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PREVENTION, MITIGATION AND ENGINEERING RESPONSE FOR GEOHAZARD IN THAILAND

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ABSTRACT

Thailand is situated in SE Asia where most of the area has been under the influence of monsoonal type of weather. Geological settings of the country is believed to be the result of the collision between Indian and Eurasian plates. The collision has great influences on the topographic, weather and tectonic activities of the area for a long time. These factors are closely related to a number of serious geohazards of the area. Such geohazards include landslide and tsunami caused by a large distant earthquake along the Indian – Eurasian subduction zone. Important geohazard cases in Thailand have been discussed and landslide is focused in order to make an optimum risks assessment.

There are three main landslide events occurred in Thailand. These landslides occurred in Nakhon Si Thammarat province in the south; Phetchabun province in the northeast; and Tak province in the west. The 2004's Tsunami event was also unexpected one to a great number of people who live along the Andaman shorelines of the country. These events have generated awareness on landslide geohazard to the nation because it took many lives and damaged properties.

As one of the key organization working on geohazard, the Department of Mineral Resources has carried out study programs in order to gain better understanding of such events and then set up activities for the prevention and mitigation for it via engineering approach. Most of our works are based upon not only a scientific approach but also concepts of people's participatory. We have set up landslide warning networks for both local and regional ones for the high risked areas throughout the country. For tsunami, we have set up our measures via education, information transmission and evacuation plan for high risked areas. Our work has created awareness among people who have been or potentially been effected by such hazards to be well prepared for the event that has yet to come.

INTRODUCTION

In recent years, there have been an increasing number of studies on tragic events related to geological processes especially in the tropical countries. Such processes include earthquake, tsunami, sinkholes, flash-flood, landslides, land subsidence and erosion.

Thailand is located in Southeast Asia between latitudes 5° 37´ N and 20° 27´N and longitudes 97° 22´E and 105° 37´E (Fig. 1, inset). The country has been under the influence of its geological setting resulted from the still-active collision of the Indian and Eurasian Plates, which began 50 Ma ago (Fig. 1). This "extrusion" of microplates toward the east and southeast has resulted in the on-going development of present topographic settings that also have influenced the formation and the intensification of monsoonal weather type of Thailand and Southeast Asia region.

The great Sumatra earthquake occurred on the 26 December 2004 with the epicenter off the west coast of the Sumatra, Indonesia. The earthquake triggered a series of devastating tsunami along the coasts of most landmasses bordering the Indian Ocean, killing a large numbers of people and inundating coastal communities across South and Southeast Asia including parts of Indonesia, Sri Lanka, India and Thailand. Many places in the region especially in the Thai Peninsula have been affected by the ground shaking after the earthquake. The earthquake has resulted in the adjustment of microplates of the region that then triggered a number of sinkhole and landslide to occur in the region as a consequence. The region has actually been under the heavy rainfall, high rates of ground weathering and erosion process, and a number of problems, which of them are caused by human activities. Deforestation and the development over the forest area also speed up all geohazards, i.e., flash-flood and landslide; sinkholes; land subsidence; river and shoreline erosion. Such geohazards have now become a national issue that needs to be well handled as soon as possible to prevent further lost of lives and properties of the local people.

As one of the key offices responsible for the prevention and mitigation of the national geohazards, the Department of Mineral Resources (DMR) has worked on the issue for over a decade. Normally, the central government responds to the event through the building of network in the local areas being

