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GEOHAZARDS IN SANDAKAN TOWN AREA, SABAH, MALAYSIA

Rodeano Roslee^{1,2}¹ Natural Disaster Research Centre (NDRC), Universiti Malaysia Sabah² Faculty of Science and Natural Resources, Universiti Malaysia Sabah

*Corresponding Author Email: rodeano@ums.edu.my

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ARTICLE DETAILS

ABSTRACT

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The geology of the Sandakan town area provides a favourable setting for geomorphological hazards occurrences. The exposed rocks in the study area and its surrounding vary in types and ages, from Late Eocene-Early Miocene Neogene's clastic sediment of the Garinono Formation, the Sandakan Formation and Volcanic Facies to vary recent Quaternary alluvial materials which are still being deposited. These rock units are dissected by numerous lineaments with complex structural styles developed during series of regional Tertiary tectonic activities. Rapid urbanization activities have caused changes in the land use. Urbanization processes may contribute to the exposure of impervious surface, loss of vegetation cover, modification of slope gradient and drainage systems. The last decade has seen slope failure, flash flood and erosion events, which have claimed lives, damaged properties and increased the cost of maintenance. The main factors causing geomorphological hazards occurrences in the study area are natural (geology, meteorology, topography and drainage system) and human factors (lack of proper planning, human activities and community's attitude). Serious efforts to increase the community's awareness to geomorphological hazards occurrences and reconstruction of natural ecosystem must be taken. To handle this issue, both prevention and mitigation are necessary. At the planning level a multi disciplinary approach to zoning, risk assessment and design with construction practices is recommended. This is to ensure that future activities will not cause further damage to natural environmental condition or ecosystem.

KEYWORDS

Engineering Geology, Geomorphological hazards occurrences, Sandakan town & Sabah.

1. INTRODUCTION

The rapid development since the eighties (80's) had a spill over effect in the Sandakan town area where lands was cleared for the construction of highways, high-rise buildings, industrial, housing area and several other heavy infrastructures. These activities had, besides spurring economic growth, also caused environmental management problems, such as streams were polluted with pesticides, flash flood, fertilizers and siltation. There was also widespread erosion in the cleared areas, slope failure and land subsidence had frequently occurred. Geomorphological hazards occurrences have presently impact the community and its socio-economic development, in addition to adding a strain to the government in the heightened costs of repair and maintenance. All these incidences are a form of passive geomorphological hazards, geological processes and meteorology where rate and size were upgraded by human being activities.

The issue of geomorphological hazards in Sandakan town area still has not caught the attention of planning and development agencies. Most geomorphological hazards can be avoided, mitigated and minimized the impact. This can be done if understanding concerning geomorphological hazards is emphasized more and effort towards integration of this aspect in the planning and development of town is implemented. These paper focus on geomorphological hazards status in the Sandakan town area and insist on management and research steps, which can be undertaken. It is hoped that by understanding of the geomorphological hazards occurrences aspects, one can optimize expenditure and increases the safety level of the in progress or future development works.

2. LOCATION AND ACCESSIBILITY

The study area lies centrally on the eastern coast of Sabah roughly about longitude line E 118° 02' to E 118°08' and latitude line N 05° 48' to N 05° 54' (Figure 1). The total covered area approximately 150 km². The mainland part of the Sandakan town area is the most accessible part of eastern Sabah. Good networks of sealed and unsealed roads connect most

of the prime towns around it. However, most of the roads are found along the coasts and valleys. Roads cutting through the mountainous areas are limited. The rest of the hills and mountains are still inaccessible and geologically unexposed, apart from the common footpaths in the jungle.

