Vulnerability Assessment of the Recently Urbanizing VDCs in the Outskirt of the Ring Road of Kathmandu - A case study in Dhapasi VDC

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Abstract: Population of the fringes of the Kathmandu metropolitan is increasing rapidly and population density is even higher than metropolitan in some VDC. The construction rate of the building are sky rocketing and the elements of the risks are increasing in both human and economic term. Thus there is urgent need of proper approach for the vulnerability assessment in these settlements. Vulnerability assessment is a complex process; only qualitative assessment process is adopted in this study. Rapid visual screening process and the questionnaire survey are used for the data collection. Fifty sample building from the ward 4 of the Dhapasi have been studied. Vulnerability assessment includes ground factors, building's physical conditions, and social (demographic and socioeconomic) aspects of the settlement. Vulnerability of the buildings and the settlement is studied on the basis of physical condition of the building, non-structural component, population density, housing density, age of the buildings and the ground condition. Land use planning, infrastructure development, building permit and the constructional trend in the Dhapasi VDC have been studied. Study shows, Dhapasi is urbanizing rapidly without development of the infrastructure. 45% of the buildings are constructed in last 5 years and reveals that most of the building constructed are vulnerable. From the study ill building construction, unplanned urbanization are the main reason for increasing vulnerability in the recently urbanizing settlements.

Keywords: Vulnerability; vulnerability assessment; urbanization; settlement.

1. Introduction

Vulnerability is defined as the intrinsic predisposition of the exposed element of being susceptible to suffer a loss as a result of the occurrence of an event with given intensity (Cardona.O.D, 2004). The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. (UNISDR, 2009). The vulnerability of a community is characterized by its susceptibility or the degree to which it is exposed to the risk posed by hazards, and its resilience or the capacity to cope with harm. (Guzman). Vulnerability is the function of the hazard, element of the risk (exposure). Building construction has been increasing without consideration of the building code which increases the physical vulnerability in developing VDC like Dhapasi, where growth rate of housing construction in last decade is 220% with the population density of 15,470 per sq.km. Different vulnerability analysis techniques have been studied and the physical vulnerability was assessed through Rapid visual screening and IIT-GSDMA method.

Urbanization is a positive trend with respect to the development process of country. The Kathmandu valley has experienced very rapid population growth during the last few decades (4.71 in 2001 and 3.8 in 2011). Different study shows, 95% of all death in the earthquake is due to the building failure (Thapaliya, 2006). From 1976-2009, the proportion of cultivated land in Kathmandu dropped from 61 % to 40% (Pant, 2010). Population growth has been increased much more in VDC than in the metropolitan and municipality.

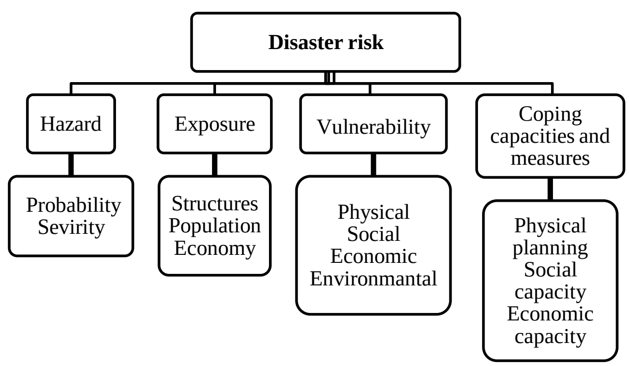

Figure 1.1 Conceptual framework to identify the disaster risk (Source :Birkmann 2006, p.23)