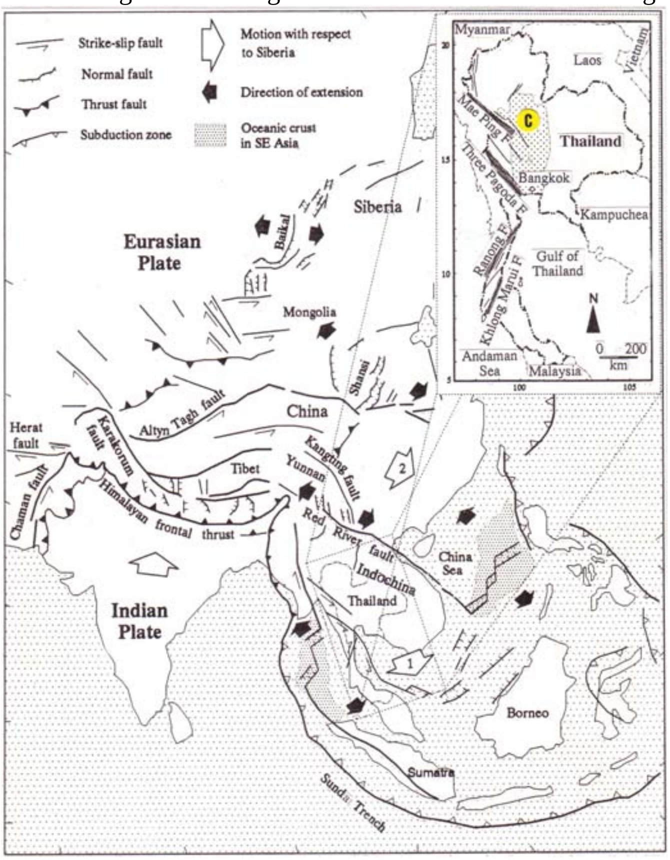

Fig. 1 Schematic map illustrating postulated post-Paleozoic "extrusion tectonics" and present-day plate configurations in eastern Asia (modified after Tapponnier et al., 1982). Numbers associated within open arrows refer to extrusion phases (1: 50-20 Ma; 2: <20 Ma). Arrows on faults in Thailand possibly correspond to Permo-Triassic motions (Polachan et al., 1991). The reversed movement on these faults may have possibly occurred since mid-Tertiary time (Tapponnier et al., 1986. The inset map shows the area of Thailand with the locations of the major fault zones and Chao Phraya Central Floodplain (C).

affected by natural hazards. The network helps on the monitoring the geohazard situation. DMR also gives technical advices and supports to the local government and administration offices. Building capacity to the local people and offices are also provided for a better understanding of natural hazard phenomena and how to prevent it.

However, the most difficult part of work is not the building of the network but the maintenance. How to maintain the network ability to alert people on the hazard and how to keep up with a standard way of life in the area where geohazard is a threat to the community are true challenges to the DMR's work. It normally takes a long time for the affected communities to achieve help from the central government.

Geohazard management varies from one type to another, as well as on a case by case basis. In the flash-flood and landslide case, most of the help are in the form of new constructions for roads, bridges and structures to stable slopes in accordance to the engineering geology of the area. These structures are still located in the risked areas where geohazards always occur and we know that, sooner or later, these structures will be wiped out by the force of nature.

In order to lay a good foundation on works related to the prevention and mitigation to the geohazards in Thailand, DMR has now tried to make the best out of our limited resources in order to sustain the geohazard management system of the local communities distributed throughout the country. A new concept has been developed under certain key concepts, which are: geological knowledge as a strong foundation, best engineering geological practice; HM King Bhumibhol's sufficient economy; and living in harmony with nature.

This paper summarizes important geohazards of Thailand and introduces the new concept, "Living in harmony with nature", with an example of the pilot project of the DMR to test out. The result is very convincing and will be applied to other hazardous areas of the country in the near future.

GEOLOGIC AND TECTONIC SETTINGS

Several authors have reviewed the geology of Thailand (Suensilpong et al., 1978; Chonglakmanee et al., 1983; Bunopas, 1981; Department of Mineral Resources, 2002). The geological map of Thailand (DMR, 2002) shows that the western mountainous terranes contain a variety of igneous, metamorphic and sedimentary rocks of various ages. Precambrian metasediments and early Paleozoic sandstone and limestone are exposed in the western part only. Thick middle Paleozoic sedimentary and volcanic rocks crop out in the eastern part (Bunopas, 1981) Permo-Triassic and post – Triassic granite plutons are found to have intruded Precambrian sedimentary rocks and early Paleozoic rocks in the western mountain terrain. These rocks also crop out in the eastern and southern parts of the country. Thick Triassic marine sedimentary sequences are also found in the eastern and western parts of the mountain range.

To the east of the central mountains, Mesozoic rocks of Jurassic and Early Cretaceous red sandstone cover the Khorat Plateau (Fig. 2). The Khorat Plateau is described as a series of Late Triassic – Cretaceous continental sedimentary sequences (Ward and Bunnag, 1964; Iwai et al., 1966). Thick sandstone of the Khorat Group form long and high escarpments along the southern and western edges of the plateau (Bunopas, 1981). The low-lying sandstone ranges are characterized by flat-top mountains (buttes) and mesas.

The Cenozoic rocks are non-marine sedimentary sequences, coal and oil bearing shale and sandstone, and continental volcanic rocks. These rocks are widespread in the northern, central and eastern parts of Thailand. Tertiary sedimentary rocks are restricted to fault bounded basins and believed to be lacustrine and lagoon deposits. Quarternary deposits cover about 40% of the land surface. These deposits include sedimentary units, which may be subdivided into fluviatile, marine, Aeolian and lateritic and interbedded alkaline basalts.

