoming unstable, which leads to significant channel realignments. The destruction of riparian forests and instream mining are two examples of human activities that accelerate stream bank erosion. As a result, stream banks become net suppliers of silt, which frequently has detrimental repercussions for aquatic species (Newell et al., 1999). Mining causes disruptions in the natural evolution of habitats and channels because it alters the availability of sediment and the geometry of channels. Additionally, sedimentation of habitats can occur downstream as a result of the shifting of unstable soils. The mining intensity, particle size, stream velocity, and channel shape all have a role in determining the distance across which mining activities have an impact. The loss of habitat above and below ground, as well as within the aquatic ecosystem, is the direct result of the total eradication of vegetation and the degradation of the soil profile, which in turn leads to a decrease in the number of animal populations. Once the equilibrium between sediment input and output has been restored, the channel widening condition is maintained.

2.6.1(b) Structures' stability

The extraction of sand and gravel from stream channels has the potential to cause damage to both publicly owned and privately owned property. Gravel mining has the potential to cause the piers of bridges to become unstable and expose subsurface pipelines and other forms of buried infrastructure. The primary causes of bed degradation, which is also sometimes referred to as channel incision, are as follows: (1) headcutting, and (2) water that is unsteady flow . Lowering the stream bed to create a nick point steepens the slope of the channel and boosts flow energy locally, which is known as headcutting. A 19-second bed degradation happens when the channel's flow capacity is increased by mineral extraction. An excavation of a pit in riparian areas results in an increase in the amount of woody vegetation that is dependent on the water table and a decrease in the amount of wet periods that occur in riparian wetlands. In geographic locations that are close to the ocean, it is possible for salt water to seep into freshwater bodies.

2.6.1(c) The state of the water

Sand mining in streams, for example, will have an impact on the river's water quality in the long run. For short-term sedimentation, excess mining materials and organic particle matter are stockpiled and dumped; for long-term sedimentation and oil spills or leaks are caused by excavating machinery and transportation vehicles. An increase in riverbed and bank erosion leads to an increase in the concentration of suspended particles in the water both at the excavation site and further downstream. The presence of suspended particles in water has the potential to have a detrimental effect on both the people who utilise the water and the aquatic ecosystems that they inhabit. The impact is amplified if there are people living downstream of the site who extract water for their own personal use. Solids that are suspended in water have the potential to substantially drive up the expense of treating the water.

2.6.1(d) Adverse Health Effects

Officials appear to have no regard for the health concerns linked with mining, as proven by their actions Ilmenite, which makes up around 70% of the sand, would be mined in this project. Extraction waste includes radioactive minerals monazite and zircon. This means that individuals living in Bestari Jaya are still at risk even after the ilmenite-silica blanket and thermodynamic processes reduce radiation emitted by naturally radioactive minerals by 5.0 mSv/a-1* (less for children and pregnant women) (Van Dolah et al.,1984). Natural radiation's somatic, genetic, and teratogenic impacts, as well as its stochastic and non-stochastic effects, have been investigated and documented at length by researchers. "Evolutionary hot spots" is the term that the researchers have given to geographical regions that have a high mutation rate. Mining at the proposed site will only contribute to the spread of the resulting ailments and poor health from the Bestari Jayas and adjoining areas to a new area, affecting thousands more people. This is because mining has a tendency to increase the rate of background radiation in the area, and mutations in human DNA increase as background radiation increases. Because of these two facts, mining tends to increase the rate of background radiation in the area. Because so few studies have been conducted, no one, not even scientists, is aware of the effects that rising radiation rates will have on the local flora and fauna.

2.6.1(e) Riparian vegetation destruction

Heavy machinery, processing plants, and gravel stockpiles at or near the extraction site. Aside from limiting soil infiltration and encouraging overland flow, heavy machinery compresses the soil, which contributes to erosion (NMFS, 1998). The temporary bridges and mounds of soil overburden and sand might cause a disruption in the normal hydraulics of the riparian zone during the infrequently occurring increased flow levels that occur once every three or five years respectively. In such situations, it may be possible to avoid water that carries high nutrient and silt loads from being deposited on riparian terraces downstream of the disturbance. This is because of the presence of riparian terraces. On these terraces, this may have a considerable impact on the recruitment of some species, namely those that are dependent on particular events for their long-term survival. In other words, a recruiting generation may be lost, so leaving a vacuum in the population structure that other species, most frequently exotics, may exploit for their own benefit (Warren & Pardew, 1998).

