Stakeholder Perception based Approach to Vulnerability Assessment: Case of Ratnapura Municipal Council Area

P. K.S.Mahanama,
Faculty of Architecture, University of Moratuwa
mahanama_pks@yahoo.com

T.K.G.P. Ranasinghe
Department of Town & Country Planning, University of Moratuwa
gayaniprasadika@gmail.com

E. J. Warusavitharana
Department of Town & Country Planning, University of Moratuwa
eme_jayani@yahoo.com

Abstract

The intention of this paper is to provide an alternative approach to thevulnerability assessment. Most of the present approaches that are involved in the vulnerability assessment process have been identified with various weaknesses. Most of the weaknesses are related to the elements that are considered in the approaches. Identifying the most suitable elements, when performing the vulnerability assessment, is crucial to the creation of disaster resilient cities. Stakeholder perceptions are vital to identify the site specific and disaster specific elements. This research develops an approach that is stakeholder perception based and mostly relevant to the site specificities. Through the literature review, thirty three elements were identified with reference to flood and landslide. Factor analysis method was applied to identify the most influential elements among them through the stakeholder perception. The Vulnerability Assessment was performed by applying the identified elements, taking Rathnapura as the case study area.

1.0. Introduction

The disaster incidents profile (2012) of Sri Lanka indicates that disasters during the period 1997-2006 indicates a clear trend of a very rapid increase, with about 200 incidents recorded in 1997 and more than 1800 events recorded in 2006.Therefore incorporating disaster risk reduction measures in the city development plans has become a major requirement since they are the means of directing the future growth of the city in a safe and sustainable manner. Any development plan or project or activityshould be incorporated with disaster risk reduction measures since all natural hazards can lead to make vast disaster in every aspects of the environment(King and Bell, 2005).Hazards are potentially damaging phenomena, but they only precipitate disasters when they impact on elements at risk (Rashed and Weeks 2002).These elements can be physical structures such as schools, roads or houses, the environment or humans or human activities (Cutter 1996 and Weichselgartner 2001).In the process of mainstreaming disaster risk reduction in to development process, VA is the preliminary and supportive technique which can be used to identify hazard risk areas. An evaluation of the risk to an exposed element from a hazardous event requires a consideration of the right elementswhich expresses its propensity to suffer damage (Douglas,2007). But these elements can be varied in terms of type of disaster and context of the area. Therefore main objective of this study is to identify suitable and important elements for vulnerability assessment considering both flood and landslides situations under different dimensions which supposed to be identified as one of the outcome of this study.

This paper discusses the definitions and concepts of natural hazard, vulnerability and risk assessments. Further it elaborates important elements that may contribute to vulnerability based on findings of literature review. Factor analysis was applied to categorize different types ofelementsunder specific dimensions .Those identified 33 elementswhich categorized under nine

dimensions were applied to assess the disaster vulnerability of Ratapura MC area which hugely get affect from landslides and floods.

2.0. Literature Review

2.1. Natural hazard, Vulnerability and Risk Assessment

Glade (2003) defines that the term natural hazard implies the occurrence of a natural condition or phenomenon which threats disastrous in a defined space and time. Some authors characterize the "natural process" as"hazard", and the "natural hazard" as "disaster", and argue that hazards are natural, but in general, disasters are not, and that disasters should not be seen as inevitable outcome of a hazard's impact (Alexander,1993).They stress on the conditions of people which make it possible for a hazard to become a disaster(Cannon,1993,United Nations,2004). Glade (2003) defines that vulnerability is commonly related to the consequences of a natural hazard. These consequences are generally measured in terms of damage or losses, either on a metric scale or on an ordinal scale based on social values or perceptions and evaluations. Characteristics of definitions of the term "vulnerability" with respect to elements at risk can be analyzed based on findings of literature as indicated in table1. Accordingly Vulnerability is the threat:

Table 1: Term vulnerability with respect to elements and factors at risk

to which people are exposed	Gabor and Griffith (1980), Cutter (2003), Amendola (1998)
To which a system acts adversely	Timmerman (1981)
To various types of buildings	Petak and Atkisson (1982)
To which different classes of society	Susman et al. (1983)
Between risk and preparedness	Pijawka and Radwan (1985)
For where vulnerable people and places are located	Liverman (1990), Comfort et al. (1999)
For socio economics groups or regions	Downing (1991)
aggregate measure of human welfare that integrates environmental, social, economic and political exposure	Bohle et al. (1994)
Biophysical, demographic, economic, social and technological factors such as population ages, economic dependency, racism and age of infrastructure	Dow and Downing (1995)
Sensitivity of land use	Gilard and Givone (1997)
Which affect characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard	Wisner et al. (2004)
Vulnerability is highly dependent on the construction material used for exposed elements at risk	Fuchs (2007)

