POSSIBLE CAUSES OF LANDSLIDES IN THE COASTAL AREAS OF THE CENTRAL VIETNAM

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ABSTRACT**:** In the last few decades, landslides have often occured in the mountainous areas of the coastal provinces in Central Vietnam during the rainy season. Typically in 1999, the torrential rainfall and flood caused the landslide over large areas of Quang Trị,Thua Thien Hue, Quang Nam, Quang Ngai, Binh Dinh provinces. About 40 people were buried under soils and rocks. Hundreds families had to move to the other places. In Quang Ngai, about 3.400 hectares of the rice field were buried by landslide debris of 1 m thick in average. The South-North transportation (both railway and road) had been blocked up for many days. This paper presents an overview on the landslides occurred, conditions and possible causes to trigger landslide in the mountainous areas of some coastal provinces in the central part such as Thua-Thien Hue, Quang Nam, Quang Ngai provinces. Some counter measures for landslide hazards management are also mentioned

SEVERAL TYPES OF COMMON LANDSLIDES

Bounded by Eastern Sea in the east, and Truongson mountain range in the west the coastal area in the Central Vietnam consists of 13 provinces prolonging from Thanh Hoa to Binh Thuan,. Truongson range takes root from upper stream of Songca River to the southern pole of Trungbo which includes the stretching mountain series with great arc shapes against the eastern sea. Hai Van Pass and Bach Ma Mountain cut through Truongson Mountain range and divided into North Truongson and South Truongson. The Truongson Mountain range is close to the sea in the south, creating lower and lower terrain from the west to the east.

Landslides happen commonly in the coastal area of Central Vietnam, especially in the mountainous areas, frequent natural hazards cause great losses to both human lives and properties in the region. The biggest event in 1999, terrible downpour and flood caused large landslides in Quang Trị,Thua Thien Hue, Quang Nam, Quang Ngai, Binh Dinh Quang Trị,Thua Thien Hue, Quang Nam, Quang Ngai, Binh Dinh provinces. About 40 people were buried by rock soils , hundreds families had to move to the other safer places. In Quang Ngai, about 3,400.00 ha of rice field were buried with the soil, rocks, gravel and sand of filling origin with average thickness of 1m. The South-North transportation (both railways and roads) had been blocked up for many days.

Landslides can be understood as the movement of the soil and rock mass from upper part of slope downwards or several sides sliding or freely falling (soils and rocks fall/roll). Landslides may happen at upper natural slopes or artificial slopes (edges/roofs) due to weight overload and other factors such as surface water and groundwater pressure, seismic force and some other forces. According to the sliding movement forms, 5 main groups can be divided by Varnes D.J, [11] such as falls, topples, slides, lateral spreads, flows, and complex. Initial research results show that the main landslide forms in the central coastal areas are falls, common slides and flows.

- *Falls:* When falls, collapse happen, a part of land of any size separates from the slope and falls down. Usually, the falls are not at large scale but occur often and strongly on the mountainous transporting lines in the rainy season, such as on the Roads QL8, QL9, QL 14, QL19, QL 21, Hochiminh Highway, etc.. Rock collapse happens when the rock boulders of any sizes separate from the slope, moving along weak sides and collapse down, then rolling, colliding and falling freely. The movement often happens very fast. Rock collapse have happened in areas of Dung Quyet Mountain (of Vinh City), Mieu mountain (Nghe An province), Ru Moc (Ha tinh province), Dakrong Bridge (Quang Tri province), Hochiminh Road, Violac Pass (Quang Ngai province).

- *Landslides: Slides truly break or cause* deformation and movement of soils and rocks towards one or some sliding sides that can be observed or supposed. Rocks and soils movement can reach out to the sliding mass foot. Landslides are the most common natural hazards along the steep hills, mountainous transport lines, and margin of rock mining deposits. The separate slides volumes are often varying from some cubic meters to several million cubic meters with speed from extremely fast (in Ban Ve, of Nghe An province) to slow (in Dau Voi mountain of Tien Phuoc, Quang Nam province). Landslides often happen in the areas of Khe Sanh, PhuLoc, NamDong (ThuaThienHue province), Huong Hoa (Quang Tri province), HuongSon (Ha Tinh province), DaiLoc, GiangHien, TienPhuoc, TraMy (QuangNam province), TayTra, Tra Bong, Son Ha, Son Tay (Quang Ngai province)...