2.7 Sustainable River Sand Mining

The primary objective of Gunaratne's (2010) study is to determine acceptable policy choices that will minimise environmental damage brought on by river sand mining and satisfy stakeholder requirements. These stakeholders include the construction industry as well as indigenous people whose livelihoods depend on sand mining. An assessment of the trade-offs between environmental conservation and sand extraction as viewed by miners is one of the four methodologies used in this study. In addition to this, the study analyses the decisions made by management. In conclusion, because sand cannot be obtained from rivers alone to fulfil the demands of the country, the study investigates other sand sources and decides which ones will have the smallest negative impact on the environment and society (Gunaratne et al., 2010).

2.7.1 What Sand Miners Think

Because there are few alternative ways for miners to make a living, they are not concerned about the industry's long-term viability. They are also opposed to the idea of Community-Based Organizations (CBOs) being responsible for the administration of the programme in its entirety (CBOs). Instead, what they would prefer is a model that has CBOs and the local government working together in co-management. The miners are of the opinion that the strict laws, regulations, and awareness programmes that have been suggested by the media and environmental groups would not be beneficial (Gunaratne et al., 2010).

2.7.2 Other Alternative Sources

It is possible that the negative effects that river sand mining has on the environment could be significantly reduced if the demand for sand could be partially fulfilled by other sources. Alternatives to river sand mining were uncovered and evaluated so that it could be determined whether or not this course of action is feasible.

The utilisation of quarry dust as well as offshore sand, land-based sand, dune sand, and land-based sand were emphasised as potential alternate sources of sand. The Canadian government is in charge of EEPSEA. It was discovered that mining offshore sand deposits is the most viable alternative to river sand mining. The building industry in Sri Lanka's Western Province is responsible for providing forty percent of the country's total sand requirement. The immediate stresses that rivers are under could be alleviated if this river sand were to be replaced with an appropriate quantity of offshore sand. However, at the moment, the cost of sand obtained from offshore locations is marginally more than the cost of sand obtained from rivers. Additionally, offshore sand is less popular than river sand due to the possibility that it may contain shells and chlorides.

As a result, the construction industry must be redirected to use offshore sand. Use of offshore sand must be mandated for large building projects and land fills in order to accomplish this goal. To encourage the construction sector to use offshore sand instead of river sand, a charge on river sand may be implemented. Because of its devastating effects on the ecology, sand extraction is now not taxed or levied. There should be an increase in the cost of off-shore sand to encourage businesses to use river sand more sustainably (Gunaratne et al., 2010).

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, it will describe the methods that was employed in this case study to determine the stability of the riverbank at Kg Telus, Teluk Belanja and Pendiat in the state of Perak. The preparation of the sample is very important since it can affect the outcome of the tests in a variety of ways. As a consequence of this, the procedure of randomly selecting and analysing all of the samples must be carried out in a consistent and accurate manner in order to guarantee the accuracy of the results. The process is outlined in the flow chart that can be found below.