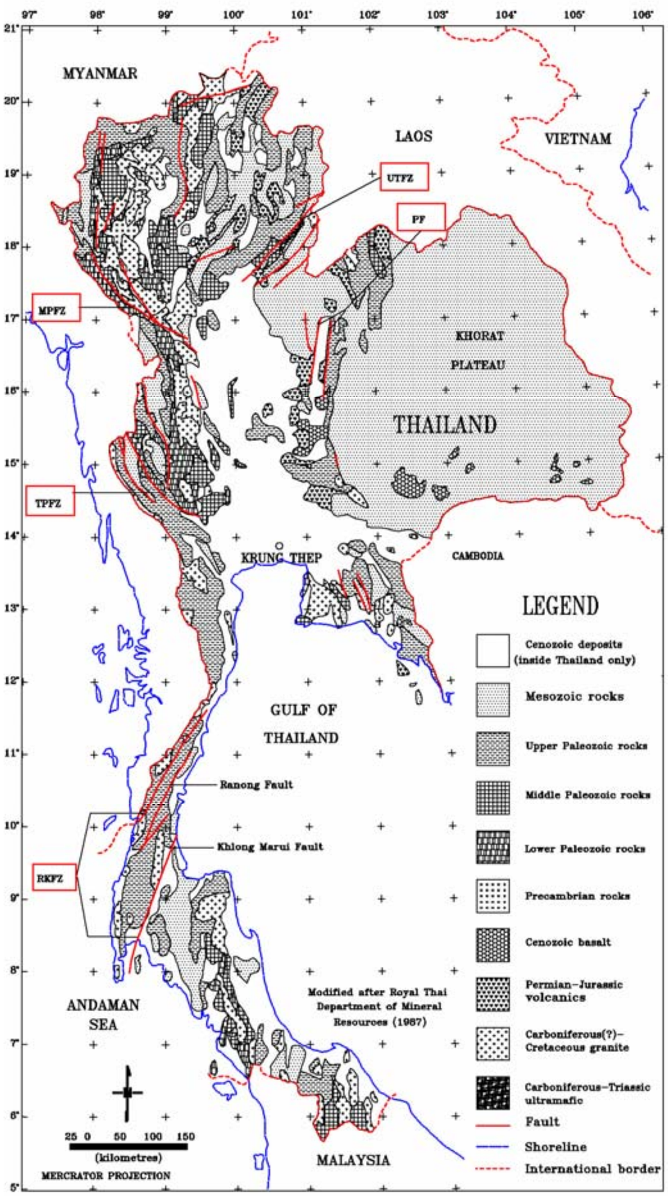

Fig. 2 Simplified geological map of Thailand (Tulyatid, 1991).

Major faults that have been active in Tertiary time through the recent in the country include the NNW-trending Moei – Mae Ping (MPFZ) and Three-pagoda (TPFZ) fault-zones, located in western Thailand, and the NNE-trending Ranong – Khlong Marui fault-zones (RKFZ) in the Thai Peninsula (Figs. 1 and 2). There are two major Tertiary basins in Thailand, the Gulf of Thailand and Chao Phraya Basin, both of which are significant sources of natural gas and crude oil of the country. Based on experiments and observations on the large-scale tectonics of Asia, Tapponnier et al. (1982) have suggested that these Tertiary faults and sedimentary basins resulted form still-active collision of the Indian and Eurasian Plates began 50 Ma ago and caused “extrusion” of microplates toward the east and southeast. The nationwide aeromagnetic data indicate that the major faults actually penetrate into the major Tertiary basins of the country. Continued from Myanmar into the western part of the country, the Three-pagoda fault-zone runs through the southern part of the Bangkok metropolitan area to joined with another subsurface fault path located to the east side of the basin.

Thailand is situated approximately 600 – 800 km northeast of the Sunda Trench and immediately east of the Andaman Sea, to the west of which the Indian Plate is subducting obliquely beneath the Eurasian Plate at the Sunda Trench. Subduction in this zone become increasingly oblique from southeast to northwest: thus, whereas there is a substantial component of north-south convergence beneath Sumatra, plate interaction is almost purely strike-slip to the west of Myanma (Fig. 1).

The Indian-Eurasian collision appears to be the cause not only of the strong shallow seismicity across the East Asian continent (Tibet, South China and Indochina; Molnar and Tapponnier, 1975) but also of profound changes in the arrangement, structure and shapes of the various blocks, which compose its lithosphere (Tapponnier et al., 1982).

The tectonic setting has created the physiography of the present landform that generally influences the monsoonal type of weather in Thailand and the East and Southeast Asia region in general since 50 Ma ago. As the protrusion of Indian into the Eurasian Plates progress, the Himalayas and the Tibetan Plateau have been uplifted and gradually elevated to the present levels. A number of workers believe that monsoon in the area began some 20 Ma ago (Ducrocq et al., 1994). The intensification of monsoon in SE Asia has increased through time resulting in the rising of rates of rain fall and erosion in the area. This can be witnessed through the increasing number of the catastrophic cases of flash flooding and landslides in Thailand and the SE Asia region in general.

GEOHAZARD AND CASE HISTORY FOR THAILAND

Important geohazards in Thailand can be divided into two groups, those related to earthquake - tsunami and flash-flooding and land-mud-slide. Brief information may be found at the DMR’s website (http://www.dmr.go.th). Note that there are other types of geohazard that have not been mentioned in detail herewith, i.e., sinkholes and shoreline erosion, due to the limitation of published space. Details of such geohazard for Thailand may be found elsewhere, e.g., http://www.dmr.go.th.