- *Flows:* The flows are characterized by the sliding material movement forming soils and rocks flows at various sliding speeds from extremely fast to extremely slow. The sliding products may be the mix of rocks, soil and water (rock mud) or dry materials. Rock mud flow is one of dangerous sliding disaster which is widely developed in the mountainous districts of the coastal provinces of Central Vietnam such as Khesanh, Huonghoa, Minhhoa, Huongson, Aluoi, Tienphuoc, Trabong, etc… The flows often cause serious consequences, the rock mud flow can destroy structures and solid infrastructural premises or can bury or sweep away all area as well.

MAIN REASONS

As we have known, slides can happen when the soils and rocks mass balance on a steep slope is broken. The seasons could be due to the reduction of soils and rock durability, or the change of slope pressure state, or both ones. According to Lomtadze [5], the main reasons causing landslide include some factors like the increase of slope by cutting across, digging or erosion; reduction of rocks and soils durability due to physical state changes such as wetness, expanding, weathering, compact decrease, natural structure destroys, changes of soils and rock magnetics; the impacts of hydrostatic and hydrodynamic pressure on soils and rocks, causing permeable deformation (ground washaway, flow, sandflow, etc.); the change of soils and rocks pressure state in the slope forming zone and slope roof work; outside impacts such as the burden over the slope, seismic and micro-seismic fluctuation, etc.. Every above mentioned reason could cause the losses of soils and rocks balance of the slope, but it is usually the impact of some simultaneous reasons. In the studied area, the above said reasons often occurred in following conditions:

1. Steepness of the slopes. When the other conditions are the same, great steepness of the slopes will be one of the main and basic reason to destroy the soils and rocks mass balance on a steep slope. Basing on the concept of topographical/terrain form and origin, the study area can be divided into 6 topographical forms as follows: i) block-denudation high-medium mountain topography, ii) block-denudation high-medium folded mountain topography, iii) low mountain topography intercalating with block-folded and block-denudation hills iv) tectonic–erosion–deposition and erosion-deposition-tectonic valley topography; v). erosion deposition low plain intercalating with relic mountain topography, vi) Coastal dune deposition plain topography. By experiences [7], the landslides rarely happened on the slopes with steepness less than 15^o, on slopes with steepness of 15^0 - 25^0 landslides lessen, with slopes and hills more than 25^0 more slides happened and in slope area of steepness of 30^0 - 35^0 or more, slides often occurred strongly. Thus, it can be observed that the first three forms have strongly dissected topography, the absolute altitude is from 1,000.00m to 2,500.00m. The largest dissection depth is 1,000.00 – 1,200.00m. Most of the rivers and originate from slopes of the high mountain systems, thus they are often steep and of V shape. The topographic slopes are from 30^o to 60^o. These topographic forms are often of favourable terrain for the slide processes.

Basing on the analytical results of the landslide state caused by natural hazards in Quang Ngai province in 1999, Nguyễn Văn Lâm and others [4] pointed out that landslides mostly concentrated at the altitude of 100-400m, and more than 400m, the flows can be found. With the slope of the topography, within 59 investigation points there were 37 points of slides happening on slope of 10-$30^{o(}$62,7%), 22 points occured on slopes higher than $30^{o(}$37.3%). Remarks were also made that the slide masses on slopes higher than 30^o were often flows mass. On Hochiminh highway, a suvey of sliding masses in 2003-2004 [3] showed that the sliding masses appeared in the mountain slopes at altitude of 300-700m in Quang Binh, Quang Tri, Quang Nam provines, 1,000.00-1,500.00m in Thua Thien-Hue and Quang Ngai provinces. Slope angles are around 25^o to 45^o. When other conditions are the same, the encreasing slope angle caused by influences of natural or human factors could become the causes destroying rock and soil stability on the slopes. The research in Ho Chi Minh Highway shows that the road talus had increased slope angles and this is one of the reasons causing landslides which is in need of proper consideration [3,6,9].

2. Reducing rock and soil durability. The reducing rock and soil durability caused by changing their physical states in moisture, swelling, reducing compaction degree, weathering, destroying natural structure as well as the relation with magnetic change phenomena [5,10].

