Disaster Risk Assessment for Sustainable Human Settlements Development

K.C. Sugathapala

Head/Actg. Director, Human Settlements Division, National Building Research Organisation, Ministry of Disaster Management, B.Sc. (BE), M.Sc. (T&CP), PG-Dip in UD, MITP, Charted Town Planner/Architect

D.S. Munasinghe

Scientist, Human Settlements Division, National Building Research Organisation, Ministry of Disaster Management, B.Sc. (Hons.) (T&CP)

ABSTRACT**:** National Building Research Organisation (NBRO), Sri Lanka conduct research studies on landslide risk management since 1986. Landslide Hazard Mapping Project (LHMP) is one of the main tools used in management of the landslide risk. NBRO initiated a new study on the Disaster Risk Assessment in human settlements. The aim of this study is to identify different risk zonings in vulnerable settlements and identify the suitable course of actions to be need for disaster risk reduction. Three categories of actions will be produced on the assessment; Building or Engineering Enhancements, Spatial Planning Corrections and Landscape Designs. The study is conducted in community and technical analysis. The outputs of the research are more useful to decision makers or decision takers to decide what kind of development should be include in the particular area, what kind of housing construction techniques are needed to construct buildings and what kind of landscapes should be incorporate into city to increase the disaster risk reduction capacity of the area.

Key words: Risk Mapping, Human Settlements, Settlements Planning, Landslide Hazard Mapping,

1 INTRODUCTION

Prior to 18th century landslides were considered as isolated events due to its natural causative factors and had a low hazard level. Also it was considered as a natural phenomenon that essentially required for the earths ever changing land form pattern. Since 1980s with the rapid development and population growth, the risk to lives and properties of human settlements increased in central hilly terrains and landslides were considered as threat to human settlements. In this background, research conducted by NBRO in late 1980s identified in-appropriate land use practices and other human interventions are the main reasons for the landslide events happening in Sri Lanka.

August 1990, was the turning point where, government of Sri Lanka decided to launce Landslide Hazard Mapping Project (LHMP) implement by National Building Research Organisation (NBRO) with the financial and technical assistance of UNDP and UNCHS. Main task of the Government of Sri Lanka and UNDP initiated landslide project was to formulate a strategy to study the landslides with a view to reduce the impacts on human settlements. Under this programme, NBRO has completed 1:50,000 scale landslide hazard maps in 10 districts and 1:10,000 scale maps in identified locations.

Later, Human Settlements Division has engaged to conduct community based disaster risk reduction programme under the PROMISE programme with the financial and technical assistance of the Asian Disaster Preparedness Canter **(ADPC)**. The programme is successfully completed and NBRO was able to develop a simple risk assessment methodology for multi hazard urban situations. Now the proposed research study is a risk identification matrix for decision makers and decision takers.

2 METHODOLOGY:

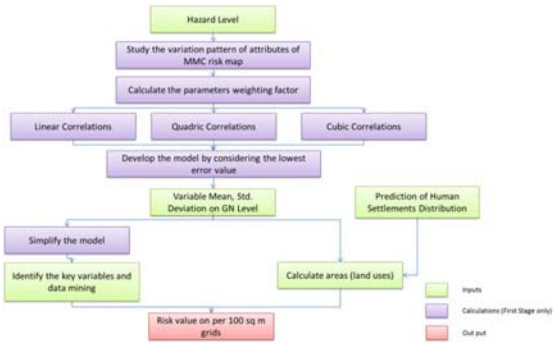

Figure 1: Methodology

In developing urban settlement risk maps there are various approaches; physical risk mapping, social risk mapping, environmental risk mapping and sometimes even the economic risk mapping. For example; physical risk map will show the physical risk of a hazard. This may be affecting people or settlements directly or maybe not. Nevertheless, Human settlement risk map is a combination of all the above approaches or factors. Therefore, it needs greater attention and methodology is more complex. Human settlement risk map is also deviated from the general equation of risk which is given below.

$$\text{Risk} = \frac{\text{Hazard} \times \text{Vulnerability}}{\text{Capacity}} \qquad (1)$$

It is always useful to go by the basic approaches especially in a multi-varying analysis of number of elements. In this approach the basis of risk reduction is elementarily indicated. Risk is a combination of hazard and vulnerability where;

Hazard – Any phenomenon, substance or situation, which has the potential to cause disruption or damage to infrastructure and services, people, their property and their environment.