Source: Findings of Literature Review

King and Bell (2005) mentionthat consideration of right elements for VA from a given hazard requires expressing its susceptibility to damage.Fuchs (2007) shows that risk is expressed as a function of the hazard, the elements at risk and the vulnerability. Therefore estimation of the level of risk of any disaster prone area can be donewiththe identification of suitable and right elementsfor assessing vulnerability.

2.2. Identification of elements that may contribute to vulnerability

2.2.1. Vulnerability assessmentpertaining to Landslide

Glade (2003) finds that there are lacks of studies on identification of right elements for VA pertaining to landslidesand mention that population, buildings and engineering structures, infrastructure areas and lines, public service utilities and economic activities should be considered asmajor elements. Kaynia(2008)shows that landslides are responsible for significant loss of life and injury to people and their livestock as well as damage to lifelines, critical infrastructure, agricultural lands, housing and public and private infrastructure and assets. Further he shows that the concentration of property on steep slopes, high standard of living and high population density all combine to make society vulnerable to landslide events even those of small magnitude. Papathoma(2007) shows that considering material and use of the buildings, number of residents and employees, characteristics of the inhabitants (population density, age) are important for identifying vulnerable settlements. Further he ensures that the elements that affect vulnerability are important to visualize the physical, human and economic vulnerability.

Vulnerability to landslides is also discussed by Glade and Crozier (2005) who determine the vulnerability of people according to their location (open space, vehicle or building). Gomes (2003) mentions that elements should be included the presence, frequency and absolute numberof human lives, infrastructure (public, residential etc.) and productive function and activities (industry, agriculture, etc.). Michael (2003) performed an analysis of the vulnerability of residents, buildings, and Roads/railway lines to landslides, material and age of the buildings and existence of surrounding wall, existence of large windows toward the mountain slope.As it is suggested by Centre (2000), the risk and vulnerability is a result of a combination of societal and natural conditions. when assessing the social vulnerability of the community, the data concerning the population are very important and include number of households per building, land use/building use, temporary houses, temporary high density of population (theatres/ski resorts/tourist buildings etc.) and buildings with particularly vulnerable populations (hospitals, elderly nursing homes, kindergartens, schools, jails).

2.2.2. Vulnerability assessmentpertaining to floods

Flood damage refers to all varieties of harm caused by flooding. It includes a wide range of harmful effects on humans, their health and their belongings, on public infrastructure, cultural heritage, ecological systems, industrial production and the competitive strength of the affected economy(Volker, 2005).The actual amount of flood damage of a specific flood event depends on the vulnerability of the affected socio-economic and ecological systems (Cutter,1996 and Mitchell, 1989).Elements supply information about the vulnerable location in terms of their elevation, their proximity to the river, their closeness to inundation areas and return periods of different types of floods in the floodplain (Alexander 1993, Heyman et al. 1991).

2.2.3. Vulnerability assessment pertaining tolandslide and flood

An interesting study has been carried out by the Department of Hydrology and Meteorology of Nepal (Shrestha, 2005). This study includes both the physical and social elements of vulnerability pertaining to landslides and floods. The physical vulnerability was calculated and mapped on the basis of a combination between physical exposure (population, households, agricultural landand road length) and hazard. The social vulnerability assessment considered factors such as telephone lines, hospitals, banks, number of inhabitants and economic diversity. This study points out the significance of vulnerability assessment since it proves that although the hazard has decreased the vulnerability has risen due to higher physical exposure and lower adaptive capabilities on varies elements(Shrestha,2005).Volker (2005) shows that elements at risk specify the amount of social, economic or ecological units or systems which are at risk of being affected regarding all kinds of hazards in a specific area as persons, households, firms, economic production, private and public buildings, public infrastructure, cultural assets, ecological species and landscapes located in a hazardous area or connected to it.