The geological structure of the coastal provinces in central Vietnam comprises soil and rock formations belonging to the metamorphic group (phylite, quartzite, marbles, mica schist, silic gneiss micmatite schist...), glaucovac sediment – clastic sediments (clay schist, sandstone, siltstone (Paleozoic); conglomerate, sandstone, siltstone, claystone, coal (Mezozoic), conglomerate, sandstone, siltstone, claystone, coal (Kainozoic), conglomerate, sandstone, siltstone, paralic coal...), breccia – acidic- neutral effusive sediments (sandstone, siltstone, conglomerate, riolite, tuf, clay schirst, sandstone, andezite, conglomerate), clastic sediments - biochemical – effusive sediments (conglomerate, sandstone, siltstone, clay), biochemical sediments (lime, lime - clay), river sediment, marine sediments, windy marine, eluvial - deluvial, diluvial deluvial, river deluvial - diluvial, intrusive formations include (granoxienite, xienite, granite, granite biotite, two micaceous granite, granodiorite...) [1].

During the rock forming process, the soil and rocks have experienced complicated tectonic cycles, creating Northern Central folding mountainous area with Phu Hoat Anticline Complex, Song Ca Synclinal Complex, Sam Nua Depression and Truong Son Anticline Complex. The soil and rock beds have been uplifted – subsided, folded, crumbled, crushed and separated by various cracture, faulting systems, forming weak sides of the soil and rock blocks in the slopes. In cases the layered faces of the claystones, faults, great fracture systems dipping to the slope surface, in this case landslides can intensively occur. The landslides statistics in 2003-2004 on Hochiminh Highway show that the slides in the study area mainly relate to East – West and North – South faulting system [6].

The weathering processes caused great impact on the physical state changes of soils and rocks in the slopes. The physical property of rocks and soils such as volume, mass, porosity, fracture, water absorption, durability, etc. change depending on the weathering degree. Being weathered, hard rocks become semi-hard rocks and if they are continuously destroyed, they will change into loose soil or cohesion soft clay. In the folding mountain area, the sliding blocks mainly relate to eluvial formations. Of 86 sliding points in Quang Ngai in 1999, 50 sliding points(58%) occurred in the weathering zone with 2m thick, other sliding points with great volume were found in weathering zone of more than 2m thick 2m [4]. North Central Vietnam is of a rainy region, with rather thick vegetation cover. The earthcrust was formed mainly by formations of clastic sediments, biochemical clastic sediments, effusive clastic sediments, etc. but due to the high and steep topography, short slopes, cutting rivers and streams the weathering crust is not very thick (rarely higher than 20 - 40m) even in the low mountain [1]. The physico- mechanical properties of the soils are shown in Table 1.

The change of physical state of soils and rocks, especially the clay such as in weathering crust, can cause to slides on the slopes and they can be observable when being wet by the rain, surface water and groundwater. The wet soil and rock make the volume increase, creating impact of the weight on those soils and rocks. For example, clay, silty clay in the weathering zone in Quang Ngai mountain area posses natural moisture of 19-41%, natural unit weight of 1.34-1.45g/cm^3, increase up to 1.69-1.83g/cm^3, 10-15% higher when being saturated [4].

The increasing soil and rock loads during suction accompanies the reducing structural bonding strength, change of liquidity index till plastic state even to liquid state, so that reduce soil's and rock's strengths (friction and bonding forces). For some weathering soil samples, the internal friction angle in natural condition is 18-21^o reduced to 13-17^o in saturation state (lower 2-7^o), unit friction reduced from 26-43 kPa to 6-16 kPa [3,4,6,9].

The reducing shear strength when water content increases is a typical phenomena of all types of clay, especially sharp increase meets when water in the soils are less stable . Some types of clay characterized by strong swelling property had increased volumes up to 25 - 30% [6], causing the reduction of bonding unique, not stable liquidity and sharply reducing their shear strengths.

Several observations carried out in various regions showed the close relationship of strongly sliding periods in slopes and slope surfaces with heavy and long lasting rainy seasons causing water level rise in the water basins and many forms of groundwater exposures. This again justifies the cause affecting relationship between the sliding potential and the change of physical properties of saturated soils and rocks.

Repeating of wetting and drying, periodical movement as well as other artificial factors will strongly affect the change of the state and physical properties of soils and rocks, especially clay soil types. The repeat of wetting and drying caused by influence of shrinkage's stress makes soils and rocks become dried and incohesive.