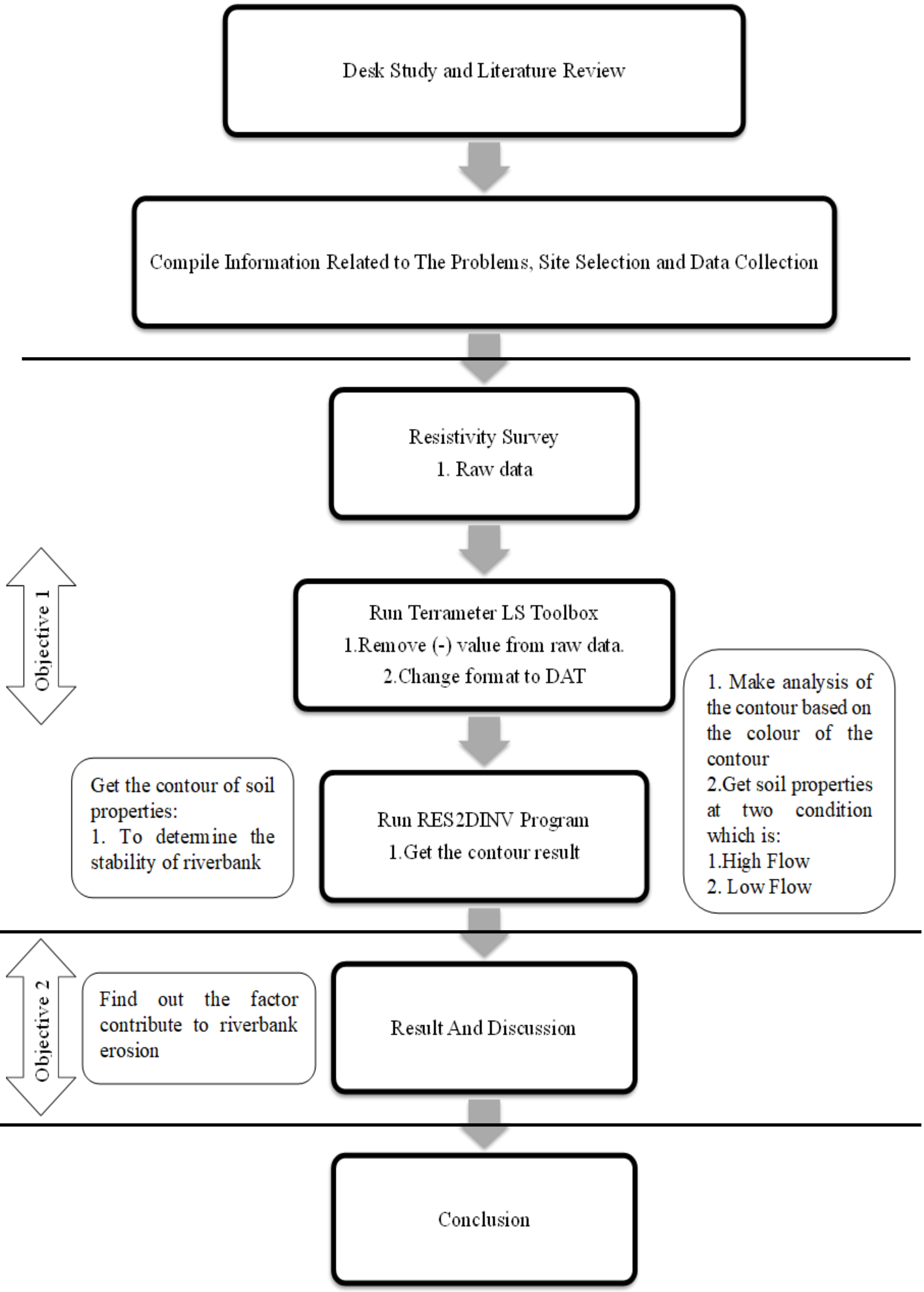

Figure 3.1: Flowchart of research

3.2 Site Selection

Sungai Perak is 93 kilometres long and spreads through the Daerah Perak Tengah and Perak Darul Ridzuan regions. In recent years, sand mining activities in Malaysian rivers have created several issues that need urgent attention. Presently, there are 13 sand mining companies along the Perak River in Perak Tengah District, which had caused deterioration of river water quality, bank erosion, riverbed degradation, buffer zone encroachment and etc. that is mainly due to the excessive sand extraction along river stretches.

Over the years a number of islands were formed in middle of Sg Perak at certain locations which could have affected the flow. Bank erosion in District of Perak Tengah have been rampant and substantial amount of allocation were needed to address this issue.

There are two different locations will be used to do the resistivity test which is the first location Kg Tepus-Teluk Belanja and Pendiat. The location is situated at Sungai Perak upstream shown in Figure 3.2 or to be specific it is from Kg Tepus-Teluk Belanja and Pendiat. The coordinate of the site is (4°31'11.3"N 100°55'43.7"E) and (4°22'44.4"N 100°53'53.9"E). At Kg Tepus-Teluk Belanja there are 2 lines of resistivity test (Figure 3.4) while for Pendiat area there are 3 lines of resistivity (Figure 3.5). The low flow and high flow are being determine by the value discharge by using the ADCP.

