Urban Form and Seismic Risk Perception: Comparing two communities in Kathmandu, Nepal

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March, 2017

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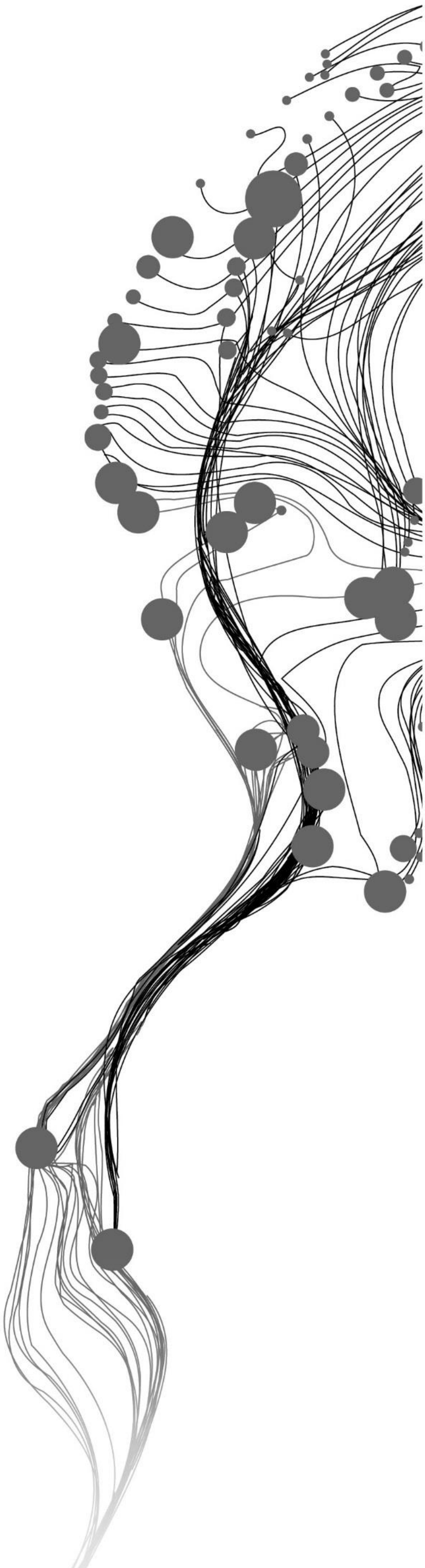

URBAN FORM AND RISK PERCEPTION: COMPARING TWO COMMUNITIES IN KATHMANDU, NEPAL

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ABSTRACT

Two powerful earthquakes struck Nepal in 2015 within two weeks with subsequent aftershocks continuing up to a month of the disaster. During the aftermath of the disaster, differences in coping mechanisms and adaptive capacity among communities were observed. Social cohesion among community members and sense of community strongly affects disaster risk perception of a community (Usamah, Handmer, Mitchell, & Ahmed, 2014) which are intrinsic characteristics that can significantly vary from one community to other. In this regard understanding perception of seismic risk among different communities becomes vital for developing an effective disaster management plans. Communities are shaped by their surroundings and urban form. During disasters, urban structure provide necessary space for continuing activities and also facilitate the recovery process for communities (Allan, Bryant, Wirsching, Garcia, & Teresa Rodriguez, 2013). This study aims to analyse distinct elements of urban form to identify its potential relationship with seismic perception of risk which is a novel approach in risk perception studies. A comparative case study of two communities with distinct urban form is used to aptly decode its influences on perceived seismic risk. Both qualitative as well as quantitative approaches are used. Expert interviews provide the basis for qualitative analysis and additional data was given by household surveys which also augment the quantitative analysis. An index for perceived risk at household level is developed which is used for multiple regression analysis and looked for spatial patterns. Furthermore, spatial analyses of escape routes and escape destinations provide insights into the immediate perception of seismic risk. The results of all the analyses are critically reviewed to present a holistic view of influences of urban form on perceived risk. The results reveal that urban form may indeed influence seismic perception of risk. However, these influences are not a consequence of an isolated element of urban form but a resultant of a combination of attributes of multiple elements. Size of open spaces and building height are found to be two of the significant determinant which may impact perception of people. It is also learned from this research the time component given by pre-disaster, during disaster and post disaster need to be incorporated while analysing perception of risk. Finally, cultural component and contextual realities seem to influence perception of risk.