Social vulnerability describes the demographic characteristic of social groups that make them more or less susceptible to the impact of hazards (Hill et al. 2001). Cutter (2003) suggests that social factors such as wealth and housing can contribute to greater vulnerability. Social vulnerability also is a factor of place inequalities. These inequalities include the characteristics of communities such as the level of urbanization, growth rates, and economic vitality (Cutter et al. 2003). Key social and demographic characteristics that are elements of social vulnerability are population density and distribution, socioeconomic status, age, experience, gender, race or ethnicity, and wealth (Hill et al. 2001).

Beck (2009) has considered elements such as population density (people/square mile), females, non-Whites, Persons under 18, persons over 65, mobile homes and median income. Carmarines(2010) has assessed vulnerability in terms of economic aspect, socio-cultural-demographic aspect and physical aspects considering six, eight and seven elements under each aspect respectively. Community based vulnerability assessment conducted for two Coastal Indonesian cities (2010) has utilized elements such as total number of households, number of children between 8–17 not currently in school, ratio of households to Motorcycles,percentage of households with access to city water supply, number of households who uses public wells and number of times rubbish is collected per week when assessing vulnerabilities in block wise.

The disaster risk and vulnerability assessment conducted for Teso, Lango and Acholi sub regions have considered vulnerable conditions with respect to asset type and elements at risk under economic, natural, constructed individual and social assets. Koh (2010) assessed local vulnerability to climate change in Korean city of Gyeonggi considering the vulnerability as a function of exposure, sensitivity and adaptive capacity. It was identified 8 elements to measure the exposure, 10 elementsto measure sensitivity and 15 elementsto measure adaptive capacity.

Literature clearly shows that the elements play a huge role in making the use of VA which directed to make effective decisions on disaster resilient planning of human settlements. The elements must vary in terms of the type of disaster or combination of more. Therefore decision makers should aware about these different elements which vary on type of disaster under suitable category of dimension.

3.0 Methodology

As a finding of literature review, thirty three elements which are suitable for VA pertaining to both landslides and flood were identified. Application of right elements in VA can be done effectively when they are in different category of dimension without overlapping each other. Therefore all above identified 33 elements should be selected based on their significance in terms of different context of city under suitable dimensions. Theseelements were ranked according to the rank values indicating in following Table 1.

Table 1: Rank values used for factor analysis

Rank Value	Qualitative Value	Description
6	Very high important	The element was very highly important in vulnerability assessment
5	High important	The element was high important in vulnerability assessment
4	Moderately important	This element was moderately important in vulnerability assessment
3	Low important	This element was low importance in vulnerability assessment
2	Very low important	This element was very low importance in vulnerability assessment
1	Not important	This element was not important in vulnerability assessment

All elements were grouped using factor analysis considering the similar variance. Tabachnick and Fidell (2005) shows that factor analysis is based on the correlation matrix of the variables involved, and correlations usually need a large sample size before they stabilize. Robert (1999) advice regarding sample size: 50 cases are very poor, 100 are poor, 200 are fair, 300 are good, 500 are very goodand 1000 or more is excellent. Hence to have fair result of this study, it was conducted 200 questionnaires by consulting 200 expertise who are involving in disaster risk reduction and climate change mitigation and adaptation programs in Sri Lanka by following snow ball method.

Kaiser-Meyer-Olkinmeasure of sampling adequacy is 0.869 and explains the satisfactory sampling adequacy which explains that the data selected for the factor analysis are fair or suitable in sample. In the correlation matrix, the highest coefficient values under each element were 0.3 to 0.9 and any elements were not removed from the list. Principal Axis factoring method is used as extraction method since it is more applicable for analysis of ordinal variables. In next analysis Rotated Component Matrix further validates the results. Idea of rotation is to reduce the number factors on which the variables under investigation have high loadings according to the relationship between factors. Rotation does not actually change anything but makes the interpretation of the analysis easier. Promax is used as rotation and interpretation method to correlate factors. This factor analysis was produced nine componenrs (dimensions) according to the identified relationships as indicated in Table 3.All componenrs indicate Eigen values more than 1 as shown in following scree plot chart.The canonical correlation value between thesenine factors is 0.309, which is more than the Cohen's criterion of 0.3. Hence, the nine factors are interrelated.

