EVALUATION OF ECONOMIC LOSSES DUE TO NATURAL HAZARD IN BAC CAN PROVINCE, VIETNAM

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ABSTRACT: Bac Can Province is mountainous area located in northern part of Vietnam where different type of natural hazards occur every year such as landslide, flash flood, soil erosion etc. The government needs to know about the economic losses exactly in order decide better planning to reduce and mitigate serious damage from those natural hazards year by year.

Process of risk assessment is concerning to the vulnerability of people, buildings, infrastructure etc to various types of hazards. From natural hazard point of view, vulnerability is defined as the expected degree of loss for an element at risk as a consequence of a certain event.

This article is going to develop and publish thematic assessments which will address the issue of increasing risks to society, the economy and ecosystems by using remote sensing and GIS technologies. At the same time, development of natural hazard maps and vulnerability maps was implemented to derive the risk map which will be used for estimation of economic losses due to natural hazard. The result focuses on evaluating the socio-economic effects of disasters after classifying them as direct, indirect and secondary effects. This result will also convey for post-disaster rehabilitation and reconstruction processes.

In addition to the objective mentioned above, that information will help to consider where will be geographical regions or what will be social or economic sectors must be given priority in the rehabilitation and reconstruction process.

1. INTRODUCTION

Landslides cause damage to buildings (in residential areas in most cases), roads, agricultural and forest areas. Blöchl A. and Braun B. (2005) have been created the method for establishing economic losses in building. Sofie Buyck (2008) mentioned about direct, indirect losses along transportation corridor as followed, direct damage means a loss in asset value, whereas indirect damage can be considered to be the loss of income and/or production and impacts on the environment.

P. Jaiswal et al (2010) introduced the method as quantitative assessment of direct and indirect landslide risk that allows estimating direct risk affecting the alignments, vehicles and people, and indirect risk resulting from the disruption of economic activities. The indirect risk estimation requires two basic parameters: the hazard scenario that defines the blockage time of the transportation lines and a socio-economic analysis of the study area to determine the most important activities in the area and their consequences to the society if disrupted.

The risk map is to be based on a hazard map, which will be provided by Risk Analysis. Another important basis for the risk map is a map showing economic values potentially affected in the research area that will be developed in GIS environment. From point of view in physical vulnerability (not in social vulnerability of populations), some projects developed a methodology for the assessment of risks caused by natural hazard. Before going to stage of economic assessment, hazard mapping and risk mapping should be made. Hazard analysis requires a detailed knowledge of the geoenvironmental predisposition factors and initiation events that lead to different type of hazard. This lies within the domain of earth scientists. The end result of hazard and risk analysis usually will be presented in the form of various maps which display the spatial distribution of hazard and risk classes. The principle of hazard mapping requires both information as the current hazard along with a set of causal factors, and establishment of a hazard model. There are three main approaches for the developing of hazard models: heuristic, statistical and deterministic approach.

Risk assessment is a prerequisite for all the methods of hazard prevention and mitigation. It consists of three steps: (1) hazard assessment - identification of past/present hazard as well as the prediction of future occurrences; (2) vulnerability analysis - identification of the location and distribution of population, infrastructure and vital economic activities exposed to a potential or present hazard; and (3) calculation of the expected loss (risk) from the hazard and vulnerability.

There are several methodologies and templates for conducting a vulnerability assessment Jere, 2005; University of Colorado at Denver and Health Sciences Center, 2004; Dwyer et al., 2004; American Petroleum Institute, 2004; US

Department of Energy, 2002). The United Nations Economic Commission for Latin America and the Caribbean (ECLAC) has extensive expertise in post-disaster impact assessment in 2004.

2. MATERIALS AND METHODS

2.1. Study area and materials

2.1.1. Study area

Bac Can is a mountainous northern province. Geographic location ranges from 22°44' to 21°48' north in latitude, from 106°15' to 106°26' east in longitude. It is of 170 km north far from Hanoi capital. Bac Can has eight administrative units including a town and seven districts with 112 communes, 4 wards and 6 towns.

Bac Can is a mountainous province in northeastern of Vietnam, the terrain is dominated by arc mountains turned east interspersed with valleys. General speaking, Bac Can can be divided into three regions as follows: one center and two other zones as western and north-west, east and northeast. The region has a tropical monsoon climate over high differentiation of the topography and direction of the mountain. The climate there is also deep differentiation, in the summer, temperature and rainfall are high, in winter temperatures, rain and under the influence of northeast monsoon.

There are of five major rivers in the northeastern region as Lo river, Gam river, Ky Cung river, Bang and Cau rivers. Because of the topographic condition, almost of rivers are short and steep. In addition, there is a Ba Be Lake, the famous beauty of the northeast region. Bac Can has plentiful land resource for agricultural development, mineral resources for industrial development. Moreover, riched forests are used to develop industry and tourism resources are unique. The labor force of Bac Can is abundant for supplying to the province's economic development.