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1. INTRODUCTION

This chapter is an introductory chapter which provides the base of the research. Firstly, an overview of the larger issue is briefly discussed and a research gap is identified. Then the research problem is conceptualized based on which the primary objective, sub-objectives and corresponding research questions are developed. An overview of the methodological outline is then briefly discussed. The chapter is concluded by providing the outline of the thesis structure.

1.1. Background and justification

Two powerful earthquakes struck Nepal in 2015 within two weeks. The April 25th tremor was measured at 7.8 in the moment magnitude scale (M_W) and the second 12th May was measured at 7.3 M_W. The disaster resulted in deaths of 8702 people and more than 22000 people injured. It destroyed almost half a million houses and affected more than 8 million people directly or indirectly. In response to the disaster, individuals and communities came together to help each other. This included voluntary mobilization of the youth and community efforts to solve immediate problems. These initiative were extremely helpful to overcome the ordeal for many individual and communities. People helping each other was one of the most important aspect of disaster recovery, especially immediately after the disaster. However, different parts of the valley reacted inversely to the effects of disaster. Some areas and communities were better at coping and adapting to the situation than others and thus were more resilient to the effects of the disasters.

Resilience as a concept has been defined and interpret diversely in literature. In context of disaster, it can be defined as "the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures"(UNISDR, 2005). It can also be viewed as set of capacities that can be fostered through interventions and policies, which in turn help build and enhance a community's ability to respond and recover from disasters (Cutter, Burton, & Emrich, 2010) in a timely and efficient manner (Cutter, Ash, & Emrich, 2014).

There is an increased acknowledgement in understanding and analysing community resilience as an integral part of disaster risk management (Doğulu, Karanci, & Ikizer, 2016). After a disaster, immediate help is directed towards a community and then to households and individuals. This ensures that the assistance provided aids the whole rather than its parts. Further, individuals and households are a part of a community and hence contribute to the resilience of a community as a whole. There are numerous factors that affects the resilience of communities. Such factors include "supports of neighbours, friends and relatives; access to communication facilities and transportation facilities; awareness programs, traditional knowledge, experiential knowledge, level of income, type of employment, geographic location, level of education" (Ranjan & Abenayake, 2014). Among these factors, many of them adhere to community relationships and highlight their importance. Social cohesion and sense of community strongly affects the community's perception and their resilience during disasters (Usamah et al., 2014).

Perception of risk is one of the crucial aspects that influences in decision making whether it is at individual level or community level. If people perceive risk to be real then it is more likely that they will act on it (Slovic, 2000). Risk perception can be understood as a "process of collecting, selecting and interpreting signals about uncertain impacts of events, activities and technologies" (Wachinger et al., 2010, p.8). This is important because it affects people's preparedness for, responses to and recovery from natural disasters (Bradford et al., 2012). In communities, the local perception of risk is an important aspect of resilience building as communities are different from each other in many aspects (Ranjan & Abenayake, 2014). In a study of two communities living in informal settlements, it was observed that these communities who live near disaster prone areas perceive disasters as a part of life and can resist and adapt to its effects (Usamah et al., 2014).

There are many factors at individual, community, and societal levels which shape perception (Doğulu et al., 2016). Among them, urban form of the settlements also affects the perception of individuals and a community as a whole. For example small, modular communities with a clear identity and defined boundaries have been found to exhibit a relatively high degree of social cohesion (Oliver, 2000). Winston Churchill famously proclaimed "we shape our buildings and thereafter they shape us". This influence is further highlighted during a disaster as "urban structure provides important sites for the continuing activities for the community and the start of the recovery process" (Allan, Bryant, Wirsching, Garcia, & Teresa Rodriguez, 2013, p.1)