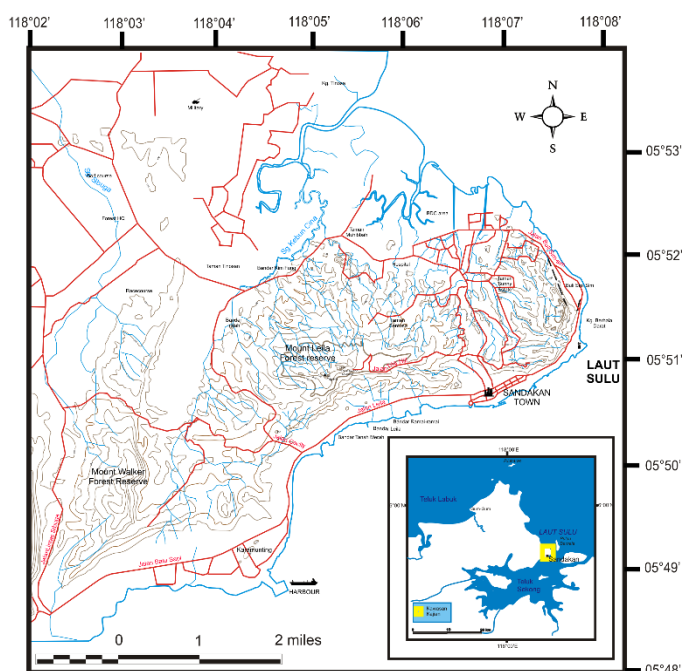


Figure 1: Location of study area

3. TOPOGRAPHY AND DRAINAGE

The topographic setting of the study area consisting lowland area of swamps, coastal plains, valleys, small isolated foothills and a linear belt of highland hills parallel to the Mount Walker and Mount Leila (Figure 2). The coastal plains and valleys vary from 1 to 3 km in width while the linear belt of hills is about a kilometre wide. The height of the highland hills is range from less than 200 feet to more than 800 feet from the sea level.

The watershed lies in the study area, and river flows westward into the Sulu Sea. Most of the rivers flow through mangrove swamp before discharging towards the Sulu Sea (Figure 1). The coastline is fairly straight but is broken by several points and headlands; Buli Sim-Sim, Tanah Merah and Karamunting bays. Grouped around the coast are the four islands, of which the largest is Berhala Island, occupying about 5 km². Structurally, a number of linear river segments that different watershed systems indicate the existence of major fractures. This structural control of many of the tributary streams is evident in the areas of sedimentary rocks; faults and less competent shale beds are preferentially eroded. The sedimentary rocks are intensely dissected and form a trellis and parallel drainage patterns.

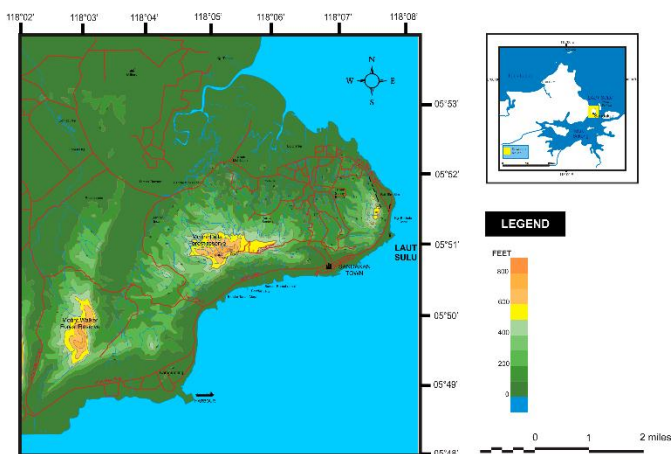


Figure 2: Topographic map

4. GEOLOGICAL SETTING

The exposed rocks in the study area and its surrounding vary in types and ages, from Late Eocene-Early Miocene Neogene's clastic sediment of the