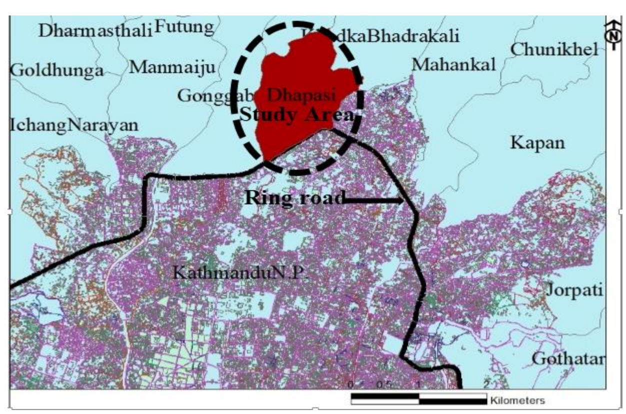

Figure 1. 2: Map showing the study area

2. Methodology for Vulnerability Assessment

2.1 Existing Vulnerability Methods

There are different tools for the seismic vulnerability assessment of buildings in the contemporary practices according to the type of the building and geographical and the site condition. Existing vulnerability assessment methods vary with different assumptions, for example, quantification of seismic hazard, building vulnerability assessment and building type. There is an increasing research in the development of seismic vulnerability assessment techniques (Alam, Alam, & Tesfamariam, 2012). The Table below shows various vulnerability factors, which are frequently utilized in different seismic vulnerability assessment techniques

Table 1.1: Major vulnerability factors considered in different vulnerability assessment methods

Vulnerability assessment method	Soft story	Over hang	Short column	Pounding possibility	Age of the structure	Building height
FEMA 154	N	N	N	N	Y	Y
FEMA 310	Y	Y	Y	Y	Y	Y
IITK-GSDMA	Y	Y	Y	Y	Y	Y
Euro Code 8	–	–	–	N	Y	Y
NRC	Y	Y	Y	Y	Y	Y
NRC	Y	N	Y	Y	Y	–
Turkish Method	Y	Y	Y	Y	Y	Y

Different methods of the vulnerability assessment are:

2.1.1 FEMA 154

To identify, inventory and rank potentially seismically hazardous buildings, Rapid Visual Screening procedure has been formulated in FEMA 154 (2002). This method is a relatively quick procedure in developing a list of potentially risky buildings, without the expensive detailed seismic analysis of individual buildings. A sidewalk survey approach is included, which enables the surveyors to classify the buildings into two classes using a cutoff scores, namely buildings acceptable as risk to life safety or buildings that may be seismically hazardous, where a detailed evaluation is required. A high score (i.e., above the cutoff score) indicates the adequate seismic resistance of a building.

2.1.2 FEMA 310

It is an advanced seismic evaluation procedures. FEMA 310 document describes a three-tiered procedure of increasing detail and reducing margin of safety for the seismic evaluation of existing buildings. Some structural, non-structural and foundation aspects have been discussed in the Tier 1 screening phase in the form of checklists for the chosen level of performance and given region of seismicity.

2.1.3 IITK-GSDMA

IITK-GSDMA is a wide-ranged guideline to assess the seismic vulnerability of different types of buildings within the Indian subcontinent region (Rai, August,2005) Particular classes of buildings, for example, unreinforced masonry (URM) and non-ductile reinforced concrete (RC) frame buildings, have been given special consideration for the assessment within this method (Rai, August,2005) which would be more suitable for the country like Nepal.

2.1.4 EURO Code 8

This document provides criteria for the seismic evaluation of existing structures. Here, the assessment process accounts both non-seismic and seismic actions for an existing building, for the period of its intended lifetime.

2.1.5 Modified Turkish method

In the Modified Turkish method, a multiple-level seismic vulnerability assessment for the existing reinforced concrete buildings is provided (Bommer J, 2002) The Modified Turkish vulnerability assessment method can be classified into three main groups depending on their level of complexity.

2.1.6 NRC Guidelines

National Research Council of Canada (NRCC) proposed a building vulnerability assessment methodology termed as NRC Guidelines (NRCC 1993), which is based on ATC-21 (1988). The NRC Guidelines consist of both structural and non-structural hazards, and the importance of the building is determined from the use and occupancy classes, where current Canadian construction practices are given more emphasis (NRCC 1993).

2.2 Rapid Visual Screening.

RVS is the simple method of the data collection from the field, based on the visual inspection alone. It is the kind of the statistical guidelines to the inspector to identify and inventory the vulnerable building. For Rapid Visual Screening the building are classified into 5 Category. **BM**: Brick with mud mortar, **ST**: Stone, **AD:** Adobe, **BC**: Brick with cement mortar,

RC3: Reinforced concrete frame with masonry type1; less than 4 storey, **RC5**: Reinforced concrete frame with masonry type1; 4 storey or more. (Type 1:-Regularly built. Type 2:-Well built.)