1.2. Research Problem

An individual's reaction to risk is influenced by their perception of this risk (Hofer & Hamann, 2016) and is greatly shaped by communal and organizational factors (The Campbell Institute, 2014). This is clearly evident directly after disasters when people live in communal spaces and/or in public open spaces and often respond to the immediate situation in a unified way. These communal spaces and their attributes in turn affect how people behave. Several studies have shown how urban form can influence urban functions and behaviour of people. For example, streets that are well-integrated in the street system attract more movement (Marcus & Colding, 2011), encouraging communal activities and interactions. Hillier, showed correlation between street patterns and perceived security (Hillier, 2004). A similar correlation is evident in times of disaster when a city's spatial and functional diversity enables communities to facilitate their own recovery (Allan et al., 2013). However, there are many factors that can influence risk perception, and in the case of seismic risk perception urban form is possibly one of them because an earthquake itself does not kill people, but collapsing buildings and other infrastructure do. The number of open spaces, their location and accessibility are crucial factors that determine risk perception and thus the immediate response of people. Stakeholders at national, international and local and community level require information regarding the functionality and availability of these urban attributes to respond quickly and effectively to disasters. However, this particular relationship between risk perception and urban form has not been studied. As such, the aim of this research is to explore this potential relationship. If these relationship do exists then to what degree and what are the underlying reasons for it? If a relationship between risk perception and urban form is discovered, it could help policy makers to develop plans and policies aimed at disaster mitigation, and immediate and long term response which is specific to a community. It could also help urban planners and designers to plan and develop communities towards higher degree of resilience. Understanding disaster risk perception of individuals can facilitate disaster preparedness as well as support recovery processes. Furthermore, this research could provide insight in how individuals in communities perceive disaster risks and how they mitigate through it. This could be used by relief workers and emergency rescue teams to respond effectively and efficiently.

1.3. General Objective

To explore the potential influence of urban form on seismic risk perception of people at community level

1.4. Sub Objectives

i. To identify the dimensions of urban form of community level;
ii. To analyse seismic risk perception of people;
iii. To identify and analyse aspects of urban form that could influence seismic risk perception of people

1.5. Research Questions

The following research questions have been defined to reach the proposed sub-objectives.

- **To identify the dimensions of urban form at community level**

i. What are the elements of urban form at community level?
ii. What are the urban characteristics of selected communities?

- **To analyze seismic risk perception of people**

i. What factors influence risk perception?
ii. Which indicators can be used as proxy for psychometric analysis of perceived seismic risk?
iii. How does socio-cultural factors affect seismic risk perception?

- **To identify and analyze aspects of urban form that could influence seismic risk perception of people from the selected communities**

i. Which aspects of urban form is perceived significant by people to reduce/increase seismic risks?
ii. How does spatial distribution of open spaces influence perceived seismic risk of people?

1.6. Methodological outline

The presented thesis is an exploratory research as it attempts to find a link between urban form and seismic risk perception which has not been studied before. To this end, the concepts of risk perception (seismic), urban form and community has been extensively studied independently and in connection to each other. This assisted in defining each concept relevant to this research and also formulation of specific research objectives and research questions. After that, appropriate site were selected and preparations were done for collection of primary and secondary data. The collected data was then analysed through quantitative and qualitative analyses to derive outcomes. The obtained results are then discussed and interpret and further elucidated with the help of expert interviews. After that conclusions are drawn and finally, the whole research is reflected upon and recommendations are made linking once again to the broader context. The process followed throughout the research can be viewed in figure 1.