Garinono Formation, the Sandakan Formation and Volcanic Facies to vary recent Quaternary alluvial materials which are still being deposited (Figure 3). The Garinono Formation (T_{es}-T_f) consists mainly of slump breccia and includes sequences of interbedded mudstone, tuff, tuffite and minor sandstone and calcarenite. The slump breccia of the Garinono Formation is made up of fragments and blocks of assorted rock types in a mudstone matrix (Figure 4). The fragments and blocks consist mainly sandstone, limestone, chert, basalt, serpentinite and gabbro. Mudstone, sandstone, tuff and tuffite form interbedded sequences at different stratigraphic horizons in the Garinono Formation [1]. The Sandakan Formation (T_{f1-3}) was deposited in a shallow marine, deltaic and partly fluvatile environment. The lithological sequence includes sandstone, carbonaceous mudstone and conglomerate [1]. The Sandakan Formation consists of sedimentary succession which has been dated to the Miocene and Pliocene age. These outcrops are usually well persevered and exhibit a mud-dominated sand-shale alternations (Figure 5). The Volcanic Facies has a thickness of about 25 to 45 metres and has a greyish to black colouration. Grain sizes in fine and can be found at the Buli Sim Sim area. The formation of the volcanic facies is believed to have its origin in the Dent Volcanic of the Early Miocene [1]. Pliocene to Quaternary sediments rests on top the Sandakan Formation. These deposits consist of high-level alluvium and recent alluvium. High-level alluvium is found around the coast and consists of unconsolidated deposits older than the recent alluvium. Recent alluvium is deposited along major river valleys and deltas and consists mainly of clay, silt and gravel. The alluvium soft, compressible and may be prone to excessive settlement.

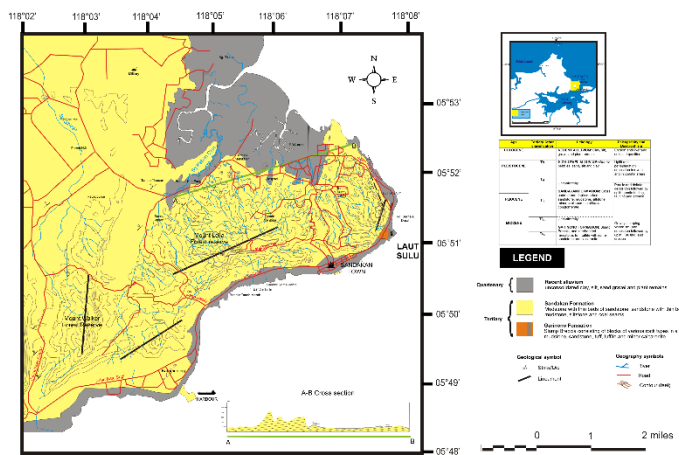


Figure 3: Geological map



Figure 4: A block of sub greywacke in clay matrix, slump breccia (Location: Indah Jaya)



Figure 5: Outcrop generally consists of fine texture, cohesive materials, highly weathered to residual soil materials (Location: Sunny Estate)

5. GEOMORPHOLOGICAL HAZARDS OCCURENCES

Many assume that the Sandakan town will not facing any geomorphological hazards. This assumption is based on idea that the Malaysia is free from main geohazards such earthquake, volcano, hurricane and tsunami which form as nature geomorphological hazards. Although this assumption is considered true, geomorphological hazards which caused more destruction and loss of human lives is which it occurs

without any early indication or insufficient information concerning the hazards. In the Sandakan town area events such as slope failure, flash flood, erosion and land subsidence form as the main geomorphological

hazards, which had caused much destruction of properties, increased the controlling cost, disturbance to public convenient and caused death (Figure 6).