Figure1: Scree Plot chart

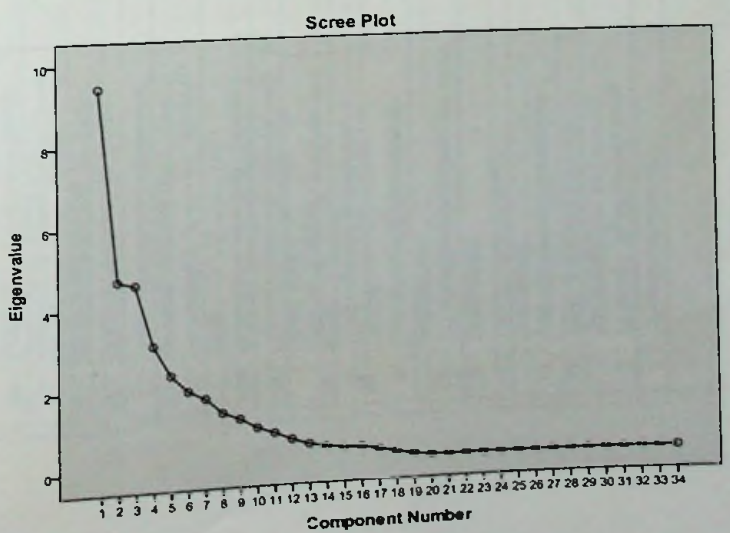

Table 3-

Rotated Component Matrix

Elements	Environment factors (1)	Education facilities and income (2)	Population characteristics (3)	Housing characteristics (4)	Economic properties (5)	Emergency Access (6)	Population (7)	Electrical and telecommunication (8)	Microorganism sites (9)
1. Population density	-.198		.243		.102	.206	.839		
2. Day and night time floating population		-.205					.548	.247	
3. Self-employed / Micro entrepreneur /informally employed			.844			.137	.273		.195
4. Proportion of female population			.825		-.154		-.266	.280	.110
5. Proportion of children and elder population			.809						
6. Number of differently-able people	.224	.196	.864	.121			-.198		-.204
7. Unemployed population		.359	.782					.772	
8. Industries (small, medium and large scales)	-.168	.635	.161		.606		-.281	.178	
9. Commercial areas (shops, ect)	-.189	.497	-.120		.731	-.200	-.190	.258	
10. Education level and Literacy Rate		.780						.366	.281
11. Availability of schools (nursery, primary, secondary)	.137	.817	.274	.306	.117		-.238		
12. Type of roof used for houses				.895		.147			
13. Type of wall used for houses	.154		.234	.838	-.158		.323	-.163	
14. Household income	-.120	.851					.216		-.249
15. Number of Samurdhi recipients	-.197	.751				.167	.366	.144	-.144
16. Condition of the roads (rough & muddy, gravel, asphalt, concrete)	.417	.191		.423	-.203	.577		.197	
17. Materials used for bridges (wood/bamboo, concrete, steel)	.153		.194	.120		.610			

18. Ecologically sensitive area(coastline, Wetlands, conservation area, forests)	.891	-.270	.135						
19. Agricultural lands(paddy, tea, chena)	.558	-.108	-.233		.473	.436	.189	.345	-.115
20. Open space, Parks and playgrounds	.684	.161		.326	.283	.339	.157	.295	.108
21. Medical centers and hospitals		.462	.265	.191	.161	.544	-.129	.428	.123
22. Electricity and Telecommunication lines	.493		.297		.580			.659	.340
23. Power plants and transmission networks	.322	.210	.553		.450	.414		.612	
24. Source of water supply	.465	.363	.345	.509		.133	.222	.183	-.233
25. Type of sanitation facilities	.255	.463	.393	.583	.135	.353	.101	.280	
26. Storm water, drainage and channel systems	.668	.154		.460		.141		.137	.166
27. Building density	-.364	-.152	.339	.311	.616	.234	.282	-.189	.122
28. % of temporary, semi-permanent and permanent houses	.285		-.267	.555	.402	.193	-.193	.257	.298
29. Solid waste dumping sites	.430	.791			.156	.154	-.148	-.113	.505
30. Land value	.325	.247	-.151	-.104	.767			-.251	-.209
31. Livestock farms	-.229	.162	.498	.274	.105	.261	.361	-.194	.520
32. Soil type/ character of slope	.630			.111	-.125		-.113		.628
33. Health condition (nutrition status/physical and mental health of people	-.112		.531	.315		.182	.409		-.123

Ecologically sensitive area (coastline, wetlands, conservation area, forests), agricultural lands (paddy, tea, chena), open space, parks and playgrounds, storm water, drainage and channel systems and soil type/ character of slope are substantially loaded on component one which is suitable to beknown as 'environment factors'. Education level and literacy rate, availability of schools (nursery, primary, secondary) are substantially loaded on component two which is suitable to beknown as 'education facilities and income'.Self-employed, micro entrepreneur or informally employed, unemployed population ,proportion of female population, proportion of children and elder population and number of differently-able people and health condition (nutrition status/physical and mental health) of people are substantially loaded on component three which is suitable to beknown as 'population characteristics '.