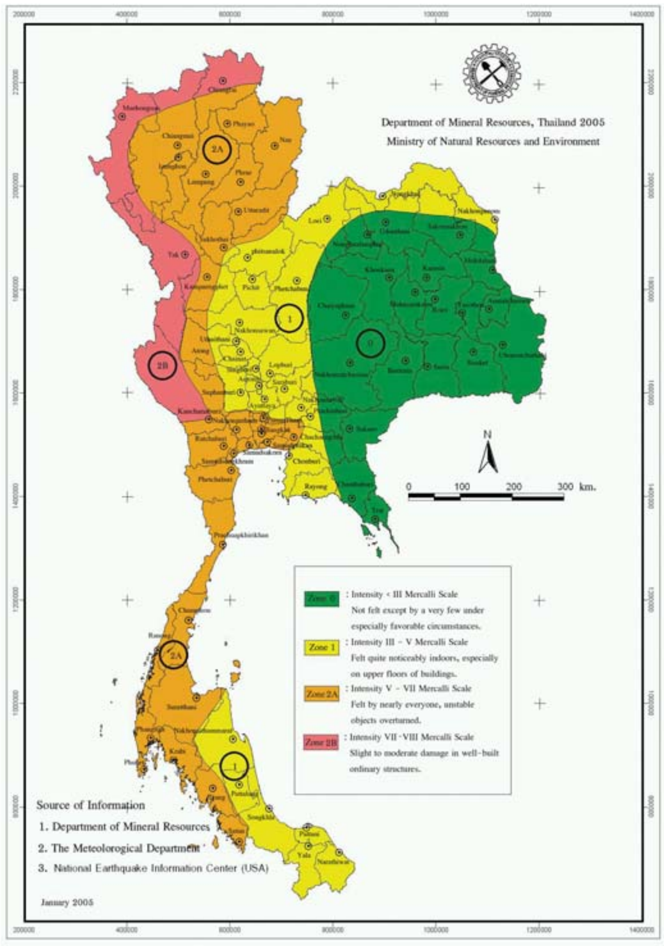

Fig. 3 Seismic hazard map of Thailand (DMR, 2005).

Earthquake and Tsunami

Seismicity events of the SE Asia area are normally located along the still-active convergent plate boundary, i.e., the Sunda Trench, in the Indian Ocean, Indian-Eurasian collision zone, and the major strike-slip fault, i.e., Red River Fault.

However, moderate sized earthquakes occur along important fault systems in Thailand especially those located to the western part. These earthquakes are believed to belated to the collision-related major strike-slip faults in Myanmar. Earthquakes of sizes 5.0 Richter and higher over a period of 32 years are listed in Table 1 below.

Table 1. Dates and epicenters of Earthquakes of 5.0 Richter magnitude and over that occurred in Thailand during 1975 and 2006.

Date	**Epicenter Location**	**Magnitude (Richter)**
17 Feb. 1975	Tha Song Yang, Tak	5.6
15 Apr. 1983	Si Sawat, Kanchanaburi	5.5
22 Apr. 1983	Si Sawat, Kanchanaburi	5.9
22 Apr. 1983	Si Sawat, Kanchanaburi	5.2
11 Sep. 1984	Phan, Chiang Rai	5.1
9 Dec. 1985	Rong Kwang, Phrae	5.0
21 Dec. 1985	Phrao, Chiang Mai	5.2
13 Dec. 2006	Mae Rim, Chiang Mai	5.1
16 May 2007	Chiang Khom, Lao (60 km NE of the Thai-Lao borderline, Chiang Rai)	6.3

Note that the relatively large earthquake listed in Table 1 with the epicenter location located in Laos, approximately 60 km from the Thai-Lao border next to Chiang Saen District, Chiang Rai Province in the northernmost part of the country. The main shock occurred at 3.56 p.m. with a magnitude of 6.3 on a Richter scale at the approximated depth of 38 km as a result of the left-lateral strike-slip fault movement of the Nam Ma Fault. This fault is also connected the same system as the Mae Chan fault located immediately south and southwest to the Chiang Saen District where being hardly hit by the mentioned earthquake (7 Mercallii magnitude).

The other well-known case is the Great Sumatra Earthquake occurred on the 26 December 2004. Even though its epicenter was located to the SW off the Sumatra coast a thousand kilometers away from the Thai shorelines along the Andaman Sea, the earthquake created a devastating tsunami that damaged not only on the shorelines along the Thai Peninsula but also shorelines of many countries along the Indian Ocean. This tsunami caused great damaged to lives and economy of many nations along the Indian Ocean. The event has awakened many earth scientists to be aware of how much this mother earth can do to human lives.

After the Great Sumatra Earthquake, the DMR has revised their seismic hazard map of the country (DMR, 2005), based on past earthquake, as shown in Fig. 3. the seismic hazard map can be used as a guidelines for general awareness of earthquake as well as the building design for different parts of the country.

In summary, past records on earthquake in Thailand have indicate a serious threat on earthquake from the still-active fault systems of both within the country and those extended into the neighboring countries such as Myanmar and Laos.