As we have known, semi-hard rocks and clays are capable in changing their durability and deformation in the time causing development of other processes, especially the slides. That's why when studying the reasons of landslides to research their rheology is important. In many research works, the timely durability reduction of semi-hard rocks and clays have been shown the figure of 70% in comparison with the instant durability, and about 10 - 50% of the standard durability (slow cut) [5,6]. So, it is necessary to differentiate between long and instant durability for these kinds of soil groups.

3. The impact of hydrostatic and hydrodynamic forces. The hydrostatic and hydrodynamic forces are often unidentified and they easily change the tress status of soils and rocks on the slope. In these cases, beside soils and rocks wetting and smoothing, the role of surface water and groundwater are very important in the sliding formation.

Due to the geological structure, especially the petrological components of the soils and rocks and the narrow, steep relief features of the folding mountain, the capacity of water storage and preserve of the solid rocks is worse, then groundwater table is often beneath 10m deep. Within the soils and rocks block beneath surface water and groundwater table, mineral grains are often subject to floating away by water, reducing their masses, as a result their floating status and weight can not be strong enough for stabling the upper soils and rocks. The upper soil and rock then loose fulcrum, moving and make the under floating soils and rock slide. Besides, the submerged soils and rocks also reduce normal effective stress on the sliding faces, decreasing the shearing strengths, creating slope instability and causing slides. Hydrostatic pressure also greatly impact on the stability of the slopes formed by fractured solid rocks, semi-solid rocks and compacted clays. In the rainy season, the water level of the fractures rises and hydrostatic pressure impacts on the fracture walls stronger. Many sliding masses in fractured soils and rocks were created in the sudden rise of the groundwater.

The hydrodynamic pressure plays considerable role in some slides of the slopes. The hydrodynamic pressure directs to the infiltration flows and the value is higher when infiltration is lower. In the sudden change of pressure gradient, hydrodynamic pressure can be the reason destroying slopes' soils and rocks stability. In the time of flood, the river water level rises suddenly causing flood at lower part of slopes or slope roof, and then water level lowers suddenly hydrodynamic pressure will be created in the infiltration soils and rocks. Total sliding force T on the slope face can be added with hydrodynamic pressure D_{td} and the stability coefficient of the slopes will be reduced. When the groundwater exposes on slope or slope roof, its hydrodynamic pressure can cause the soil drifting phenomenon or make it soft around a layer or a zone due to influence of underground erosion. Pressured water in the slope often drifts and liquefies soils and rocks. Because of the above said phenomenon, the soils and rocks masses lose fulcrum and begin moving, creating slides. Thus, the stability coefficient could be identified by the following formula [5]:

$$\eta = \frac{fN + CL}{T + 1.D_{td}} \qquad (1)$$

In which:

N, T – components of normal and tangential forces of a soil and rock unit on the slope surface,

f, C – friction coefficient and intensity of unified force in the length L of slope,

D_{td} – unit hydrodynamic pressure,

$D_{td} = I\gamma_n$, I – hydrodynamic gradient at groundwater's flow out point.

The long-lasting heavy rains are the important supplementary sources to ground- water. On one hand, water decreases the shear strength of the rock and soil masses in the slope and it changes the stress condition to the harmful direction to slope's stability in the other hand. Under the effect of surface flow, the slope's surface will be eroded and the protection works will be destroyed, so the slope instability probably increases. That's why landslides always occur along with heavy rains. Many big landslides in provinces of Central Vietnam were due to heavy rains and the big sliding areas usually coincide with the regions having great annual rainfall (table 2).

4. The change of stress condition in the slope casing by load release. Rocks and soils in the natural laying conditions are always in some stress state balanced with forces within rocks and soils. However when the surrounding environmental condition changes, the stress within soils and rocks will decrease and disperse. For example, there are always the released phenomena of compressed forces inherent or remnant at the banks or valley of a rivers, slopes and rock masses, at the excavated slope talus of railways, highways, mining sites, slopes of the project's excavation etc. The release of stresses in hard and partially semisolid rocks leads to the widening of the fractures and making the appearance of new releasing loads – elastic slacken fractures. The releasing loads develop nearly paralleling slope surface or slope making many faces and weak zone. The closer to the ground surface more fractures could be found and obviously apparent; contrarily, in the deeper, the less fractures can be found and more difficult to observe. If the rock's exposed surfaces are parallel to the bedding or laminated surfaces, the leasing loads fractures develop along the bedding surface and develop parallel to the slope surface. Generally, the loads releasing fractures are always unfavorably oriented to the slope stability or slope surface that's why the soil and rock movement occurs in the linear loads releasing fractures and form loads ladder's slope, structural sliding and rock fall relief.