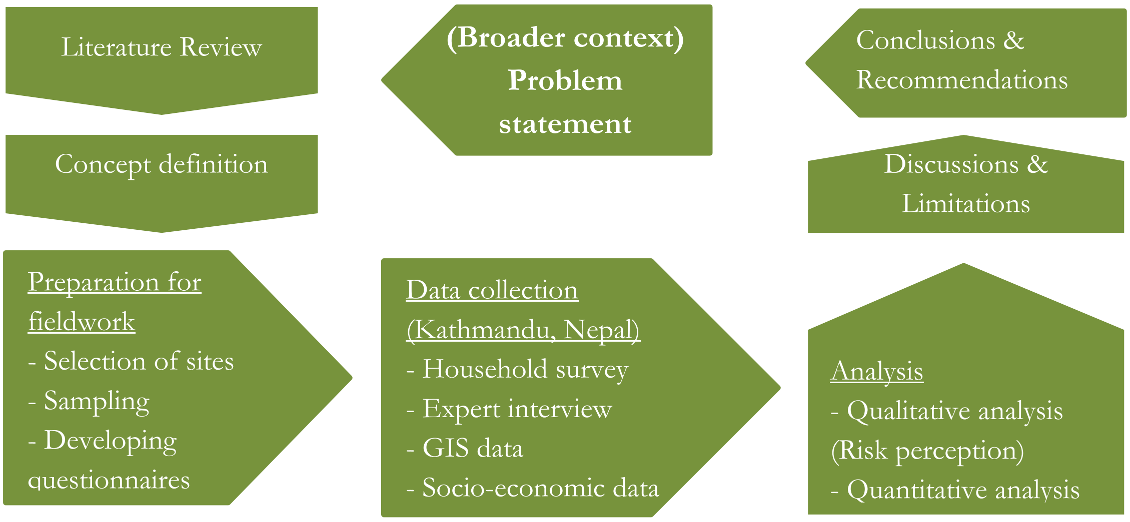


Figure 1 The methodological outline followed during the research

1.7. Outline of the thesis

The following sequential chapters present the outline of this thesis.
Chapter 1 is a brief **introduction** to the identification of the research problem, its background and provides justification for it. It also explains the objectives of the research and outlines the research questions.
Chapter 2 is a detailed study of the relevant **literature** which is required to ground the research problem in the sphere of existing theories. Here, the primary concepts are explored and defined for the purpose of this research.
Chapter 3 provides the detailed overview of the **methodological approach** undertaken and the processes followed during this research.
Chapter 4 presents the **results** of the data gathered from the survey. It gives a summary of the perception of people and describes some of the key component of urban form.
Chapter 5 provides a detailed **discussion** of this research in terms of the obtained results by critically reviewing them and presenting its relation with literature and the broader context. It also discusses in reference to methodological shortcomings and presents the limitation of the study.
Chapter 6 is the final chapter that provides **conclusions** derived from this research. It concludes with recommendations on furthering the research.

2. LITERATURE REVIEW

This chapter provides a review of the relevant concepts which are urban form, risk perception (seismic) and communities. It provides the theoretical basis of the entire research. Here the concepts are reviewed separately and also in relation to each other where possible. The conceptual framework has been developed based on the literature and it is presented at the end of this chapter.

2.1 Urban Form

In simple terms, urban form can be described as the physical and spatial characteristics of a location. It is "the spatial pattern of the large, inert, permanent physical objects in a city" (Lynch, 1981, p.47). It can also be described through three distinct elements, first, the town plan, or ground plan (comprising the site, streets, plots and block plans of the buildings); secondly, building fabric (the 3dimensional form); and thirdly, land and building utilization" (Conzen, 1960, pg.4). Urban form constitutes different dimensions depending upon the scale and can be described as 'morphological attributes of an urban area at all scales' (Hess et al., 2016). As such, varying scale constitutes varying attributes such as building materials, façades and fenestration at much localized scale, to, at a broader scale, housing type, street type and their spatial arrangement, or layout (Mike Jenks et al., 2008). Urban form should also take into account historical developments while reflecting upon the recent developments of a given area (Rose, 1967).

The dimensions of urban form are diverse and scholars have tried to explain it through its physical attributes and non-physical attributes. Some researchers have tried to explain urban form through its functions or through its development patterns. In this approach urban form is characterized by the way its urban centre has developed and is developing. In such a characterization density, continuity, concentration, clustering, centrality, nuclearity, land use mix and proximity are assessed (see Galster et al., 2001). If urban form is to be characterized by its properties then density, layout, infrastructure, accessibility, land use and building type are the dimensions of urban form (Mike Jenks et al., 2008).