2.3 *Interpretation of RVS Score*

Having employed the RVS procedure and determined the building's Final Structural Score, *S*, which is based on the Basic Structural Hazard Score and Score Modifiers associated. Basic score and the score modifier is adopted from Paudyal 2008. (Paudyal, 2008) The probable damage can be estimated based on the RVS score and is given below. This table can be used as indicative to determine the necessity of carrying out simplified vulnerability assessment of the buildings.

Table 1.2: Expected damage as a function of RVS Score

RVS Score	Damage potential
S < 0.3	High probability of Grade 5 damage; Very high probability of Grade 4 damage
0.3 < S < 0.7	High probability of Grade 4 damage; Very high probability of Grade 3 damage
0.7 < S < 2.0	High probability of Grade 3 damage; Very high probability of Grade 2 damage
2.0 < S < 3.0	High probability of Grade 2 damage; Very high probability of Grade 1 damage
S > 3.0	Probability of Grade 1 damage

Source: Goyal

2.4 *Methodology*

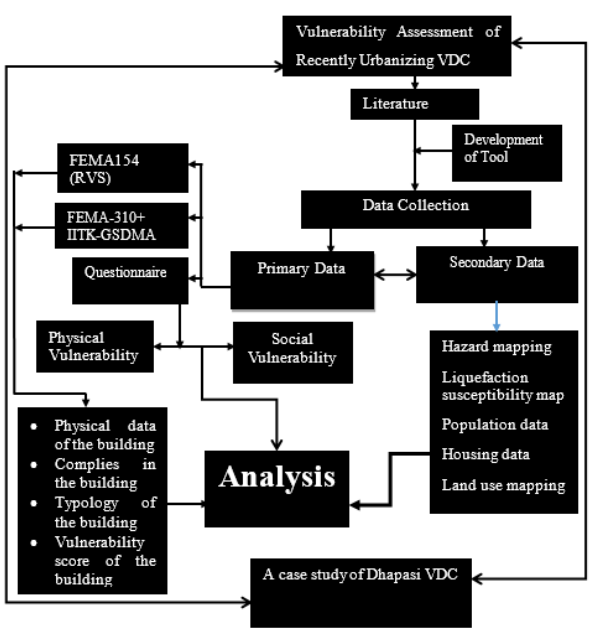

Figure 1. 3 Methodology for vulnerability Assessment

3. Case study

3.1 *Geology*

Dhapasi situated in the center of the tectonic bowl-shaped Kathmandu valley with the topography ranging from the flat to sloping landscape, adjacent to the Bisnumati River. Most of the land sandy soil with relatively high water table. According to the liquefaction susceptibility mapping of the Kathmandu valley by the UNDP, lower range of the Dhapasi near the river is highly susceptible to the liquefaction. Frequency which is dominated by the marginal fluvio-deltaic facies(river bed material) (Paudyal Y.R., 2012). There is very less soil explorations done in the valley except for the ground water exploration. The soil parameter for the building design and detail geotechnical information of the Kathmandu valley is not available. Most of the building of Dhapasi is low-rise residential building of 2-5 storey mostly made of reinforced concrete and few with adobe and brick masonry. The soil of Dhapasi have multiple resonance frequency, first resonance frequency is about 1 Hz and another is about 5Hz. And when the frequency of the building is equal or near to the ground frequency, resulting a case of resonance so the building with low and mid-rise are more vulnerable. Top 10-20m of the sediment layer plays an important role in making the second resonant effect in the basin. (Paudyal Y.R., 2012) The multiple amplified frequencies in a particular area can make a resonance effect both for low-rise as well as tall buildings of the valley.

3.2 *Ward wise household distribution*

The rate of the building construction in the Dhapasi has been increased rapidly due to location and the weak regulation for the building permit system. Ward 9 has maximum number of building.

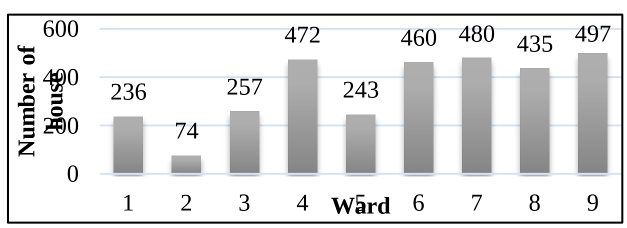

Figure 1.4: Ward wise household distribution

3.3 *Housing and population change in Dhapasi*

The population and the housing in the Dhapasi is sky rocketing. Due to different socio-economic and the availability land in relatively low price, population have been migrating in Dhapasi. With the increase in the population housing rate is also increasing in the same manner. All the old buildings are dominated by the modern RCC buildings.