In the rocks and soils of brittle-elastic and elastic fractures, the sliding phenomena in the side of slope zone and slope surface is developed differently a little bit. For example, in some semisolid rock types and clay soils, the degree of compaction under the influence of elastic forces always accompanied with hybridization and swelling. Such type of change of physical state in the foot of slope or slope surface, i. e. the slope foot causes decreasing slope's strength and finally leading to the slope's instability [5]. The decrease of the compaction degree of rocks in the sub-zone laying next to the food of slope or slope's surface surely leads to the stress concentration in the sub-zone of adjacent slope. With existing of semi rigid rocks or clay soil of low durability in the sub-zone, rocks change into plastic state and press out of the slope's foot to develop the magnet changing phenomena. All phenomena relating to the change of rock's stress state in the zone of slope formations and zones of above mentioned slope construction are the causes of fracture's appearance (fracture line) along or parallel to the slope's edge or slope itself and originate the rockslide.

5. Increasing loads on the slope. Increase loads on the slope, slope surface and the adjacent areas; seismic and micro-seismic vibrations, other dynamic and static forces of both temporary and long time may be the causes of forming landslides [5,10]. Construction of houses, buildings on the slope, storage, piling of wastes, road embankments, and activities of complex types of machine (crane, bulldozer, excavators, conveyors, cars and railway transportation) may increase sliding force. Drilling and explosion works usually reduce rock stability causing the movement of rocks and soils. Earthquakes cause the seismic acceleration and rock movement in a time unit and that's why increase the shearing forces and greatly affect to the slope and slope surface stability.

Table 1 Average values of physico-mechanical properties of deluvi-eluvi in the Northern Central Vietnam [1]

Physico-mechanical properties	Metamorphic		Clastic sediments		Biochemical (Limestone)
	Clay	Mix clay	Clay	Mix clay	Clay
Clay particle < 0,005mm, %	37	21	42	26	52
Water content W_{tn}, %	24	21	32	17	37
Unit weight ρ, g/cm^3	1.88	185	1.72	1.74	1,64
Dry unit weight ρ_c, g/cm^3	1.51	1.51	1.30	1.48	1.19
Specific gravity ρ_s, g/m^3	2.72	2.70	2.72	2.70	2.80
Porosity coefficient ε_o	0.80	0.79	1.09	0.82	1.35
Degree of Saturation G, %	82	74	80	56	76
Liquid limit W_c, %	47	40	52	37	56
Plastic limitW_d, %	25	25	30	23	36
Plastic index I_d, %	22	15	22	14	20
Liquidity index B	-0.07	-0.27	-0.09	-0.50	-0.07
Internal friction angle φ,	19	22	19	23	20
Cohesion c, kPa	50	29	39	20	30
Module of total deformation E_o, kPa	6700	6900	6300	6600	4700
Coef. of compressibility a_{1-2}, MPa^{-1}	0.19	0.18	026	0.20	0.39
Coef. of permeability k_t, m/s	3.2.10^{-9}	5.4.10^{-9}	8.1.10^{-8}	3.5.10^{-9}	4.5.10^{-7}

Table 2 The heavy rains causing serious landslides in central provinces of Vietnam [2]

No.	Time	Landslide locations	Rainfall per a rain (mm)	Annual rainfall (mm)
1	11 - 1964	Que Sơn, Quang Nam	300 – 1000	2,500-3,500
3	12 - 1986	Sơn Tra, Quang Ngai	500 – 1227	2,500-3,500
5	11 - 1999	Phu Loc, Thua Thien Hue	nearly 1000	2,400-3,000
6	9 - 2002	Hương Son, Ha Tinh	500-700	2,400-3,200

SOME SOLUTIONS TACKLING OVER LANDSLIDES

Landslide hazard as above mentioned is one of natural hazard types that occurs naturally and causes losses to human lives and properties.. The purpose of management over landslide hazard and its ricks is to conduct evaluating and assessing work in order to find out counter measures, propose the strategy, direction of the mitigation and risk management.