While the emphasis is in the physical aspect of urban form, it also evident that non-physical properties such as density is a prominent aspect of urban form. Non-physical attributes are more prominent at community or city scale where the physical and non-physical elements interact and repeat themselves to form urban patterns. Lozano (1990) groups these patterns which have strong similarities and can be grouped conceptually into what are called concepts (Lozano, 1990, p.55). The elements of these concepts maybe street pattern, block size and form, street design, open space configurations (Jabareen, 2006). As evident, there are various ways how urban form can be categorized but for ease of understanding and its simplicity, this study does not use the process oriented definition of urban form. Here, urban form is used in its simplest form which is given in figure 2. which is taken from (Jenks et al., 2008).

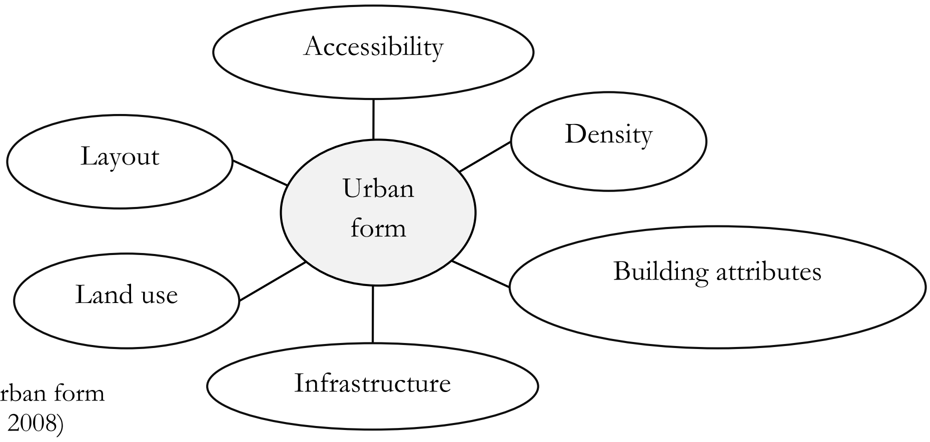


Figure 2 Dimensions of urban form
Source: (Mike Jenks et al., 2008)

Accessibility measure is a multi-layered concept and can be assessed in various ways. The traditional measure of accessibility is infrastructure based which aims to analyse performance of a transport system using indicators such as 'average congestion', 'average speed on network' etc. (Geurs & Ritsema van Eck, 2001). There are several other measures of accessibility such as activity based and utility based which looks into the number of opportunities or the benefits that individuals can gain from the land use transport system. During a disaster access to open spaces and emergency services become crucial. This can be analysed in terms of number of open spaces, hospitals and travel time from a given destination to these services. Other factors such as width of the road can also be important factor which can allow large emergency vehicles to reach the designated locations.

Density in its generic form can be calculated as number of people per hectare or number of households per hectare. However, this generic evaluation often fails to capture the true dynamics of the inherent complex nature of cities as it fails to provide information on how the urban density is distributed and how it manifests itself. Calculation of urban density is hindered by what the term 'urban' constitutes (Roberts, 2007) and thus the implications of calculated output highly depends upon the chosen units and how the area is defined. Further, perceived density can be subjective measure of how people view crowding and congestion. So it is better to use multiple density measurements to get a truthful view of calculated results (Jenks & Dempsey, 2005).

Land use is a broad concept and links with most of the other aspects of urban form directly or indirectly. It can be simply understood as the functions observed in a given area. The distinction of land use can have further classification based on the scale of an area. At neighborhood level land use mix is influenced by the demands and requirements of its residents (Urban Task Force, 1999). As such there is not a universally good land use mix and differs from neighborhood to neighborhood. Land use can be assessed in terms of residential, commercial, institutional, green spaces etc.

Building attributes measurements are dependent on the scale chosen. For example it can be assessed as housing types such as row housing, independent housing etc. To measure this, noting exception to the predominant housing types per streets can be an efficient way (Jenks et al., 2008). When individual houses are considered detailed considerations can be taken such as number of bedrooms, construction type, floor heights, building age, materials used etc. which can be important indicators for measurements.

Infrastructure measurements are essential in understanding urban characteristics. Availability of roads, electricity, cooking gas, communication services, sewerage systems are some of the basic infrastructure measurements which should be considered. Infrastructure measurements are more essential in developing countries (Jenks et al., 2008) because it is quite possible that one or many of these services are not available to the community.