Percentage of temporary, semi-permanent and permanent houses, type of sanitation facilities, source of water supply, type of wall used for houses and type of roof used for houses are substantially loaded on component four which is suitable to beknown as 'housing characteristics'. Industries (small, medium and large scales), commercial areas (shops, ect), building density and land value are substantially loaded on component five which is suitable to be known as 'Economic properties'.

Condition of the roads (rough & muddy, gravel, asphalt, concrete), materials used for bridges (wood/bamboo, concrete, steel) and medical centers and hospitals are substantially loaded on component six which is suitable tobeknown as 'emergency access locations. Population density and day and night time floating population are substantially loaded on component seven which is suitable to beknown as 'population'. Electricity and telecommunication lines, power plants and transmission networks are substantially loaded on component eight which is suitable to beknown as 'electrical an telecommunication. Solid waste dumping sites and livestock farms are substantially loaded on component nine which is suitable to be known as 'microorganism sites'.

4.0 Case Study

The case study for this research is based on the project on "Disaster resilient city development strategies for Sri Lankan city" which is implemented by UN-Habitat in collaboration with University of Moratuwa in year 2012. This section of this research elaborates how the vulnerability elements have been applied, taking Ratnapura Municipal Council (MC) as a pilot city.RatnapuraMC is a city located in Sabaragamuwa Province of Sri Lanka which is frequently affected by floods and landslides. Rainfalls during the monsoon season are caused by the influence of both the south-west and inter monsoons, characterized by intense rainfall, and contributing to the highest amount of rainfall. During the monsoon, the two rivers Kalu Ganga and Way Ganga, which are flowing across the area, make riverine floods in Ratnapura MC Area which affect human lives. Landslides areone of the major hazards in Ratnapura MC Area which mainly affects the hilly areas. It will lead to rock falls, deep failure of slopes, shallow debris flows, decline of economy, damages to infrastructure and property and even loss of life.

Figure2: Geographical Location of Rathnapura MC

Source: Survey Department

The vulnerability assessment for RatnapuraMC was conducted taking the major dimensions and its respective elements obtained from the factor analysis method. The Table3 shows the different vulnerable elements and their significanceunder nine dimensions. The elements shown in Table 3 were selected based on the above literature review and stakeholder opinions obtained at the stakeholder meeting conducted at Ratnapura MC Area.The most significant elements were obtained from the rotated component matrix, by selecting values more than 0.5. They were highlighted in Table 3.

To measure the aforementioned elements, authors developed relevant indicators for each element. Then with the help of Geographical Information System, the indicators with respect to each element were spatially measured by dividing entire Ratnapura MC area into 10m×10m cells. In this manner, nine maps were prepared to represent the above nine dimensions.Then the vulnerability levels were classified based on the quantile interval method under 4 classes as low, moderate, high &very high. Figure 3, 4 & 5 show some of the dimensions prepared in this manner. Subsequentlyeach dimension was weighted considering the average values of vulnerability elements obtained from the factor analysis method. Finally the composite map was prepared by overlaying 9 weighted dimensions while classifying them under the same category of level of vulnerability. Figure 6 shows the final composite vulnerability map and dark area show the very high vulnerable locations.