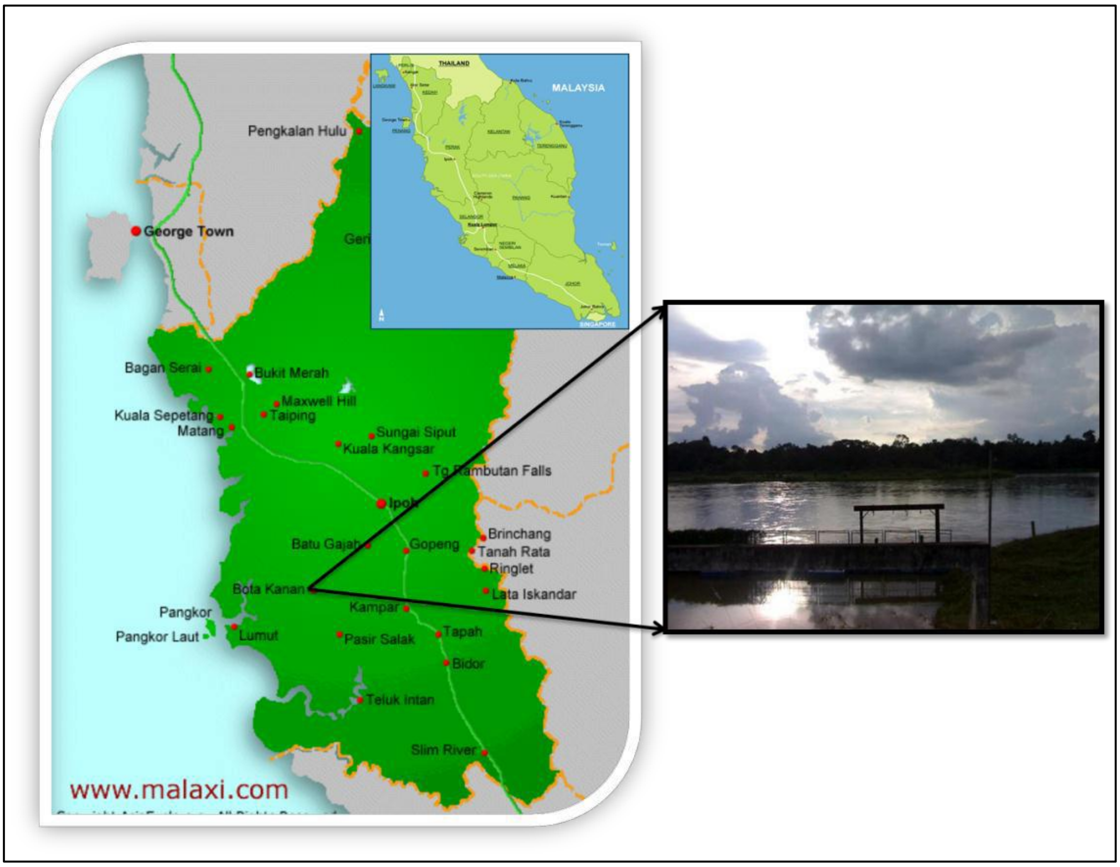

Figure 3.2: Study area

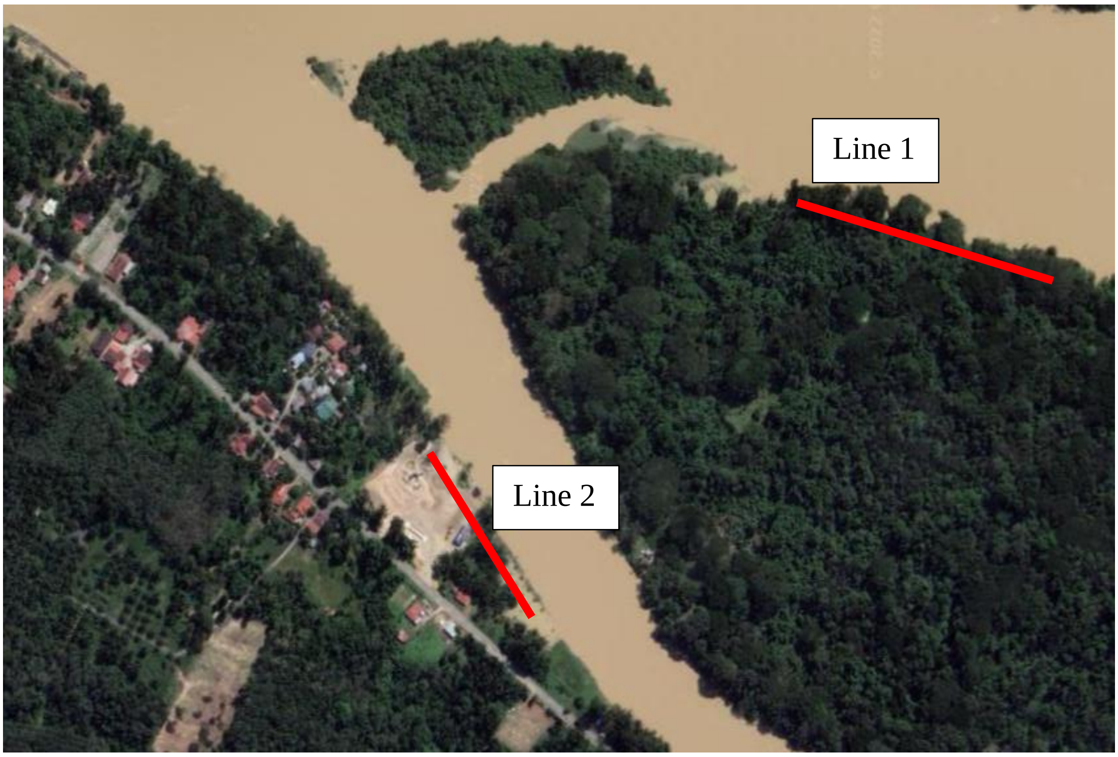

Figure 3.3: Detail Location of Resistivity for Line 1 and Line 2

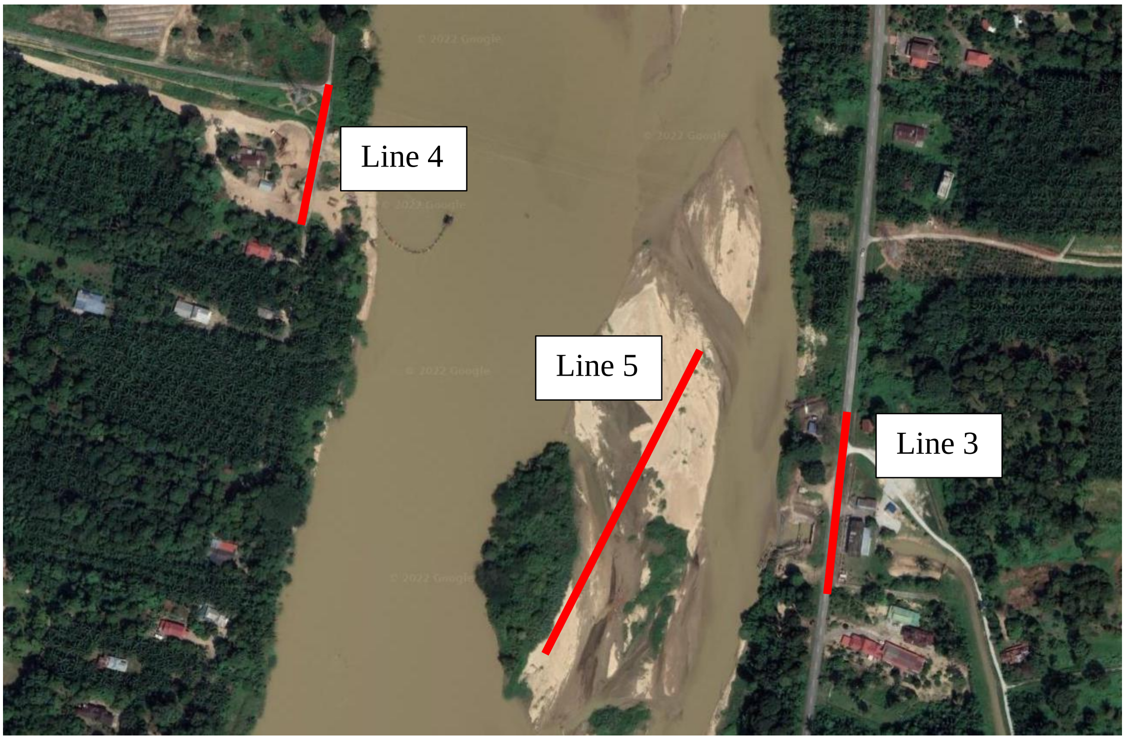

Figure 3.4: Detail Location of Resistivity for Line 3, Line 4 and Line 5

3.3 Resistivity Measurement

3.3.1 Introduction

The geo-electrical properties of rocks and soils vary widely (in terms of hardness/competency, composition, grain size, fluid saturation type and degree, fracturing/faulting quantity, etc.). As a result, the electrical resistivity of subsurface materials varies widely, reflecting the diverse underlying circumstances. Fine-grained materials (like sand and clay) tend to have a lower resistivity than coarse-grained materials (like sand and gravel) (clays, silts, etc.). Lithified bedrock, for example, might have a resistivity much higher than sediments. Earth materials have a much reduced resistivity when water is present. As little as one percent water can reduce the electrical conductivity of earth elements by an order of magnitude.

Electrical resistivity surveys are typically used in conjunction with electrical resistivity measurements to estimate the characteristics and quantity of the underlying sand. The sort of earth material found beneath the surface was identified using electrical resistivity methods. The sand body will be identified by comparing the resistivity discrepancies between different ground types. This technique may cover a huge area in a short period of time. Figure 3.5 depicts the configuration for the electrical resistivity survey. Figure 3.6, on the other hand, displays an example of electrical resistance.

A multi-electrode resistivity metre is now the primary tool for conducting electrical imaging. Electrodes (usually between 25 and 100) are positioned out in a straight line with a constant spacing in these surveys. For each measurement, a computer-controlled system is employed to automatically pick the active electrodes (Griffith et al., 1993). The ABEM Terrameter LS system and the Pole dipole technique were employed during the survey of the proposed site. A low-cost microcomputer can be used to analyse the survey data.