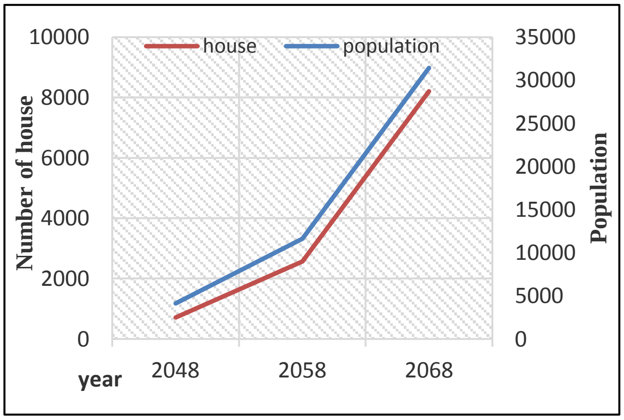

Figure 1. 5: Showing the increasing rate housing and population growth in Dhapasi

Figure 1.5 shows the population increasing rate is followed by unplanned housing construction which increases vulnerability.

Table 1.3 shows that ward wise distribution of the registered immigrant household in Dhapasi. Although the number of immigrant is higher in the ward 7 as a whole. Last decade immigrant in ward 7 (78) is lower than the ward 4 (183) which shows the ward 4 is urbanizing in last decade. This data still lacks the information about non registered immigrant in Dhapasi.

Table 1.3: Ward wise House hold change in last 16 years

Ward	Last 5 years	6-15 years	Before 16 years	Total
1	48	52	27	127
2	11	12	0	23
3	58	62	12	132
4	183	72	10	265
5	62	61	23	146
6	105	109	40	254
7	78	98	98	274
8	79	80	24	183
9	59	99	20	178
Total	683	645	254	1582

Figure 1.6 shows the housing pattern in the 1999 and the present map of the housing in Dhapasi. Initially low land price, easy accessibility from ring road, services as hospital, schools, commercials and government offices acts as the driving factors for immigrant. Its sound environment, facilities and the community are also the other factor. At present the land price in the Kathmandu metropolitan is high as well as due to the loose building permit system in the VDC people are migrating from core area of Kathmandu to these area, Which is even more than people migrating from outside valley (Dhapasi VDC, 2069).

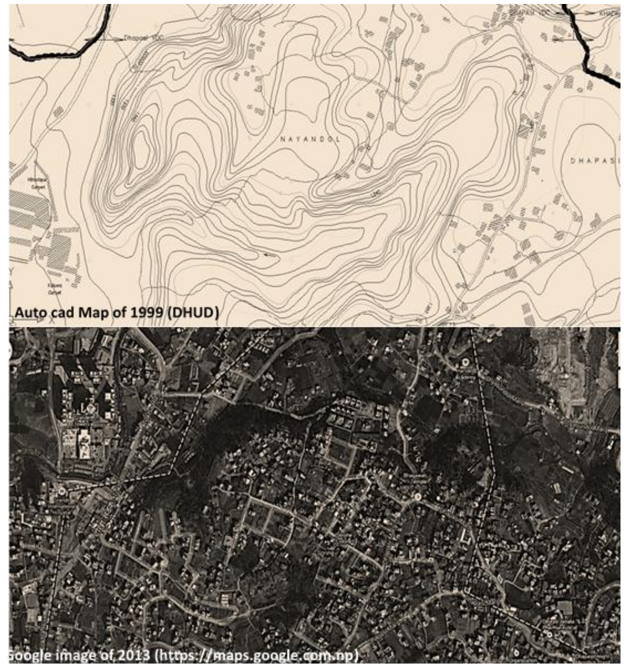

Figure 1. 6: Upper map showing the image of Dhapasi in 1999 and lower map showing the present image of the Dhapasi

3.4 Present construction trend

All the building recently constructed are modern with the use of the modern engineering construction material like brick, cement, sand, mortar, reinforcement etc. With non-engineering technology these building will be the lump of the concrete which can easily be damaged by the medium magnitude earthquake as in the Haiti in 2010. In Haiti One-story, single family dwellings comprise 63% of the housing stock in metropolitan Port-au-Prince and 72% in surrounding urban areas. Roughly 60% of all residential structures in Haiti are regular one-story dwellings, regardless of economic class were either damaged or collapse (Anna F. Lang, 2011).