Layout of an area can be difficult to quantify. However, there are spatial network analyses which can be undertaken to see the relationships between spaces of a given area at any scale. Multiple centrality assessment (MCA) is one of these assessment through which urban street patterns can be assessed through network analysis which are represented in relational graphs (Porta, Crucitti, & Latora, 2006a, 2006b). Street connectivity can also be analysed through the ratio of streets to intersection (Lowry & Lowry, 2014).

The assessment of individual urban elements can provide a detailed description of the urban characteristics and can provide valuable insights. However, it should be understood that many aspects are inter-related and overlap amongst themselves. Open spaces is one of the example which can be assessed in terms of land use, accessibility and urban layouts. It also links with density. In context of a disaster, it becomes necessary to also view the overall relationship of these elements such that the crucial aspects are not misinterpreted and underlying significances are captured.

2.1. Community

Community can be simply defined as a group of people living within a given geographic boundary. However, communities are complex entity that can have varied attributes based on their origins, geographical boundaries, language or shared values. This has led to diverse understanding of the concept of community which has been identified by various authors. A community can be a discrete social entity who share a collective identity and purpose based on geographical boundaries (Manderson, Valencia, & Thomas, n.d.). It can also be explained as "a human system of more than two people in which the members interact personally over time, in which behaviour and activity are guided by collectively evolved norms or collective decisions, and from which members may freely secede" (Boothroyd, 1990 pg. 81). Here the emphasis is on the collective which can be found in most definitions of a community. The notion of community is reinforced by social cohesion in absence of which its sustained development is not possible. This is often perpetuated though traditions and a unifying cultural heritage that develops over a period of time. According to Upadhya (2006) culture is the most prominent factor that ties a community together. A community can have humble beginnings instigated via a shared geographic boundary which later evolves into a complex entity sustained through culture and traditions. In this research, a generic view of community is used which is defined as a group of people within an identifiable geographic boundary that share something in common. This generic understanding of community recognizes the fundamentals of what a community constitutes and thus allows for diverse communities to be taken into consideration.

2.2. Urban form, sense of community and human behaviour

Rivlin (1982) noted the connection between urban form, place attachment and the development of local connections linked to a human's personal history and feelings of comfort and security. Giddens, 1984) described 'ontological security' as a human's initial point of security in the ongoing certainty and control of everyday life, sufficient and necessary to license them to participate in their activities of daily living and to achieve higher-order psychosocial development. Reliance in others and their community is seen as the deepest-lying element of the basic resilience system needed to control existential anxiety. A person's basic routines are profoundly disrupted by critical situations, when habitual ways of interacting with the world are swamped by a disaster. Self-identity and personal growth at any stage of one's life are hampered if one is stuck in a hostile, unpredictable, un-safe, anxiety invoking environment (Butterworth, 2000).

The provision of human services such as markets, post offices, banks and health care posts can impact on a person's sense of place and a community. For example, in rural areas, a post office or a simple bus stop area might enhance sense of the place "by representing a point of contact with the worlds both beyond and within" (Kearns, 1991 pg. 519). Kearns used the words, 'health of place', to depict a community's grade of unity and vitality; it can be seen that this term associates health with sense of place and sense of community (Butterworth, 2000). Hence, urban forms of any given place directly effects the behaviour of the people and ultimately the community as well.

Social support and interaction are the key elements to sustainable and conscious communities: "community life is sustained when social networks are strong, when there are humans with common interests and who feel a sense of common fate" (Berkowitz, 1996, pg.452). In most cases social support and interaction is provided by the urban squares and courtyards in the community themselves. Berkowitz specified that prospects need to be created to encourage inhabitants to physically see each other, in order to get to know each other through mingling and talking. Safe, attractive public spaces and venues need to be built to encourage community mixing. He stated that the route to community participation begins with seeing, and knowing, trusting, and finally acting it. Human initially tend to evaluate buildings as urban forms for their overall, affective impact, rather than for specific part (Rapoport, 1982). This follows that human's inclinations for specific urban areas or forms or classes of housing reflect the sense that these environments hold for them. Therefore, cities, squares, parks and houses not only stimulate specific feelings in beings, but offers clues about the outlooks of the people who planned them, and also about those who occupy or use them (Butterworth, 2000).