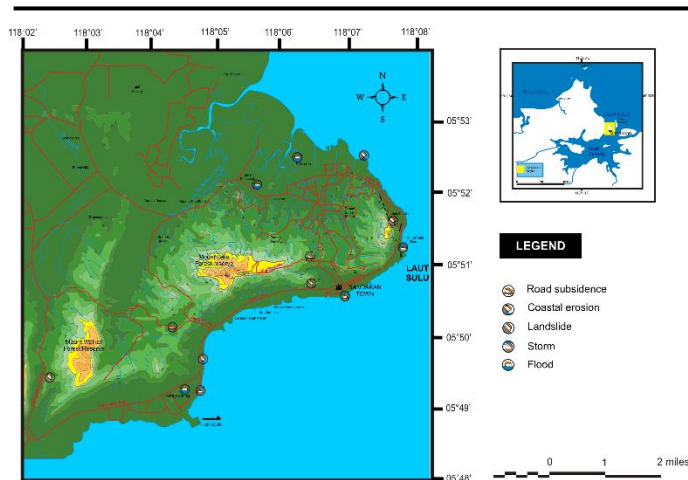


Figure 6: Geohazards map

5.1 Slope Failure

Slope failure has long been regarded as one of the major geomorphological hazards identified in the study area (Figure 6). Slope failure is one of the processes by which the earth fights back at man's encroachment, causing



Figure 7: Dangerous slope failure near by the Indah Jaya

5.2 Flash Flood

The lowland portions in study area and shore lands are constantly subjected to annual floods, which occur yearly. Flooding affects are very significant in terms of lands areas and population exposures (Figure 6). These flash flood problems are caused by several factors. The following are the main factors contribute to the flooding problems in Sandakan town area;

5.2.1 Natural

This factor is related to the geological setting of Sandakan town area. The exposed rocks in the study area and its surrounding vary in types and ages, from Late Eocene-Early Miocene Neogene's clastic sediment of the Garinono Formation, the Sandakan Formation and Volcanic Facies to vary recent Quaternary alluvial materials. The rock formations in the study area are generally highly weathered and capped by a thick zone of highly weathered, loosely consolidated materials. These weathering products are easily eroded and are eventually transported and deposited into the study area as hundred tonnes of loose soil and silt. Another natural factor is the geographical setting of Sandakan town is located along the coast and seawater encroachment is common in the lower portions of the river channels during high tide.

5.2.2 Artificial

great destruction of life and property. Several factors contribute to occurrence of slope failure and these are categorized into geological, geomorphological, climatological, and anthropological. Included in the geological factors are: the dense occurrence of geological faults providing zones of weakness; the presence of clayey material within the sliding area. Geomorphological factors include steepness of slopes, relief, elevation, valley configuration and ridge form, deep tropical weathering, lack of tropical forest and high rainfall (Figure 7). The anthropological factors are those that result from man's activities such as steeping of natural slope due to road building, distability of slope toes due to road cutting and removal of vegetation protection (Figure 8). Consideration of these hazards must be put in development to counter their disruptive effects.

Slope failure take place when slope materials are no longer able to resist the force of gravity. This decrease in shear resistance resulting in slope failure is due either to internal or external causes. Internal causes involve some change in either the physical or the chemical properties of the rock or soil or its water content. External causes, which lead to an increase in shear stress on the slope usually involves a form of disturbance that may be either natural or induced by man [2]. The triggering mechanism of slope failure in Sabah is most likely involved heavy rainfalls causing water saturation of slope material and loss of cohesion along rapture plane. Heavy rainfall, provided water that rendered rock and earth masses heavier and weakened cohesion along water lubricated bedding slide planes [3].



Figure 8: The cutting of hill slope, removing trees and vegetation from the hill slope reduces the stability of the slope (Location: Highway Batu Sapi - Sibuga)

Artificial factor is man - made and attributed to the presence of the quarries. Quarry related activities create disequilibrium in the environment by contributing to the volume of materials brought into the drainage system. Subsequently, siltation rate is disproportionately increased, the river bed becomes shallow and water movement is restricted during rainy days (Figure 9).

5.2.3 Poor planning

This factor pertains to infrastructure development in relation to drainage. Most of the road in Sandakan town area was designed lower than the surrounding area. In most of the areas, the drainages constructed a few centimeters below the roads are not will maintain in most of the drainage reached the road level due to dumping of various types of eroded materials. Runoff water, instead of flowing freely is restricted in the lower lands, which are located mainly along the main roads. Another factor, which contributes adversely to the above-mentioned situation the sub-stratum of the low land areas and the presence of tall grasses along the drainage lines, which further impede water movement. Most of the lowland flooding areas underlain by impermeable materials whose highly porous but low permeable characteristic will induce water absorption and retention and will eventually lead to flooding problem. On the other hand, the continuous growth of the drainage grasses may be attributed to the lack of regular drainage maintenance program (Figure 10).