Flash-flooding, Land- and Mud-slide

Thailand has been greatly influenced by the monsoonal weather type in a tropical region. The geological and weather factors have resulted in high degree of weathering and erosion. Thick soil normally covers most of the landform, especially in the forest and mountainous areas where steep slopes are common. Over the past century, deforestation has resulted in over 80% reduction of forest area of the country. Even though the government has launched many programs to stop the deforestation through the reforestation campaign, helped people to make use of forest in a sustainable way, etc., the deforestation is still a national issue and a threat to the Thais and their nature. Besides, high-land agriculture makes the area covered with shallow-root vegetations that decrease the soil slope stability. As a result, there have been increasing number of flash-flooding and landslide cases in many areas as summarized in Table 2 below. Among these cases, there are several serious events include: Pipun, Nakhon Si Thammarat Province (1988); Nam Kor, Phetchabun Province (2001); and the latest event of Ban Nam Ta, Uttaradit Province (2006). Further information on the landslide and flash-flooding cases history in Thailand may be found at the DMR's website: http://www.dmr.go.th/geohazard/update_landslide. DMR has also compiled a landslide hazard map of the country based on the rate of precipitation and the degree of ground slope. The result is shown in Fig. 4.

Table 2. A summary of flash-flood and landslide events in Thailand during 1988 and 2007.

Place	Date	Damage
Ban Kathun Nua, Phipun District, Nakhon Si Thammarat Province	22 Nov. 1988	230 casualties, 1,500 houses, 3000 acres of agricultural land, A total damage of $30 million.
Ban Khiriwong, Lanska District, Nakhon Si Thammarat Province	22 Nov. 1988	12 casualties, 152 houses (210 houses partly damaged).
Wang Chin District, Phrae Province.	4 May 2001	43 casualties, 4 missing, 18 houses damaged, A total damage of $3 million.
Tambon Nam Kor, Lom Sak District, Phetchabun Province	11 Aug. 2001	136 deaths, 109 injured, 4 missing, 188 houses damaged, 441 houses partly damaged, total damage cost $20 million.
Tambon Mae Ramad, Mae Tuen Khanechue and Charao, Mae Ramad District, Tak Province.	20 May 2004	8,846 people, 2,135 households were being affected, 5 deaths, 391 injured.
Sob Khong, Tambon Mae Suad, Sob Moei District, Mae Hong Son Province.	22 May 2004	400 people, 120 households were being affected,
Lab Lae, Tha Pla and Muang Districts, Uttaradit Province; Sri Satchanalai District, Sukhothai Province and Muang District, Phrae Province.	23 May 2006	Uttaradit Province: 1,478 cases of landslide in 3 districts, 26 villages: 71 deaths, 32 missing; Sukhothai Province: 320 incidents of landslides, 7 deaths, 1 missing. Phrae Province: over 200 landslide incidents, 5 deaths.

The DMR has initiated the forming of landslide monitoring networks throughout the country in the effected areas for more than five years (see http://www.dmr.go.th/geohazard/update_ landslide/landslide_network.htm). The network has been set through a series of seminar meetings for capacity building of the local community with the supply of efficient equipments for the network group to be able to monitor the rain fall and the land slide of their areas. This activity is still going on especially during the rainy season of the year.

PROBLEM SOLVING APPROACH

The prevention, mitigation and management on geohazard in Thailand have been based on the social and economic development approach. Governmental offices are normally key players on the works, which normally involve major construction projects. The pre-existing approach takes a long time in order to achieve annual budget from the central government. The process normally takes a long time resulting in the not-in-time delivery of helps and construction needed for the process. It is often found that any construction built in the effected areas may not come from the true need of the local people. The budget for the maintenance of the constructions, i.e., dam, dyke, walls, etc., would rarely be prepared at the beginning of the project making these constructions at risk of becoming damaged from the next hazardous event. Local administrative offices are not capable of the management and maintenance of any constructed structures alone.