Table 4: Vulnerability Dimensions obtained from the factor analysis method

Vulnerability Dimension	Vulnerable Elements	Indicators
Environment factors	Ecologically sensitive area (Forest)	Area covered by forest
	Agricultural lands (paddy)	Area covered by paddy
	Open space, Parks and playgrounds	Area covered by Open space, Parks and playgrounds
Education facilities and income	Education level and Literacy Rate	% of GN wise population based on education level
	Availability of schools (nursery, primary, secondary)	Number of primary and secondary schools
	Number of Samurdhi recipients	Number of Samurdhi recipients
Population	Population density	% of GN Population
Population characteristics	Self-employed / Micro entrepreneur /informally employed	% of GN wise self employed
	Proportion of female population	% of GN wise female population
	Proportion of children	% of GN wise children (14 > Age Group)
	Proportion of elder population	% of GN wise elder population (60 < Age Group)
Housing characteristics	Type of roof used for houses	% of GN wise houses with different roofing materials
	Type of wall used for houses	% of GN wise houses with different wall types
	Source of water supply	% of GN wise houses with different water sources
	Type of sanitation facilities	% of GN wise houses with different sanitation facility types
	% of temporary, semi-permanent and permanent houses	% of GN wise temporary semi-permanent houses
Economic properties	Industries (small, medium and large scales)	Spatial distribution of industrial areas
	Commercial areas (shops, ect)	Spatial distribution of commercial areas
	Building density	GN wise building density
	Land value	Spatial distribution of land values
Emergency Access	Condition of the roads (rough & muddy, gravel, asphalt, concrete)	Condition of the roads (rough & muddy, gravel, asphalt, concrete)
	Materials used for bridges (wood/bamboo, concrete, steel)	Materials used for bridges (wood/bamboo, concrete, steel)
	Medical centers and hospitals	Availability of Medical centers and hospitals
Microorganism sites	Solid waste dumping sites	Spatial locations of solid waste dumping sites
	Livestock farms	Spatial location of livestock farms