In addition to practical infrastructural requirements, communities and human have deeper desires which must be met, in order to be fully sustainable, such as sense of community to develop a conscious perspective (Berkowitz, 1996). Sense of community has been defined as "a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together" (McMillan & Chavis, 1986, pg. 9). Sense of community tries to illustrate the relationship between the individual, the social structure and the urban forms (Chavis & Wandersman, 1990). Sense of community is seen to reflect the symbolic interaction in which people involve as they use features of the physical environment. The sense of community hence arises from the common symbols people use to label their sense of belonging to and shared affiliation in a particular territory, as well as designating their particular personal territory (Butterworth, 2000). Usually communities like these develop organically over time, resulting from comprehensive configurations of communication, legends and identification. Affiliation can derive from the figurative boundaries and benchmarks that people use to denote their neighborhood/community (McMillan & Chavis, 1986), such as roads, buildings and landmarks. In local neighborhoods and communities, the symbolism of locally treasured architectural landmarks / urban forms can provide a sense of shared identity, as well as assist as a border from other districts. They provide people with a sense of membership and belonging. As a community/neighbourhood's buildings - private houses as well as public landmarks - provide the physical background by which people exists, go to community events and communicate with each other. Thus it follows that people will develop a collective emotional connection to their local built community benchmarks (Butterworth, 2000).

2.3. Risk Perception

Risk is the probabilities of consequence of adverse events (Slovic & Weber, 2002) and risk perception can be simply understood as people's intuitive risk judgments (Slovic, 1987). It can also be defined as "the subjective assessment of the probability of a specified type of accident happening and how concerned we are with the consequences"(Sjöberg, Moen, & Rundmo, 2004). Similar explanation is given by Febrianti (2010, pg.7)who refers risk perception as "subjective opinions of people about the risk, its characteristics, and its severity including multiple factors: individual's knowledge, of the objective risk, the individual's expectations about his or her own experience to the risk, and his or her ability to mitigate or cope with the adverse events if they occur". There are primarily two theories developed which tries to explain risk perception: the psychometric and the cultural theories.

The psychometric theory is rooted in disciplines of psychology and decision science (Sjöberg et al., 2004). The paradigm investigates the means by which people make quantitative decisions on their perceived risk from a situation and is widely referred to in the literature (Jasanoff, 1998; Slovic, 2000). It uses questionnaire to derive responses about risk characteristics (awareness, worry and preparedness) which is later quantified. This approach uses psychophysical scaling and factor analysis which used to generate quantitative representations or "cognitive maps" of risk perception (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, Fischhoff, & Lichtenstein, 1980)The derived responses are then tested against factor analysis to reveal the dread factor. If the dread factor is high, the perceived risk is also high.

The criticism of this approach is "it neglects individual differences in risk perception because of using aggregate data analysed using principal component analysis, and the explanatory power of the model is largely due to the inclusion of the dread items" (Sjöberg et al., 2004, p.25). Critics also argue that the psychometric scale is not fully able to grasp perceptions of natural events, such as earthquakes, because it is more fitting for studies of man-made hazards (Brun, 1992).

Cultural theory was developed by anthropologist and sociologists. The main principle of cultural theory is that "human attitudes towards risk perception are not homogenous but vary systematically according to cultural biases" (Olczyk, 2005, p.45). Many authors have expressed similar views such as "perception of risk goes beyond the individual, and it is a social and cultural construct reflecting values, symbols, history, and ideology" (Weinstein & D., 1989). It focuses on importance of culture on shaping human behaviours. It assumes that different cultures react to risks differently which is governed by values and beliefs which are controlled by the social context or relations (Coles, Hirschboeck, & Fryberg, 2009). This emphasis on social factors is logical as the perceived risk is against hazards. During disasters the actions of people are highly influenced by community settings for good or bad.