Figure 1. 7: Settlement development process in Dhapasi

Figure 1. 8: Proper settlement development process

3.5 *Land fragmentation*

There are no any guidelines for the division of the land; unplanned fragmentation of the land is also increasing the vulnerability. Large chunk of the stepped agriculture land has been converted into the slope land for the building construction. Due to this the floor area of the most of the building has been reduced in the ground or building are attached to the either side of the plot which may cause the ponding effect.

Figure 1. 9: Unplanned land fragmentation pattern with temporary road in the Dhapasi

4. Analysis

4.1 *Building permit system*

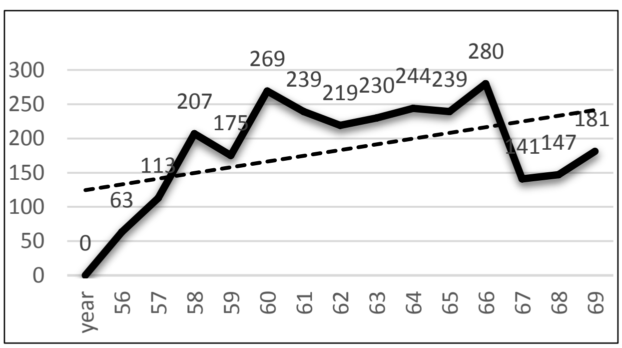

Figure 1. 10: Number of building permitted from 2056-2069 by Dhapasi VDC

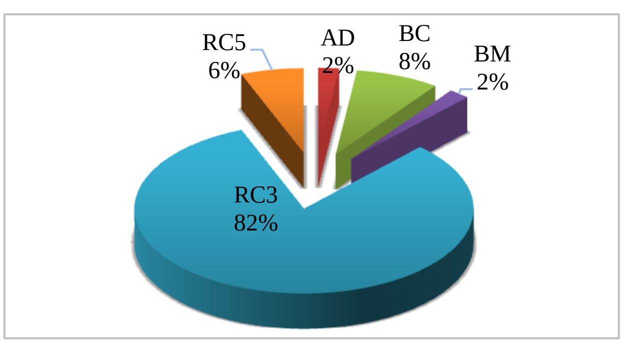

Figure 1. 11: Building distribution in study area by type

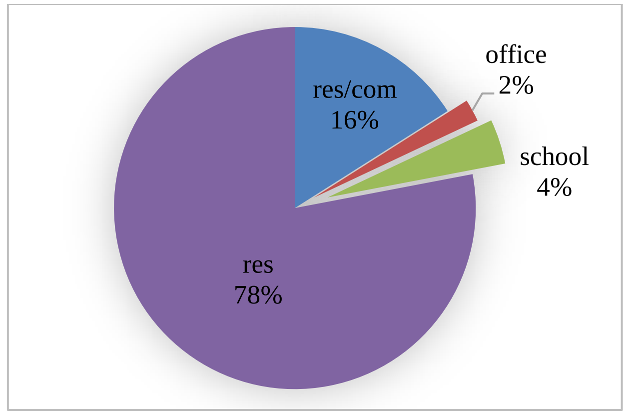

Figure 1.12: Building distribution according to use

4.2 *Buildings in the study Area*

Most of the building in the Dhapasi are recently built and are of Frame Structure type, used for the residential purpose and are low rise in type. Few of the building which are constructed before 2055 are load bearing structure with cement mortar or mud mortar.

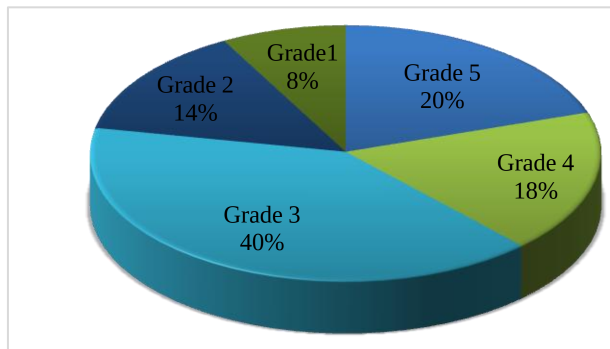

Figure 1. 13: building according to grade of damage

4.3 *Building Uses and configuration*

Building are used for the various purpose. 78% of the buildings are used as the residential building where 16% of the building are used for the both the commercial and residential purpose creating soft story in the ground floor.