Figure 9: Flash flood at Sibuga area [4].



Figure 10: Improper monitoring and maintenance of the drainage channel (Location: Mile 6) [5]

5.3 Erosion

Erosion is a process involving the removal of solid particles by action of water and wind, generally resulting in denudation or height reduction. Erosion was geomorphological hazards phenomenon which often threatened settlement (Figure 11). Incident become more critical because there was squatter's settlement along the river bank or near by the river areas. Erosion involves the reduction of mass and is commonly observed in the study area at beaches and coastal areas (Figure 12a), extending from Sandakan town towards the northern and eastern part of the study area (Figure 12b). Dominant force in this erosion is periodic motion of the waves, aided by low and high tides. Prominent signs erosion can also be found at exposed hill tops and slope cuttings, where rain and other natural

elements act as propagating agents. In this context, erosion can be classified into three main types based on severity, which are:

- a) **Sheet erosion.** Also known as sheet flowing, is the movement of water across a slope surface. This is an early stage of erosion in which the flow of fluid and materials are governed by surface features.
- b) **Rill erosion.** Sustained sheet flows will produce rills, which are micro channels a few centimetres in depth and width. The lack of vegetation contributes to the formation of rills.
- c) **Gully erosion.** Favourable conditions will eventually cause rill erosion to evolve to gully erosion, causing the formation of gullies which become a permanent feature of the slope.

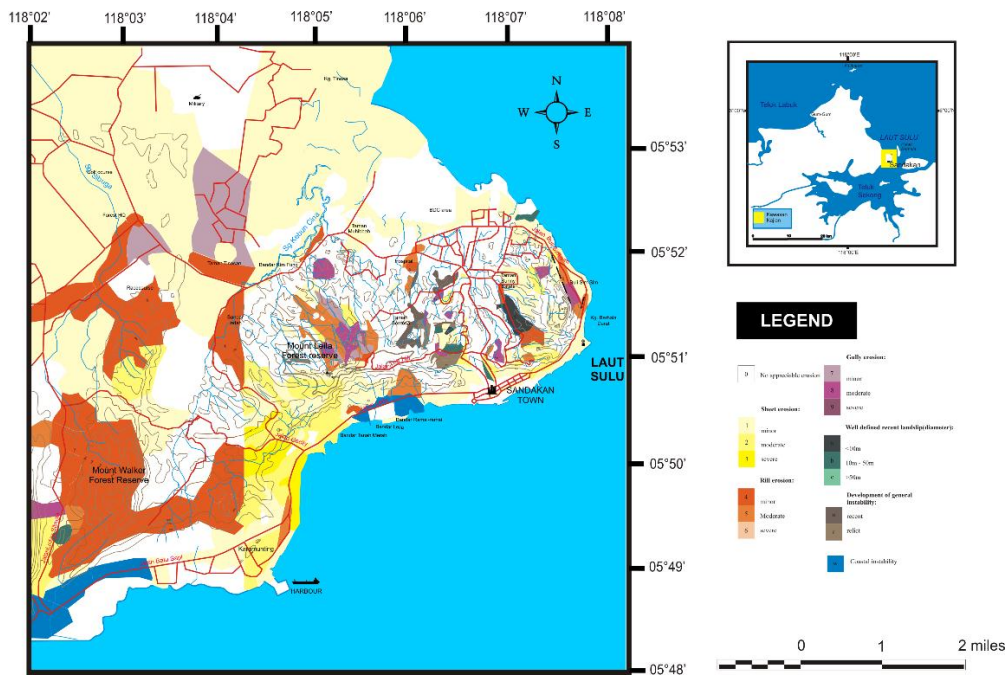


Figure 11: Erosion map of Sandakan town area



a.