Generally, climate is favorable for agricultural development but the terrain is mountainous so climate should also bring a number of natural disasters such as landslides, mudflows or floods.

2.1.2. Materials

All material is divided in to 3 types as satellite image, map (topo map and thematic maps), statistic year book and report about damage caused by disaster.

- SPOT 4 image date 2008;
- Topographic map scale 1:50,000;
- Land use map date 2005 at scale 1:50,000;
- Gemological map at scale 1:100,000;
- Road network map at scale 1:50,000;
- Statistic year book and report year by year from 2000 to 2009.

2.2. Methods

Generally speaking, disasters normally occur when hazards meet vulnerability. The potential for a hazard to become a disaster mainly depends on a society's capacity to address the underlying risk factors, to reduce the vulnerability of a community and to be ready to respond in case of emergency. In fact, there are no internationally agreed minimum criteria for an event to be classified as a disaster. This is due to the variable manner in which hazardous events impact on population, economies or ecosystems.

The scope, scale and methodology of landslide hazard and risk assessment can vary significantly depending upon the aims and objectives of that evaluation. Establishing landslide hazard map is being carried out using qualitative or quantitative approaches. The qualitative methods essentially depend on expert opinion in dividing an area into different zones of varying landslide susceptibility. In a simple zonation, using the techniques of overlaying vulnerability of road segment according to geomorphologic characteristic or vulnerability of land use type, potential of economic loss for the Bac Can mountainous northern region could be estimated.

In order to evaluate transportation losses, at first, a database was constructed that contained information about road characteristics and geomorphic condition in which road was built. Damage was measured with variables such as monetary reconstruction costs per square meter, the relative loss compared to an estimated replacement value of road section under study, some point damage scale are presented in the authority report. In addition, the criteria "road type" and "pre-disaster condition of the road section" were recorded and analyzed in relation to the damage that had occurred.

It seems that not all disasters affect the agricultural land and agricultural production sector in the same way nor with the same intensity. In some case, some disasters affect mainly only farming as flooding at particular level of depth or duration of staying as well as type of crop or stage of growth for that type of crop. Each flooding or landslide brings different severe impact on the agricultural sector. Others type of disaster such as mudflow have significant impact on agriculture, even though those effects depend on the characteristics of the phenomenon and its geographical extent. Some disasters, such as earthquakes, destroy storage silos and affect the availability of foodstuffs, affect the agricultural sector only indirectly.

It is also important to consider the time of year when the disaster occurs for both permanent and annual crop. In the first case, if the plants are in flower the damage will be definitive to that year's crop, because, with the flower destroyed, the plant will not produce fruit and the anticipated harvest will be considerably reduced, if not totally lost. The same may occur with annual crops. The impact of the disaster is not the same if it occurs when plants are very young, because it may be possible to replant. When disaster occurs shortly before harvest time, the investment has been greater and it will surely be impossible to reutilize the land that year. Naturally, the magnitude of the damage in these two cases is different. For that reason, the type of crop should be mentioned.

In the event of a disaster, permanent crops usually suffer more serious damage because they grow more slowly. When plantations are partially lost, the land must be planted again; often infrastructure must be rebuilt (canals, drains, storage facilities, etc.), and several years must pass before the new plants will produce.

On describing the damage, the type of crop involved and the geographical extent of the damage should indicate. If it is a permanent crop, damage will occur in different degrees, depending on whether the crop was totally lost, or only partially damaged, if the damage only affects this year's production, etc. One phenomenon may cause all these different types of damage, the phenomenon must describe, in order to be clear with respect to the multiplicity of probable effects when calculating costs.

Immediately after the disaster, the government concentrates on quantifying the nature of the damage. The information they would like to know include types of crop involved, the yields and all other indicators such as geographic extent. Statistical series for several years should also be examined, because they will explain trends and yields in the regions affected and will indicate, in quantitative terms, what the production and its value would have been, had when the disaster not occurred.

Followed by ELAC methodology, evaluation of economic losses consists of three types as direct damage, indirect damage and secondary which will be described more detail here.

1. DIRECT DAMAGE

Direct effects on the agricultural sector refer to a range of damage to the supply of fixed and circulating capital, which may be broken down into that sustained by arable land (which it may take years to recover); that sustained by infrastructure, including irrigation works, installations, silos, etc.; that sustained by equipment (tractors and other farm machinery); and by stock (of cattle and harvested crops, pasturage inputs, etc.).

a) Loss of land

When land is destroyed by erosion or total sedimentation it is difficult to estimate its cost because replacement is not possible. The resource has been lost and nothing can be done about it. In those cases, it should be assigned a value equal to what that land would produce in 10 years, according to average production levels in the zone.

b) Damage to infrastructure and equipment

Production infrastructure (machinery, equipment, irrigation works, warehouses, etc.) may suffer damage. In order to calculate those losses, estimates should be made in each case of the amount lost, in terms of kilometers of irrigation or drainage canal, number of farm or livestock installations totally lost (preferably in m2 constructed), etc, in term of square meters of damaged construction.

c) Production losses

When crops are completely destroyed by a disaster, the surface area affected should be quantified and the costs incurred by farmers, according to the maturity of the crops that should be estimated so as to obtain the total cost of the crops lost.