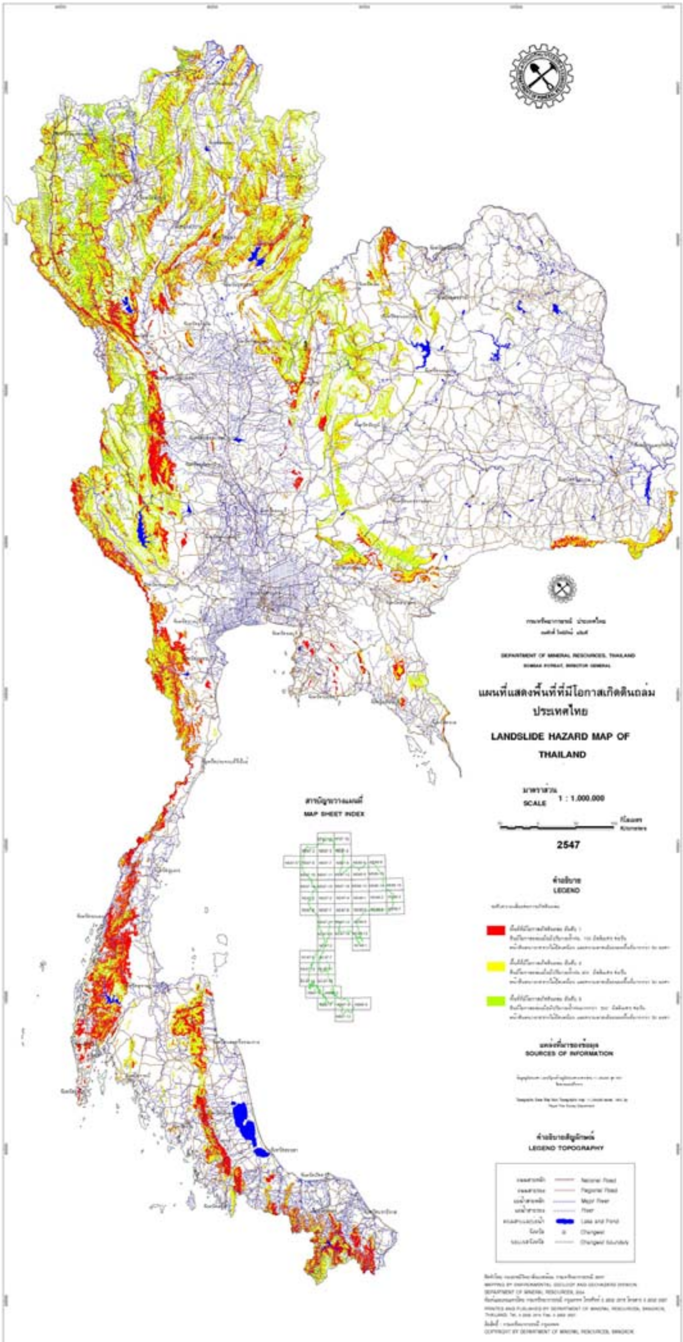

Fig. 4 Landslide hazard map of Thailand (DMR 2004). The red, yellow and green areas represent the highest, moderate and lowest risk, respectively.

As mentioned above, it can be clearly seen that the conventional approach applied to the geohazard prevention work has created a few serious problems including: a waste of money, poor management and maintenance work, low level of local people's participation, and unsustainable. Because of the negative sides mentioned, an alternative approach has been developed as shown below.

A New Approach

Due to all the lessons learned in the past, the present study introduces a new concept on the handling of geohazard through a new approach. The concept has been developed based on the concept of "living in harmony with nature". To do that, geological knowledge of the effected areas must be studied thoroughly. Planning and implementing of the plan should be carried out quickly, delivered in time, using low budget, easy to be managed, multidisciplinary and integration, and, last but not least, achieved local people participation. As a result, the project could be easily implemented whenever in need.

Sufficiency Economy

The new approach on dealing with management of geohazard event has taken one of the most important concept, which is the "Sufficiency Economy" into account.

The "Sufficiency Economy" is a philosophy that His Majesty the King has expressed in his speech as a guideline since 1974. The concept serves as a guideline how to live and behave for people at all levels from family, the community, to the governmental level both in developing and administering the country, to follow the "middle path", especially in developing the economy to keep up with the world in this globalized age. Sufficiency means moderation, reasonableness, including the necessity of having an adequate internal immune system against any impact caused by both external and internal changes. Intelligence, utmost thoroughness and carefulness are needed in bringing the various fields of knowledge to be used in every step of planning and executing the work to be done. At the same time the basic mentality of the people must be strengthened, especially that of government officials at all levels, theorists and also businessmen, to make them have an awareness of virtue and honesty. They must have a proper knowledge and lead their lives with perseverance, endurance, consciousness, wisdom, and carefulness so that they will be well-balanced and ready to cope with rapid and widespread material, social, environmental and cultural changes from the external world.

IMPORTANT CASE HISTORY

Once the approach has been developed, it is worth seeing how it works in the real situation. This study applies the new approach on geohazard prevention and mitigation to the case of the flash-flood and land/mudslide at Ban Nam Ta, Uttaradit Province. This on-going project has started in early 2007 under the cooperation of a number of offices including: the DMR, Local Administrative Offices, the Chaipattana Foundation, National Parks, Wildlife and Plants Conservation Department, Irrigation Department and Forestry Department, with supports from the Petroleum Authority of Thailand.

Flash Flood and Landslide at Ban Nam Ta, Uttaradit

Fig. 5 A photograph showing piles of sediments washed down from the flash-flooding of the area. .