Landslide tackling

To reduce or mitigate a specific landslide mass occurred or potentially occurring we need to analyze landslide's mechanism and reasons; to find suitable treatment solutions and successfully execute them.

To reduce the sliding possibility and prevent the development of landslides we have to implement the following steps [2]:

i) Collecting the information on influencing factors such as relief, geology, groundwater, geological engineering properties of soils and rocks in natural and saturated conditions…
ii) Analyzing the seasons causing landslide,
iii) Establishing the calculation diagram for evaluating the landslide's causes,
iv) Establishing procedures for landslide protection for potentially sliding masses; to treat the existing ones to ensure safety for the project in required time,
v) Implementing of selected measures,
vi) Controlling the deformation of the inside banks during and after treatment;
vii) Revising and adding additional measures if it is necessary.

The engineering and non-engineering measures are usually used to deal with landslides. These measures normally are based on a principle allowing or not allowing to use reinforced works, treatment should be undertaken to reduce the ricks until limit level where the sliding disaster occurring and increasing the ability to prevent land mass from sliding.

The non-engineering measures could be used as follows:

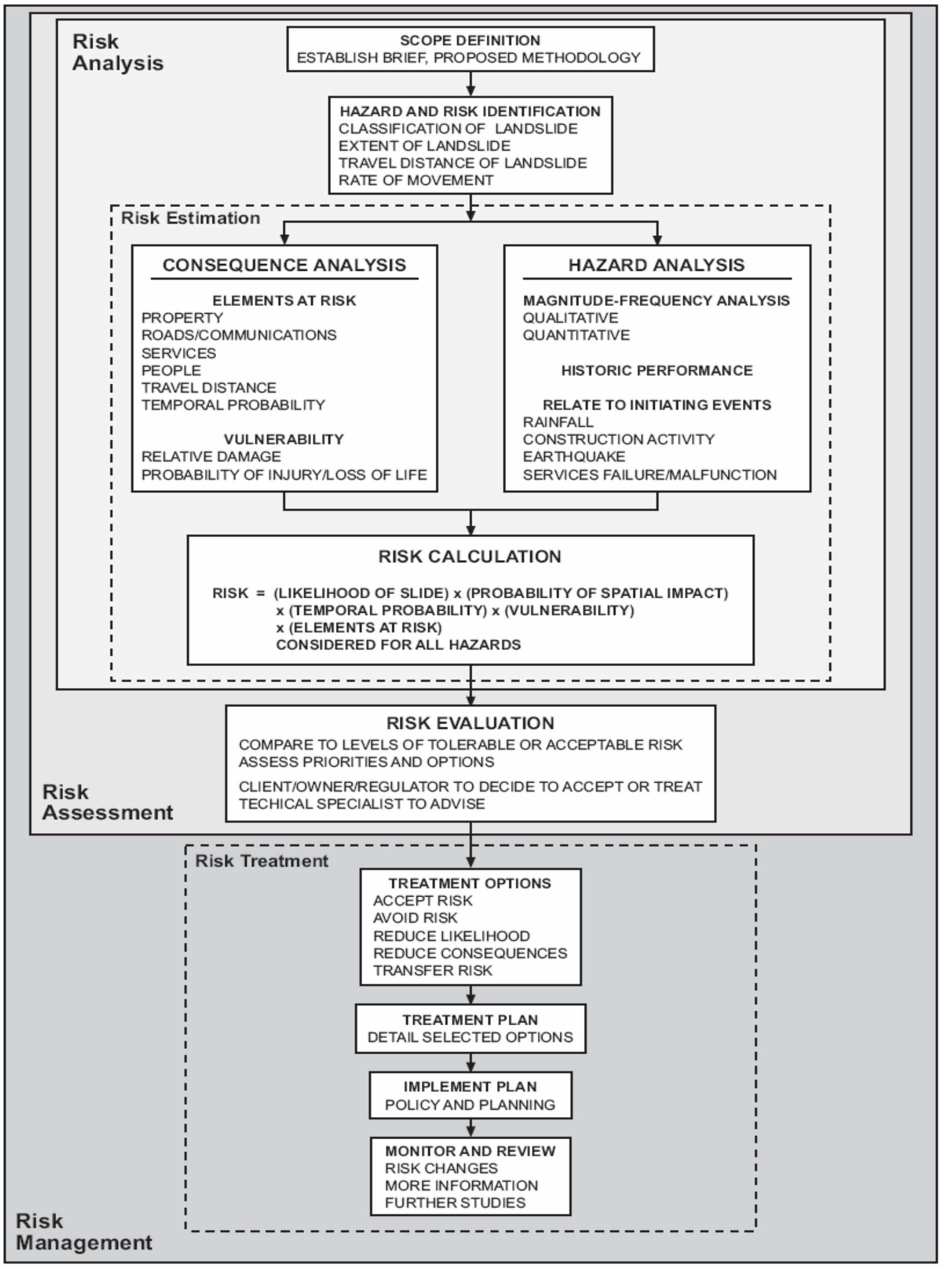
i) To maintain and develop the vegetation in the mountainous regions,
ii) To increase the quality of the survey, investigation, design and execute the works on the slope,
iii) Monitoring and prediction of deformation of slope with high landslide risk and causing big losses.