According to the building code, the shape of the building should be rectangular with the length ration not greater than 3 times its breadth. 66% of the building are irregular in plan with ‘T’ or “L’ shaped, due to the shape of the plot, functional purpose and so architectural purpose. 74% of the surveyed buildings have vertical irregularity. Large overhang are constructed in order to increase the floor area of the upper part. The projection of balcony and the trend of designing of kitchen, store with puja and washing room in the top floor also helps in increase of the vertical irregularity.

4.4 Building distribution according to the grade of damage

Building damage is the function of the vulnerability. Higher the score obtained lower will be the grade of damage. The Grade of damage is calculated according to the expected damage as a function of the RVS score by (Goyal). 88% of the building are reinforced concrete building. Most of the old building fall in the damage grade of 5. Building taller than 5 storey fall in the damage grade of either 4 or 5.s

4.5 Age of the building

Dhapasi lies in urban expansion zone, lots of building are constructed in the recent year and many buildings are in the stage of the construction. 48% of the building are constructed in the last 5 years. The scenario of the building age is similar in the Dhapasi VDC.

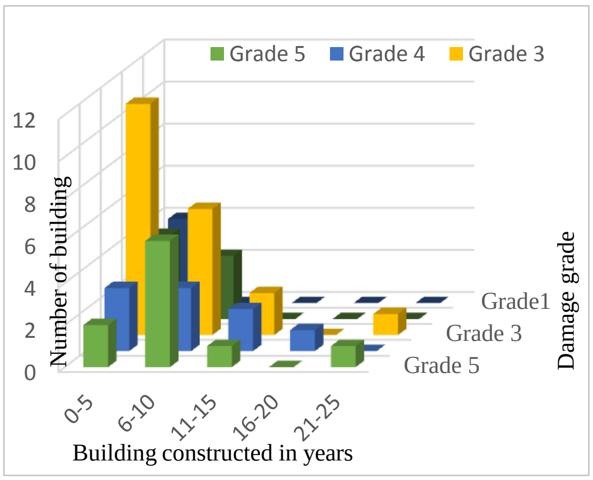

Figure 1. 14: Distribution of buildings on the basis of age and grade of damage.

Figure 1.15 shows the distribution of vulnerable and non-vulnerable building on the basis of the age of the building.

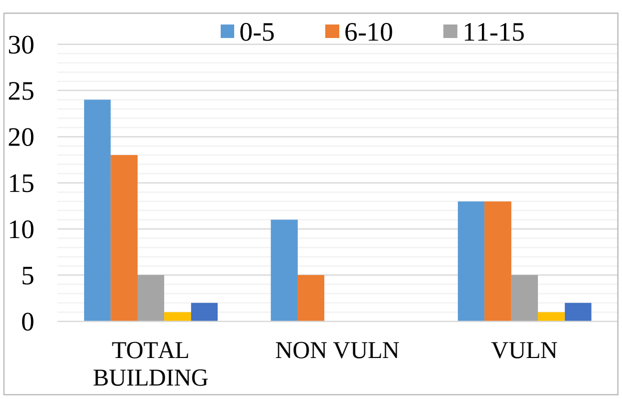

Figure 1. 15: Distribution of the building on the basis of age of building, vulnerable and the non-vulnerable buildings

4.6 Non Structural component

Non-structural elements include roofs, parapets, flower pot, chimneys, and facade claddings, which might cause injuries outside the building. Problems such as falling and breaking of the facade claddings are related to the material used and the method of application. The roof specifications are also examined for the problems that might cause injuries outside the building as falling of the roof covering etc. The cupboard book self and the utensils in the kitchen are other falling hazard. These nonstructural components are unknowingly increasing the vulnerability.