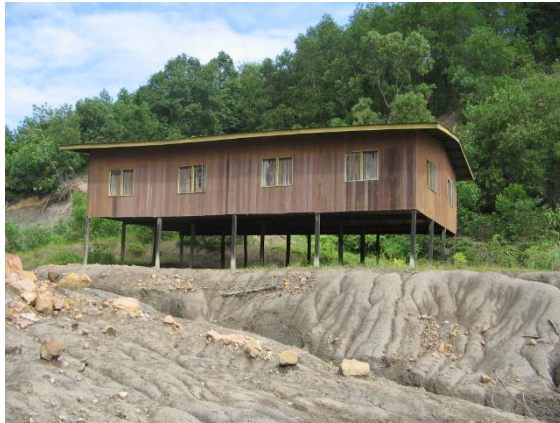


b.

Figure 12: Intensively erosion processes (Location: a. Kim Fung and b. Sunny Estate)

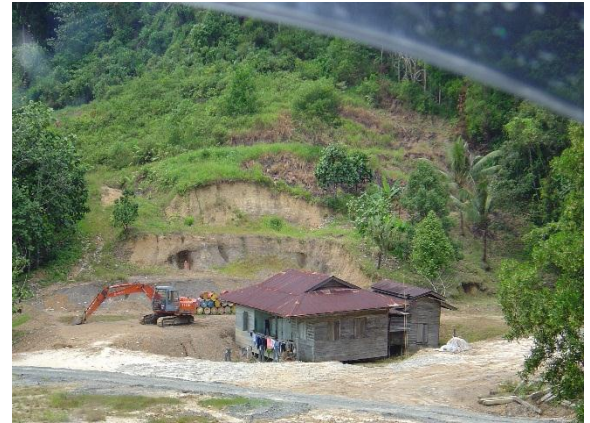
5.4 Land Subsidence

Land subsidence is a geohazard least understood by the public (Figure 6). At the Sandakan town area land subsidence seems to be the geomorphological hazards phenomenon which had and will threaten the infrastructures. Land subsidence is associated with slime (clayey soil),



a.

which experienced different consolidation and this situation always cause serious destruction to building structures (Figure 13a). In other cases, land subsidence is formed due to erosion of the land surface in round form and deep banks. This incident is linked with decreased in ground water table and caused destruction of properties and disturbance to traffic (Figure 13b).



b.

Figure 13: Land subsidence occurrences (Location: a. Batu Sapi & b. Highway Batu Sapi – Sibuga)

6. DISCUSSIONS

There a rise major difference between incidents, danger and hazards. Geological processes or meteorology is a natural phenomenon therefore they only form as events. Danger of geology arise when incident is a potential threat to human or properties. Hazards occur as the incident has caused death and destruction of properties [6]. This perception is important because one incident of geology such slope failure or flash flood for instance is not a hazard if it doesn't involve lives or properties. On the other hands, many areas are in danger of geomorphological hazards if geological process is present naturally or worsened by human activities is very potential to cause the occurrences. Therefore, the geomorphological hazards aspect is an important aspect in the planning and management of Sandakan town area. In the management of geomorphological hazards, complete information of data base of geomorphological hazards is required. For every occurrence of geomorphological hazards, among the important information required are types of geomorphological hazards, time and area, phenomenon mechanism, cause and effects factors, types of destruction, geological aspects and meteorology. This information will enable forecasting of geomorphological hazards risks and effective mitigation steps implemented before any development planning is recommended. At the Sandakan town area information concerning geomorphological hazards is very limited. Only information on flash flood is systemically collected. However, information on flash flood is mostly concentrated on time and areas and height of floods and estimate of destructions. Data on geomorphological hazards such as slope failure, erosion and land subsidence were not collected and kept properly. Only incidents on loss of lives or destruction of properties were reported and most slope failure, erosion and land subsidence incidents don't have any record unless those reported in the newspapers.