If livestock has been totally destroyed, it will be necessary to determine the number of animals involved, multiply it by the average estimated market value to obtain the total sum involved. Care must be taken to calculate permanent crops separately from annual crops. Estimating the replacement value of permanent crops is somewhat more difficult. To this end, annual costs involved in restoring the plantation to its former levels of production must be identified. (Income lost while the plantation is growing should be included as an indirect effect).

As for the criteria for determining the value of direct damage, it has already been stated that, in most cases, the real replacement costs or market prices of the destroyed goods at the time of the disaster should be used, although efforts should be made to avoid use of the speculative prices which may occur. Some will be easy to calculate, such as the recovery of both capital and production inventories, given that the prices of those elements are usually available in the trade sector.

2. INDIRECT DAMAGE

Indirect damage consists mainly in farm and livestock production which will not occur during the recovery period.

3. SECONDARY COSTS

In order to calculate the overall effects of damage on the gross domestic product, an amount of production in normal conditions should be calculated in order to obtain a basis for comparison with anticipated post-disaster production.

3. RESULTS AND DISCUSSION

3.1. Database for economic losses assessment

- Build the database according to four blocks as followed:
    + Landslide database: Location, multitemperal.
    + Hazard factors: Geomorphology, topography (DEM, slope, length of slope etc).
    + Element at risk: Houses, road network, land use type.
    + Triggering factors: Rain fall, temperature.
- Risk analysis: Hazard map, vulnerability map, risk map.

3.2. Map output

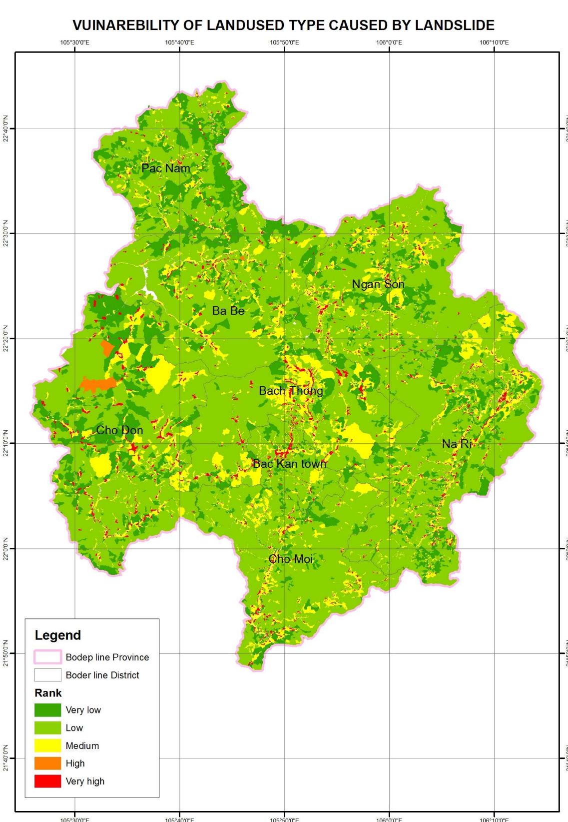

Fig. 1. Map of vulnerability of land use type caused by landslide

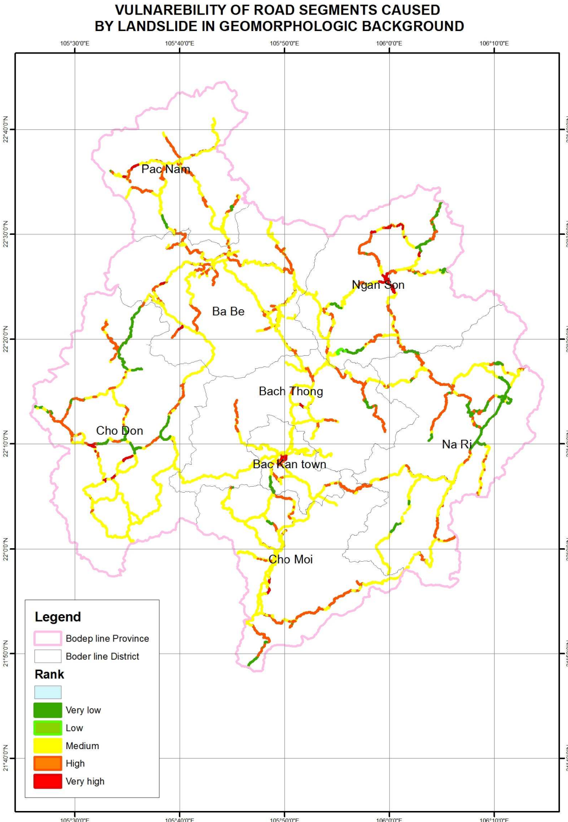

Fig. 2. Map of vulnerability of road segment caused by landslide in geomorphologic background