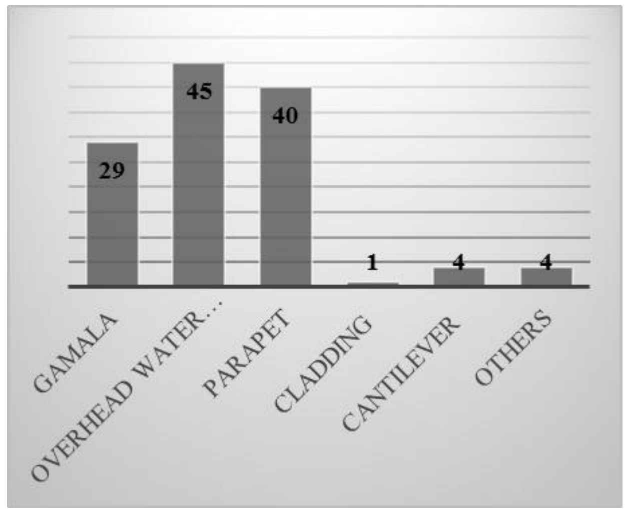

Figure 1. 16: Different non-structural element increasing vulnerability

4.7 People perception

People believe that the ill construction is main cause of the increase of building vulnerability. But the construction pattern and the material trend has not been changed. Another prominent cause of increasing vulnerability is the unplanned urbanization, which need to be addressed by the local authorities.

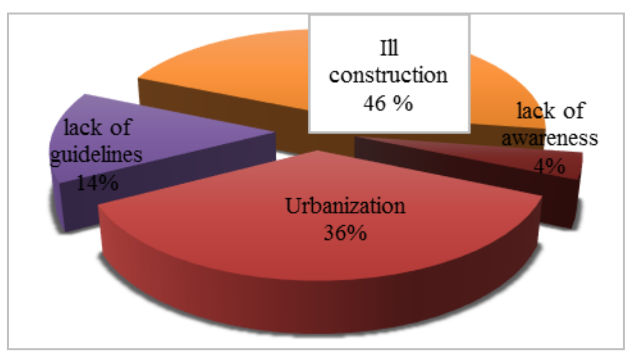

Figure 1. 17: Causes of increasing Vulnerability

People believe owners are responsible for the enforcement of the guidelines. Most of the owners have architectural drawing of their houses but building is totally different from the drawing, so VDC must be strict and proper monitoring should be done for the proper enforcement of the guidelines.

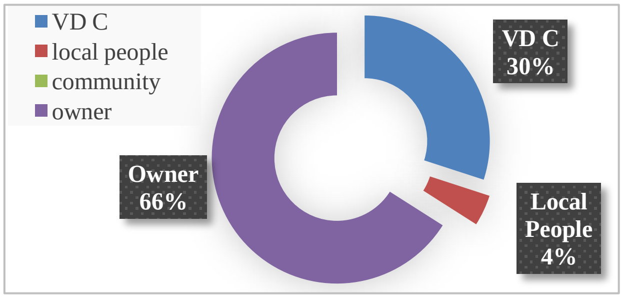

Figure 1. 18: Responsibility of implementation of guidelines.

5. Conclusion

Vulnerability of the building in the settlement like Dhapasi is increasing day after day due to the construction technology, use of the material workmanship and the violation guidelines for the safe building construction. Population and the houses are the main parameter to determine the vulnerability of the any region. Population in the Dhapasi is increased by the about 160% in the last decade and the housing construction rate is much higher than population change rate(about 200%) although the population size of the house is 4 person per house that means the house construction should be 1/4th of the population growth. Most of the recently constructed building falls in the damage grade 3 or damage grade 4 have architectural drawing but these drawing only acts as formality, 80% of the building differs from the architectural drawing. From the people perception it is also clear that vulnerability is increasing due to the ill construction practice. The increase in the vulnerability is due to the lack of the proper monitoring by the village authority during construction. So proper and strict monitoring provision should be made.

6. Suggestion and Recommendation

This study focus on the seismic vulnerability. So future study may focus on vulnerability assessment for the multiple hazard. Infrastructure vulnerability, social and the environmental vulnerability are the few important parameter of the settlement vulnerability, further study may incorporate all these factors. Risk assessment of the recently urbanizing area can be done. Detail seismic evaluation of the buildings which fall in the damage grade 5 can be done, which helps to get the actual vulnerability.

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