Vulnerability – A concept which describes factors or constrains of an economic, social, or geographic nature, which reduces the ability of a community to prepare for and cope with the impact of hazards.

Capacity – The resources and skills people possess, can develop, mobilise and assess, which allow them to have more control over shaping their own future and coping with disaster risks.

Risk – The probability that negative consequences may arise when hazards interact with vulnerable areas, people, property and environment.

Hazard levels is being identified through the LHMP programme maps and on these maps have been categorised into 4 levels: landslide likely to be occur, landslide moderately to be occurred, Landslide less likely to be occur and landslides not likely to be occur.

Using the above rationale NBRO in 2009 developed a methodology for urban risk mapping. The pilot mapping exercise was conducted in the Matara Municipal Council (MMC) Area.

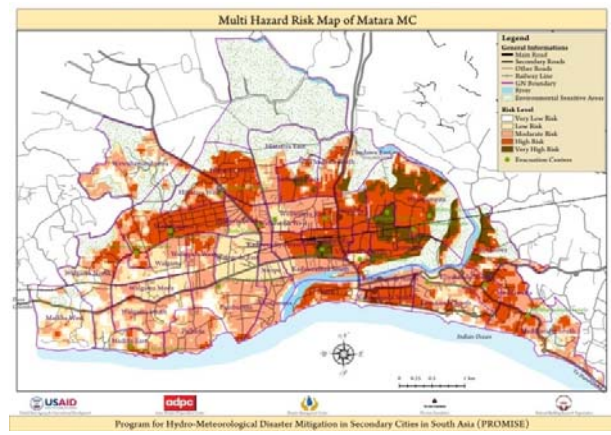

Figure 2: risk Map produced for the Matara Municipal Council Area

In this exercise, more than 100 variables have been examined. In this regard, one key aspect that needs to understand is variables that have high and low relationship to risk status in risk assessments. For this purpose, scatter diagram was prepared for identified variables and its relationship with risk. These variables were identified through desk studies as well as stakeholder consultation process.

Relationships with variable and composite risk are to be understood for determine the exact correlation value. In the calculation, variable values are converted into z values. Therefore, the correlation is calculated between risk values and z values of particular variable. Scattered diagram was used to analyse various patterns.

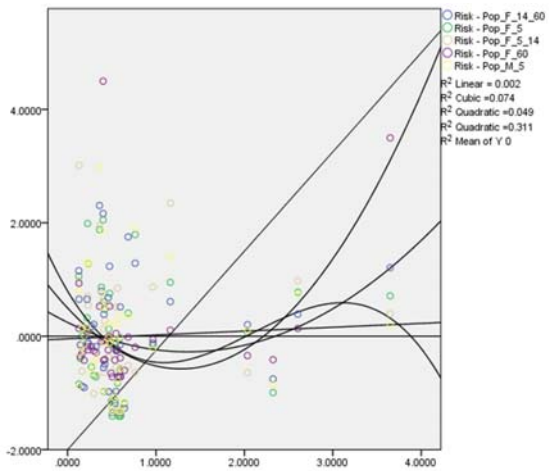

Figure 3: Scatter Diagram of Female Age structure

Pearson correlations were calculated to understand the relationship between risk and the variable. Then it converted into positive values because relationships had been already considered for the preparation of risk map.

Considering the above values the risk equation can be assessed the risk status of different settlements and also it can be used for comparing of inter-relationship between variables. The variables are consisting of z-values and it should be related to whole country details. Therefore, mean and standard deviations of variables are calculated by considering the country details from 2001 census data. Following table shows the calculated mean and standard deviation values for building characteristics (permanent, Semi permanent and temporary);

Table 1: Country Values for Building Character

	Permanent(x)	Semi-permanent (x)	Temporary (x)
Mean (μ)	224	97	3
Std. Deviation (σ)	137.13	28.68	4.20
K (leaner)	0.205	0.074	0.061

Here the K is constant factor of risk and variable in the site.

Considering the above data, risk in the particular GN division can be determined as if the total permanent houses are increase more than 224 or semi-permanent houses are increase more than 97 or temporary houses are increase more than 3.