Figure3: Dimension – Environment Factors

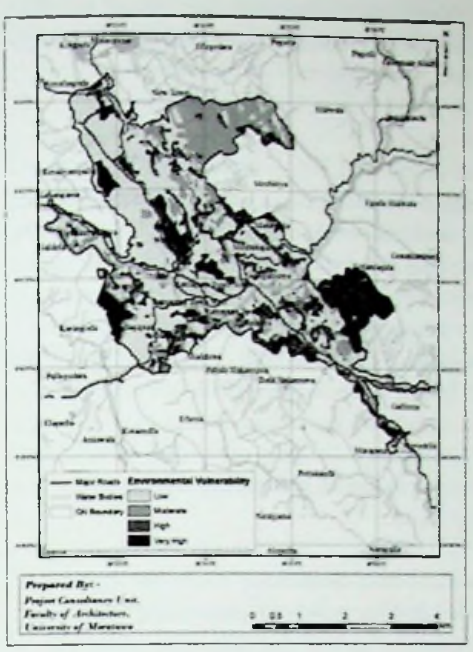

Figure4: Dimension – Economic Properties

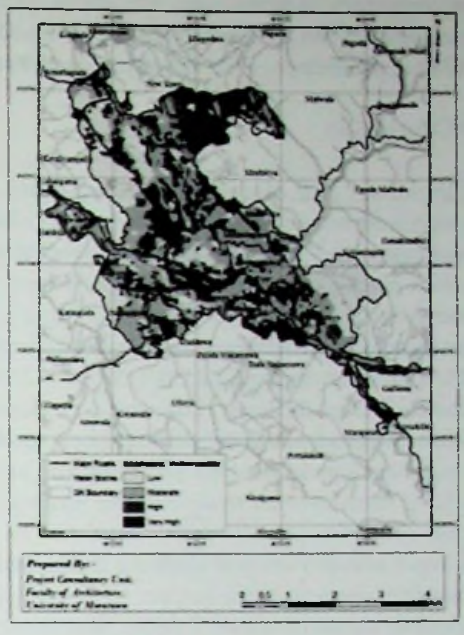

Figure5: Dimension – Population and Housing Characteristics

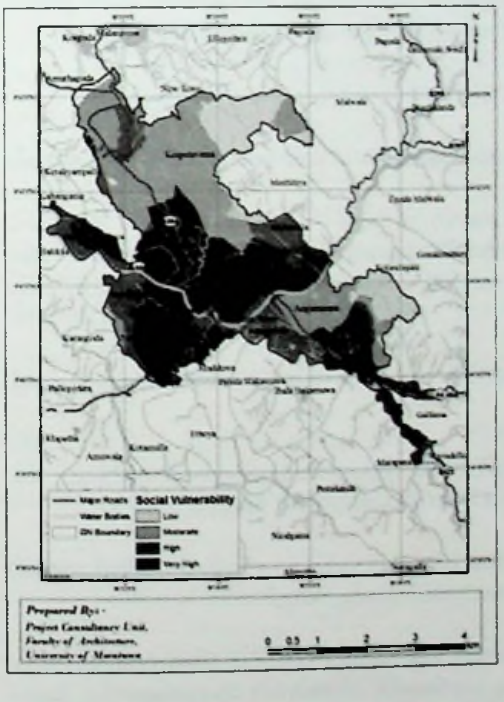

Figure6: Composite Vulnerability of Rathnapura MC

Source: Compiled by the Authors

The final composite map was further validated at ground level considering different levels of vulnerability in flood and landslide prone areas with respect to various types of elements. The final outcomes indicate that the above identified thirty three elements are more suitable forperforming VA pertaining to Landslide and flood disaster situations, since it shows the high level of applicability and accuracy in ground level.

4.0 Conclusion

An important goal of vulnerability assessment is to create an index of overall vulnerabilityfrom suitableelements. At present, there are no standard and accepted elements for vulnerability assessment with respect to different types of disasters. The responsible organizations related to disaster management sector adopt different elements and different dimensions to perform vulnerability assessment. As a result of this, it is hard to measure & compare the vulnerabilities of cities by means of developing a vulnerability index. Identification of suitable elements to perform vulnerability assessment and develop a vulnerability index is more useful in comparing the vulnerabilities of different cities where the flood and landslide are dominant.Therefore the factor analysis method used in this research guide the professionals who involved in disaster management sector, to select and categorize vulnerability elements in more objective manner and weighing them in order to develop the final vulnerability index.

The main results obtained from the factor analysis method help to identify the most significant vulnerable elements with respect to flood & landslide. It also helps to group the significant vulnerable elements under 9 major dimensions. The values obtained for different vulnerability elements under factor analysis method are also important in assigning weights for such elements. The factor analysis methodology adopted in this research is perform well with varying elements under different indicators, and permit the subjectivity in selection of elements. It also highlights the importance of expert judgment in the process of vulnerability assessment. This paper demonstrates further validation of nine dimensions taking Ratnapura as a case study area.

6.0 References

Alexander,D.(1993) Natural disasters-ulnerability to landslides: Landslide hazard and risked. *Chichister*,175–198

Amendola(1998)Approaches to risk analysis in the European Union. Risk assessment and management in the context of the Seveso II Directive.ed.Kirchsteiger, C.,*Elsevier, Amsterdam*, 3–18

Beck, A.J. (2009) A comparison of selected Wisconsin counties using an atmospheric hazard vulnerability assessment

Bohle, H.G., Downing, T. and Watts, M. (1994) Climate change and socialvulnerability: the sociology and geography of food insecurity,*Global Environmental Change,* 4, 37–48

Camarines,S(2012).Comprehensive house hold vulnerability and capacities analysis:, Bicol region, Phillipines, Available from http://www.actionagainsthunger.org/

Centr, J.H.(2000) John Heinz III Center for Science, Economics and the Environment: The Hidden Costs of Coastal hazards, Implications for risk assessment and mitigation, *Island Press*, 219

Community Based Vulnerability Assessment in two Coastal Indonesian Cities Resilient Cities Conference (2010),*Bonn.*

Camarines,S(2010)Comprehensive household vulnerability and risk analysisCommunity based Disaster Risk Reduction Project, *ACF International – Philippine Mission.*

Cutter, S.L., Boruff, B.J. and Shirley, W.L. (2003) Social vulnerability to environmental hazards, *Social Science Quarterly* 84(2), 242-61.

Cutter, S.L., Mitchell, J.T. and Scott, M.S. (2000) Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Annals of the Association of American Geographers* 90(4):713-37

Disaster incidents profile (2012) of Sri Lanka

Douglas, J. (2007) The Physical vulnerability modelling in natural hazard risk assessment,Natural Hazards and earth system sciences,*Copernicus Publications on behalf of the European Geosciences Union*

Dow and Downing (1995), Dow, K. and Downing, T.: Vulnerability research: where thingsstand. *Human Dimensions Quarterly*, 1, 3–5

Downing (1991), Downing, T.: Vulnerability to hunger and coping with climate change in Africa, *Global Environmental Change*, 1, 365–380

Fuchs,S., Heiss, K. and Hübl, J. (2007)Towards an empirical vulnerability function for use in debris flow risk assessment, Natural Hazards and earth system sciences,*Copernicus Publications on behalf of the European Geosciences Union*

Gabor, T. and Griffith, T.(1980)The assessment of community vulnerability to acute hazardous materials incidents, *Journal of Hazardous Materials*, 8, 323–333

Gilard and Givone (1997), Gilard, O. and Givone, P.: Flood risk management: new concepts and methods for objective negotiations, edited by: Leavesley, G.,Lins, H., Nobilis, F., Parker, R., Schneider, V. and van der Ven, F., Destructive water: water-caused natural disasters, their abatement and control, IAHS Press, Oxfordshire, 145–155, 1997.