One reason why data base of geomorphological hazards was not collected systematically were the characteristic itself and sphere of influence [6]. Therefore, no government agency is fully responsible towards it. Department of Irrigation and Drainage (DID) for example will concentrate on floods and felt that it is not their authority if floods occur due to weakness of the town drainage planning. Until now it is still not clear which agency is responsible to record slope failure, erosion and land subsidence incidents. The Department of Public of Work (DPW) and Department of Minerals and Geoscience (DMG) are two institutions which were regularly contacted if any slope failure and land subsidence incidents occurred. Geomorphological hazards issue in the Sandakan town area is not new things. Incidents which caused loss of lives and properties treated it as national issues. Policies, guidelines and mechanism on management need to be formed to tackle this issue. Several proper, clear and effective procedures are needed. At the planning and early investigation, information concerning geomorphological hazards threats need to be given priority. For this special maps and data base need to be prepared for planning officer and investigating consultants. At the local government level, a multi purpose team at least engineering geology consultant needed to assist assessment of project. Suitability and recommend important steps to overcome the geomorphological hazards issue. At the national level one multipurpose institution who acts on forecasting controlling and avoidance of geomorphological hazards need to be formed soonest. The institution can play their role in the preparation of geomorphological

hazards data base and increase the public awareness of the impact of geomorphological hazards. At the same time, several acts, guidelines and rules readily available need to be amended or reproduced. More important several government agencies such as local authorities, DPW, DID, Department of Natural Environmental (DNE), DMG and Department of Meteorology (DM) need to initiate discussion on strategic on how to overcome the geomorphological hazards issues on investigation basis and long-term.

7. CONCLUSIONS

The following conclusion may be gathered based on the available information for the present study:

1. The main geomorphological hazards in Sandakan town area are slope failure, flash flood, erosion and land subsidence.
2. The geological and climatological setting of Sandakan town area has a major impact on the existing of major geomorphological hazards in the state.
3. The main factors causing geomorphological hazards occurrences in the study area are natural (geology, meteorology, topography and drainage system) and human factors (lack of proper planning, human activities and community's attitude).
4. Geomorphological hazards in study area could be avoided and mitigated by efficient enforcement of environmental regulation, sustainable land use planning and management, increase in community's awareness and reconstruction of natural ecosystem.

8. RECOMMENDATIONS

Geomorphological hazards had been the most critical issues at the Sandakan town area. Frequency, size and impact the community kept on increasing. Geomorphological hazards incidents mostly are due to human activities. Therefore, by planning, management and proper construction, these occurrences can be avoided. Settlement of the geomorphological hazards issues required multipurpose approach and long-term planning. Cooperation among government agencies such as DPW, DID, DNE, DMG, DM and local authorities are needed at all levels and should be continuously. Research therefore needs to have integration approach and need to be performed systemically. In spite of that geology discipline can contribute at all levels of avoidance and control of these geomorphological hazards occurrences.

REFERENCES

- [1] Lee, D.T.C. 1970. Sandakan peninsula, eastern Sabah. Geological Survey Department Report, 6, 1-74.
- [2] Roslee, R., Tahir, S., Omang, S.A.K.S. 2006. Engineering Geology of the Kota Kinabalu Area, Sabah, Malaysia. Bulletin of the Geological Society of Malaysia, 52, 17-25.
- [3] Roslee, R., Faisal, M.M., Tahir, S., Omang, S.A.K. 2004. Effect of Geology on Mass Movement in Bundu Tuhan Area, Sabah, Malaysia. Borneo Science, 15, 45-55.

[4] Teppo, Y. 2006. The Borneo Post News Paper: 22 December.

[6] Komoo, I., Pereira, J.J., Sulaiman, M. 1996. Geobencana di Lembah Kelang. Seminar Geologi dan Sekitaran: Impak dan Pengauditan. Universiti Kebangsaan Malaysia, Bangi, Selangor.

[5] Lajiun, J., Villiamon, S. 2006. Daily Express News Paper. 22 December.