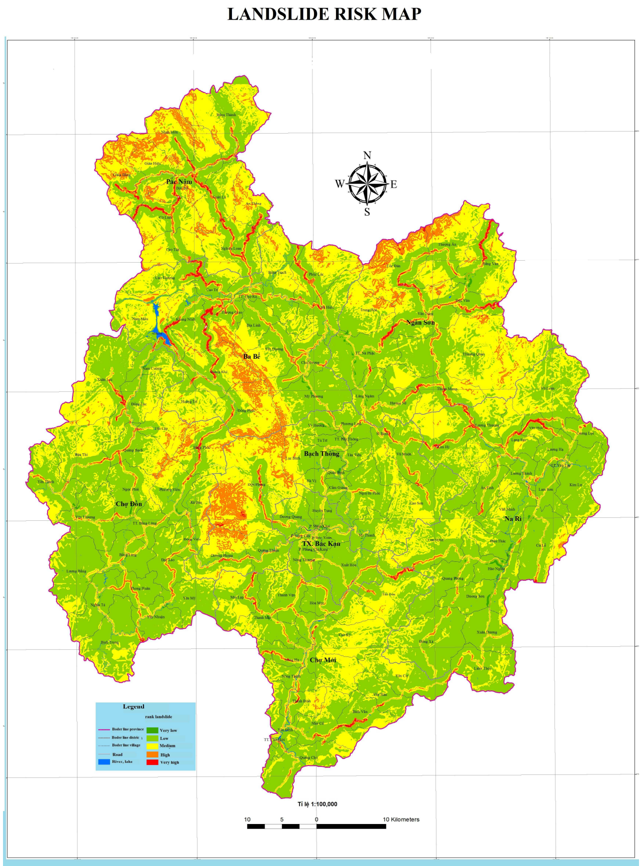

Fig. 3. Risk map

3.3. Classification of economic losses

Table 1. Area of land use type exposed to vulnerability level (in ha unit)

Vulnerability level	1	2	3	4	5
Reserved land of reforestation for protection		1565.6	9691.2	1973.8	25.4
Reserved land of reforestation for production		3035.3	16296.4	2205.3	10.0
Land of natural forest for specializing use	2.6	6315.6	8098.4	482.4	0.3
Planting forest for production	0.1	4729.5	9420.8	630.4	1.2
Land of planting forest for production		3684.0	11454.6	1780.2	93.5
Land of planting forest for protection		428.9	966.4	632.6	12.1
Mountains without forest	0.7	779.5	2483.0	379.8	2.3
Specializing land for rice field	0.5	2438.5	8643.5	1003.7	7.2
Other land for rice field		2128.1	8287.4	1689.1	16.5
Land for rice field in the moutain		76.4	338.6	113.7	4.8
Other land for annual crop		597.9	2458.2	571.6	9.3
Land of fields in the mountainsfor other annual crop		316.8	3139.0	1564.9	51.5
Land for permanent fruit		60.9	366.1	100.2	0.4
Land for other permanent crop		68.5	529.4	215.6	5.8
Land for permanent industrial crop		93.9	52.0	319.0	1.0
Land for settlements		942.1	6476.5	1740.9	31.2
Land for urban settlement		96.8	644.7	117.1	3.0
Land for mining activities		132.8	1299.2	341.9	1.3
Land for national defense		790.7	1699.2	250.1	1.4
Grassland with improvement		175.4	812.2	79.1	

4. CONCLUSION AND RECOMMENDATION

Results from recent projects focused on assessing major risks from rapid, large volume landslides from region to region in the world, highlight the importance of multidisciplinary studies of landslides hazards, combining subjects as diverse as geology and geomorphology, GIS and remote sensing, GPS and socio-economic profiling. Moreover, the availability of a wide range of remote sensing data along with data from other sources in digital form and their analysis using GIS, has made it possible to prepare different thematic layers corresponding to the causative factors that are responsible for the occurrence of landslides in a region.

Landslide risk management is underdeveloped in this region. Therefore it is necessary to develop and apply tools for integrative risk management. Such tools can consist of maps identifying dangers and risks, to be used by planners or administrative authorities. In order to cope with risks, one must be familiar with the scale of possible landslide hazards. This task can only be accomplished out in cooperation with the other discipline as well.

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