The engineering measures could be used as follows:

i) Reducing the sliding force by adjustment of slope angle,
ii) Increasing the resisting force by drainage measure
- Eliminating the surface water by forestation, grass planting for prevent slope from erosion, Making the drainage trenches, collecting water to a hole and then pump it out from excavation,
- Eliminating the influence of groundwater by system of vertical and lateral boreholes for water drainage.

iii) Increasing the resisting force by reinforcement measures:
- Jetting shortcreet into fractures to increase the bonding force and internal friction angle of rock mass.
- Using precast rock bolts to increase the friction force at the sliding face.
- Building retaining and protective walls to increase the resisting force of rock mass
- Using piles to increase the united force of rock mass.

Depending on the certain case a single or a complex measures could be applied.



Figue 1 Flowchart for landslide hazard management
(Australian Geomechanics Society, 2000) [10]

Landslide risk management

The losses causing by landslide hazards depend on the resisting and response capacities of people to landslides. This concept is concentrated in formula: "disaster will happen when risk occurs together with vulnerability" (Wikipedia's definition). That 'is why a natural risk can not lead to a natural disaster in the not vulnerable area. Lanslide disasters always affect human activities on slopes as well as in adjuntion areas where the disaster always causes risks to people and environment.

According to Australian Geomechanics Society, 2000 [10], Landslide hazard management needs to be implemented and based on risk's analysis and evaluation and at last treating, eliminating the risks (Figure 1).

Identifying and analyzing risks over an area need to follow three steps: i) analyzing and evaluating landslide's dangers (happening and having ability to occur) to determine types and their characteristics; secondly to determine the people background who are affected by landslide basing on analyzing the affecting characteristics; and thirdly to determine the location, intensity, frequency and spatial tendency of the landslides with great losses causing capacity.

Basing on risks estimation, risks evaluation in comparison with an acceptable level, the risk management will be implemented by their mitigation measures. These measures are oriented to two goups of measures: first group comprises the treatment, mitigation measures to eliminate landslides threats and second group comprises the mitigation measures reducing the losses caused by landslides.

CONCLUSSIONS

1. The conditions in the coastal provinces of Central Vietnam geomorphogically are characterized by strong differential relief, rather stiff mountain side, complicated geological structures with many faults, highly weathered crumble fold rock layers, big and concentrated rainfall… landslide hazards are very common. They often occurred in the rainy stormy seasons going along with heavy rains and often brought out by human economic activities such as road construction, deforestation…, causing great consequences and lives and properties losses. Together with climate change and abnormal disaster conditions, the happening of landslides become more diversely and complicated.

2. The research on disasters in the coastal provinces of Central Vietnam now has just begun, mostly concentrates on discovery and treatment of big sliding masses strongly affected economical and social activities. The landslide disasters management has become the requirement of the social sustainable development. However, the scientific bases for analyzing, evaluating and managing the disasters in Central part of Vietnam in particular, and in the whole country in general are still new and they have to be paid more attention In the future.

In order to mitigate landslide hazards it is needed to establish an unified multisectoral programme. Basing on this administrative management, the regions having big landslides threat need to install a observation system for early warning landslides risks and set up the information networks. Besides, it is necessary to consult with authorities on the landslides mitigation plan; promulgate the basic knowledge to the community on recognition, prevention measures to deal with landslides threats.

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