Based on above data, risk composition of housing characteristics can be shown as follows;

R=HV/C

R= k (x -μ) / □

$$\frac{dR}{dx} = \frac{d\{k(x-\mu)/\sigma)\}}{dx}$$

$$\frac{dR}{dx} = \frac{k}{\sigma}$$

Example of use:

Assume leaner relationship:

R = (137.13/0.205 ([permanent houses] - 224) = 0.061 ([temporary houses]-3)/4.2

= (669.12 / [Permanent House]-224) = 0.0145 x {[Temporary house]-3}

Differentiation would be;

$$\frac{[temporary\ building]}{[permenant\ building\ ]} = \frac{0.061 \times 137.13}{0.205 \times 4.2} = 9.71 = 10$$

[Permanent Building]: [Semi-Permanent Building]: [Temporary Building] = 1: 1.72: 9.71

<u>This mean, Risk came from construction of a temporary house in the settlements is equal to risk came from 10 of permanent houses are constructed in the settlements</u>.

Accordingly, this can be used to identify the risk management strategies of the settlements as follows;

How many shanties to be upgraded to semi-permanent structure to reduce risks?

Selection of best alternative among variables to be changed into reduces the risk in terms with the cost factor.

3 HUMAN SETTLEMENTS RISK ZONATION MAP

Based on above calculations NBRO is expecting to prepare human settlements risk zoning map which can be used for decision makers to take their decisions very logical and rational manner.

For this purpose, Human settlements risk zonation maps will be prepared by considering the followings;

- Building Characteristics
  (Updated on 5-10 year Period)
- Land use
  (Updated on 5 – 10 year period)
- Demography
  (Updated on 10 year period)
- Landslide Hazard
  (Updated on requirements)

- Slope Angle
  (Updated on requirements)

These layers will vary on time to time. Censes survey will be carried out during 10 year periods. Therefore, population analysis and building characteristics will be updated during 10 year period time. Land uses and building locations will be analysed on the remote sensing techniques. The figure 4 shows a human settlements risk map in Padiyapelella area as pilot study.

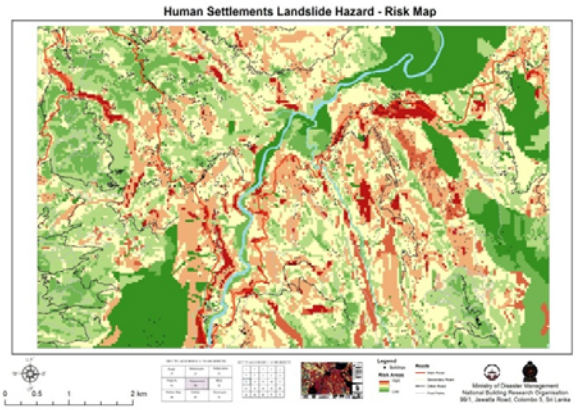

Figure 4: Human Settlements Landslide Hazard - Risk Map

4 CONCLUSION AND RECOMMENDATIONS

Risk assessment is one of important layer for the development planning. It will be very useful if the assessment can describe; what are the suitable options that can take for reduce of risk in the particular area. Different risk assessments methods have been introduced by several organisations and institutions. But this model is more important because it says what extent the risk should be reduced and what are the cause of actions that should follow.

By using the values, final composite human settlement landslide hazard risk map was prepared to understand the variation pattern of the hazardous risk in the areas. These maps are very useful to understand the suitable areas for particular works.

On the other hand, these maps will facilitate for the future disaster management projects to understand the cause of actions to get for mitigate the landslide hazards.

Based on those, the sustainable development can be achieved by mobilisation of resources/ constructions on suitable locations. Therefore NBRO is going to recommended using these risk maps for the preparation town plans, understanding the mitigation practices and different course of actions.

5 REFERENCES:

Cruickshank, R. (1995). Manual on field mapping for landslide hazard zonation. Colombo: National Building Research Organization.

M.I.D.H., W. (2010). Landslide Hazard and Risk analysis of Kandy Municipal Council area, Sri Lanka. Building Research to Face Future Challenges (pp. 42-52). Colombo: National Building Research Organization.

Piyasiri M.L Hettige, J. L. (1194). Manual on land use & management map production for landslide hazard zonation. Colombo: National Building Research Organization.

Sugathapala K.C., Munasinghe. D.S. (2010). Risk Mapping as a Tool for Disaster Risk Reduction in Urban Areas of Sri Lanka. Building Research to Face Future Challenges (pp. 95-102). Colombo: National Building Reseach Organization.