The event occurred as a result of heavy rain fall in the areas of three provinces, which are Uttaradit, Phrae and Sukhothai. The flash flood and landslide occurred during 10 p.m of 22nd May 2006 and 3.00 a.m. of 23rd May 2006 after a heavy rainfall of 330 mm poured during a 24-hour period (with an accumulated amount of 400 mm over a 72 hour period). The area that has been mostly affected is at Ban Nam Ta (Fig. 5), Tambon Nam Man, Tha Pla District, Uttaradit Province, where a total of 19 deaths and 16 people missing and over 50 houses being destroyed.

The physiography of the Ban Nam Ta area is steep mountainous with thick soils weathered from tuffaceous and granitic rocks that are widely distributed throughout the area. Streams in the area exhibit extensive down cutting v-shaped channels running through a series of steep hills and cliffs (Fig. 6). Due to the steep terrain with running water cutting at the base of the cliffs, the Ban Nam Ta area is one of the risked

Fig. 6 A photograph showing a general view of the Ban Nam Ta area showing a stream and sediments (foreground) washed down from the land-slump area (hills at the background).

areas for mass movement (land and rock slide) especially during the rainy season. The trigger of land slide and flash flooding could be occurred with only one heavy down pour of rain with over 200 – 300 mm. within a 24-hour period.

Planning and Action. Usually, the government's reaction in response to the disaster event after the relief would be the construction of large structures to overcome the water holding capacity of all the dams in the area. This standard solution has repeatedly proved to be wastes of time and money because the root problems are still unsolved. As we already know that the causes of the landslide and flash-flooding include a number of factors, which are: geological factor including soil types, high amount of precipitation over a short period of time, steep sloped areas, and finally, the deforestation.

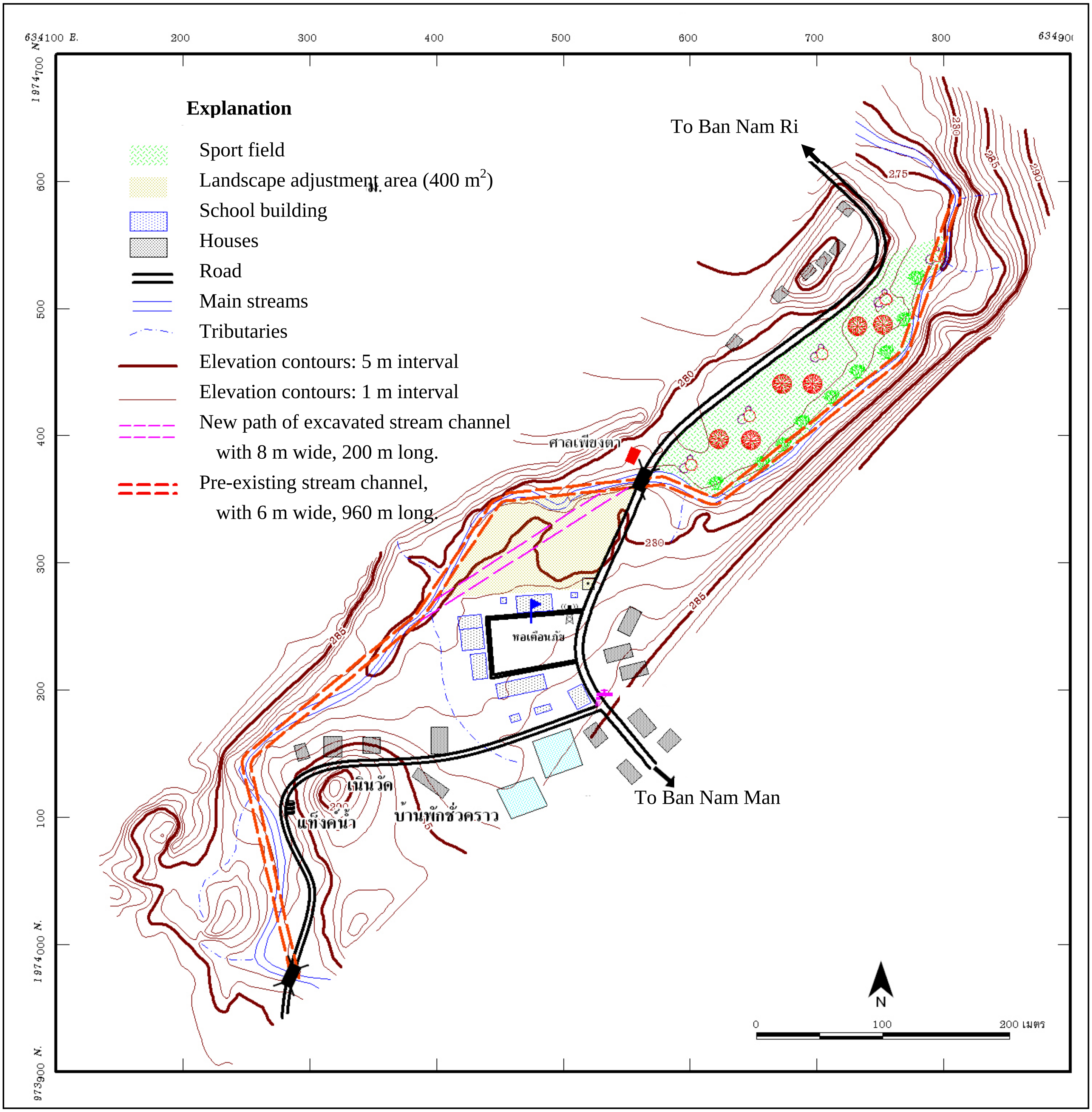

Fig. 7 A plan view of the working area with the comparison of pre-existing and the newly excavated path of the stream channel to reduce the risk of landslide and over-flown of water to flood the village area.