Glade, T. (2003) Vulnerability assessment in landslide risk analysis, *Die Erde*, 134, 123–146

Glade, T. and Crozier, M. (2005) The nature of landslide hazard impact, Landslide hazard and risk, ed.Gladem, T., Andersonm, M. and Croziem M., *Wiley, Chichester*, 43–74

Gomes, J.(2003) Landslide susceptibility and risk maps of Regua (Douro basin, NE Portugal), *Proceeding of the IAG and IGU-C12 Regional Conference "Geomorphic hazards: towards the prevention of disasters", Mexico City, Mexico*

Hill, A.A. and Cutter, S.L. (2001) Methods for determining disaster proneness.AmericanHazardscapes: The Regionalization of Hazards and Disasters. ed.Cutter,S.L.*Washington D.C.: Joseph Henry Press,* 13-36

Kaynia,A.M. (2008) Probabilistic assessment of vulnerability to landslide: Application to the village of Lichtenstein, *Baden-Württemberg, Germany, Engineering geology*, volume 101

King, A. and Bell, R. (2005) RiskScape New Zealand: A multihazard loss modelling tool, in: *Proceedings of Earthquake Engineering in the 21st Century (EE-21C) conference*, topic 8: Technologies and trends for disaster monitoring and reduction

Koh,J, (2010) Assessing Local Vulnerability to Climate Change and its Implications: *the Case of Gyeonggi-Do, Gyeonggi Research Institute*

Messner, V. and Meyer, F. (2005) Flood damage, vulnerability and risk perception -challenges for flood damage research, *Department Ökonomie ,Permoserstr*, 15

Michael-Leiba, M., Baynes, F., Scott, G., and Granger, K.(2003) Regionallandslide risk to the Cairns community, Nat. Hazards, 30, 233–249

Mitchell, J. (1989) Hazards research.Geography in America.ed.Gaile, G. and Willmott, C. *Merill, Colombus*, 410–424

Papathoma, K.,Neuh¨auserl, B., Ratzinger1,K., Wenzel1,H. and Dominey-Howes, D. (2007) Elements at risk as a framework for assessing the vulnerability of communities to landslides, *Published by Copernicus Publications on behalf of the European Geosciences Union*

Petak, W. and Atkisson, A.(1982) Natural hazard risk assessment and public policy, *Springer, New York*

Pijawka, K. and Radwan, A. (1985) The transportation of hazardous materials: risk assessment and hazard management, *Dangerous Properties of Industrial Materials Report*, September/October, 2–11

Rashed& Weeks (2003) Assessing vulnerability to earthquake hazards through spatial multicriteria analysis of urban areas,*International Journal of Geographical Information Science*,17 (6)

Robert C. MacCallum, Keith F. (1999) Widaman, Shaobo Zhang and Sehee Hong, Sample Size in Factor Analysi, Psychological Methods, 1999. Vol.4. No. 1.84-99

Susman, O., O'Keefe, P., and Wisner, B. (1983) Global disasters: a radical interpretation. Interpretations of calamity.ed. Hewitt, K., *Allen &Unwin, Boston*, 264–283

Tabachnick and Fidell (2005), Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis, *Practical assessment, research and evaluation*, Volume 10 Number 7

Timmerman, P. (1981), Vulnerability, resilience and the collapse of society,*Environmental Monograph, 1, Institute of Environmental Studies, University of Toronto*

Volker,M. and Messner,F. (2007)Flood damage, vulnerability and risk perception challenges for flood damage research, UFZ Discussion Papers

Weichselgartner, J. (2001) Disaster mitigation: the concept of vulnerabilityrevisited, *Disaster Prevention and Management*, 10, 85–94

Wisner,B.(2004) Assessment of capability and vulnerability, edited by: Bankoff, G., Frerks, G. and Hilhorst, D., Mapping vulnerability, *Earthscan, London*, 183–193