Fig. 8 A photograph showing the preparation of the reinforcement site at the base of the hill slope next to the stream channel.

Recently, strategy to solve the landslide and flash-flooding problem is not to overcome but to live in harmony with the nature. The mind map for this solution has incorporated the sufficiency economy concept that includes three basic characteristics, which are: moderation (sufficiency), reasonable and having enough internal immune system against any impact caused by both external and internal changes.
This project has carried out based on the king's sufficiency economy and involved a number of parties, thus applies various fields of knowledge to be used in both planning and executing the work to be done for the good living condition of the people.

The working steps involve the study on rehabilitation and development of landscape through the preparation of the semi-detailed 1:4,000 scaled elevation (topographic) map and the study of soil layers and rock structures through the application of various geophysical surveys and shallow exploration well, as well as open pit.

The geophysical surveys carried out in this study include refraction seismic survey and electrical resistivity survey. The results are pseudo-geological layers of the area.

The master plan has been created based on the gathering and integration of all relevant information achieved through various works and field work in the area. Figure 7 shows the layout of the activities that need to be put into the site.

The rehabilitation of the affected area include: the excavation of the stream channel to the size of 8 m wide and 2 m deep with a U-shape section, as well as reroute the stream to have the least curves in order to reduce the over flown of water over the levee or the banks. The excavation would increase the rate of excess water drainage of the area.

Fig. 9 A photograph showing the piling of soil bags as a part of the reinforcement of the slope at its base carried out by local people task force.

The prevention work includes the adding of enforcement fence along the base of the hill's slope, especially along the stream channels. This would prevent the lost of lives and properties of the local people whose houses are located along the streams. The works include: the enforcement of the base part of the hills through the use of I-shaped driven piles (Fig. 8), adjustment of the slope angles, making of the revetment slope, and the piling of soil bags along the hill's base for a distance of 200 m with the height of 5 m.

People Participation. Local people have been well informed on the work and activity being introduced into the area. Throughout the working process, local people always get involve, including the planning and the activities carried out in the field (Fig. 9). Capacity building has been carried out along the work progress, including the learning on the cause of and factors that control landslides, as well as the conservation of the environment to promote the love of natural resources of the local area.

Result. The work for the fiscal year 2007 has been completed. Stream channel has been readjusted to increase the drainage flow rate and the slope's base has been enforced. This has made the area ready for the upcoming rainy season. However, the work may not as solid as those built from concrete, e.g., concrete dams or pavement. This construction is not meant to last forever but it should be good through a couple of rainy seasons. The main idea of building such site is not to stand against the force of fierce water flow but to put in the least resistance to such force and let it flow through the area as soon as possible to decrease the overflow of water. Instead of spending a vast amount of money to build a strong concrete dam as usual, it may be a better idea to solve the problem the way is has been described above. The project has spent a tiny fraction of money compared to a similar project that builds a concrete dam to store water.

DISCUSSION

Facing with various types of geohazards, the DMR has at least achieved its new goal on the merging of geological engineering and the new approach based on the king's sufficiency economy. However, only time can tell whether the work is going to be successful or not, especially in the long run. The work may cost a lot less than the mega project designed to solve the same problem in the same area. However, maintenance is also vital to keep the mitigation and prevention set ups to always properly function at all time. Timing of setting up the system is also an important factor. The mega project would normally need a long set-up time to be launched whereas the current project can be started almost immediately. The approach and project's activities are also important to the participation of the local people as well. Mega project tends to keep the local people out from the (insight) information and related activities, whereas the current project brings the technical staff and the local people together. All these factors are vital to the success and fails of the project.

CONCLUSION

The new approach on solving geohazard problems under the theme of "living in harmony with nature" through the application of the king's philosophy of sufficiency economy has ignited a new hope to the people in the rural areas. The work can be easily carried out without having to wait for a huge amount of lump-sum money to start the hazard mitigation and prevention project. Technical supports on geological engineering are still there from all involved parties but the project activities and the budget money has been drastically changed. This type of project could safe a lot of time and money for the country so that they can make use of their time and effort in more useful projects.

However, monitoring of the project is vital to the evaluation of the project's result in the long run. Whatever the outcome of the project would be, the goal of the work here is to help people to have a better and safe and healthy living condition. With the available technical and technological supports and the new way of approach introduced in this work, it is of course possible to successfully achieve the final goal mentioned.

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