The cultural theory, too, has its criticisms. This criticism arises from grouping of people's (social units) behaviour and attitudes into 4-5 classes which doesn't aptly represent the complexity of human behaviour (Olczyk, 2005). It is further criticized for its weak methodological approach and empirical testing (Sjoberg, 2000). It is also considered difficult to operationalize (Armaş & Avram, 2008). However, it is still considered an important approach as sociological studies emphasize social influences mediate risk perception against hazards (Short, 1984). This theory also explains "important features of the social fabric at risk, contributing to an enhanced comprehension of risk perception and tolerance" (Olczyk, 2005, p.50).

2.4. Hazard risk perception (Seismic)

It is important to understand how people perceive risks of hazards because it gives insights on how they would behave during an occurrence of a disaster and could highlight their vulnerability against the risk. Further, it "provides the basis for understanding and anticipating public responses to hazards and improving the communication of risk information among laypeople, technical experts and policy makers" (Slovic, Fischhoff, & Lichtenstein, 1982). Past research has shown that mitigation measures, both structural and non-structural, when applied before investigating public perception of the hazard can be resisted by the public (Nascimento, Guimaraes, Mingoti, Moura, & Faleiro, 2008). This behaviour is understandable as people often oppose what they neither know nor understand and deem such measures unnecessary.

Kasperson and his colleagues believe that "risk and hazard events interact with psychological, social, institutional and cultural processes in ways that can heighten or attenuate individual and social perceptions of risk and shape risk behaviour (Kasperson et al., 1988). A study in Romania concluded that people's behaviour during a natural hazard is influenced by factors such as infrastructure, personal attributes, community support, access to resources/services, and institutional management (Armaş, 2006). The perception of risk is further dependent on the type of hazard as each hazard has its own attributes and affects the people differently. The proximity of hazards, its intensity and the return period are some of the factors that could affect how it people view the risk of it.

Seismic risk perception is simply defined as the perceived risk in relation to a seismic event. In seismic activity prone locations such as Nepal, it is essential to understand how people perceive these seismic risk as it shapes how people in different communities respond to it and eventually contributes to the resilience of communities. Understanding how earthquake risks are perceived by the public is an important first step for assessing a community's seismic vulnerability (Armaş, 2006; Armaş & Avram, 2008). It also gives an insight on how the people and community as a whole would cope against if an earthquake occurs.

Perception of seismic risk among the potentially affected population depends on demographic (sex, age, education, etc.) and social-economic factors among others. It is partly based on past experiences and memory. This is because disaster experience can change personal perceptions of hazards, and changes individual attitudes and behaviour concerning hazard preparedness. Past experiences also invoke memories of harsh conditions suffered during a disaster and keeps it real. The reality that a given natural hazard is possible and probable makes the risk of it real too. Slovic (2000) noted that if people perceive a risk to be real, then they would behave accordingly.

It is also closely connected to desire to leave for a safe area and degree to which the subjects consider the possible effects as well as how much they could retrieve their losses (Armaş, 2006; Armaş & Avram, 2008). This could be the result of social cohesion and bond within communities which are often heightened during times of disaster. A strong affective bond offers a feeling of safety and leads to neglect and even total denial of the danger (Armaş, 2006). This perception of risk and seismic adjustment attitudes are also shaped by the emotions and actions of other members of the community. When people observe increase in seismic adjustments of neighbours and other community members they tend to follow (Mileti, 1999). This shows that people's perceptions of earthquake risk and adjustment behaviours are governed by social-cultural processes.

It is quite clear that seismic risk perception can be influenced by many socio-cultural as well as psychological factors. If this understanding holds true, then it can be assumed that if perceptions affects human behaviour than the opposite should also hold true, i.e. human behaviour can be influenced if we can influence their perception of seismic risk. This manifestation of risk will ultimately shape how individual and communities as a whole respond before, during and after an earthquake. If properly understood, this knowledge could be crucial in developing mitigation measures and effective emergency preparedness and evacuation measures at household, community levels and even at national level.

However, it is quite difficult to define indicators that capture the entire determinants of risk perception. Risk perception may differ from one hazard to another and from one community to the other. However, risk perception is assumed to have similar and/or comparable attributes (Hofer & Hamann, 2016). Here, the list of factors that influence risk perception is derived from a report for DRIVER (Driving Innovation in Crisis Management for European Resilience) on risk perception. Figure 3 shows the important determinants of risk perception.

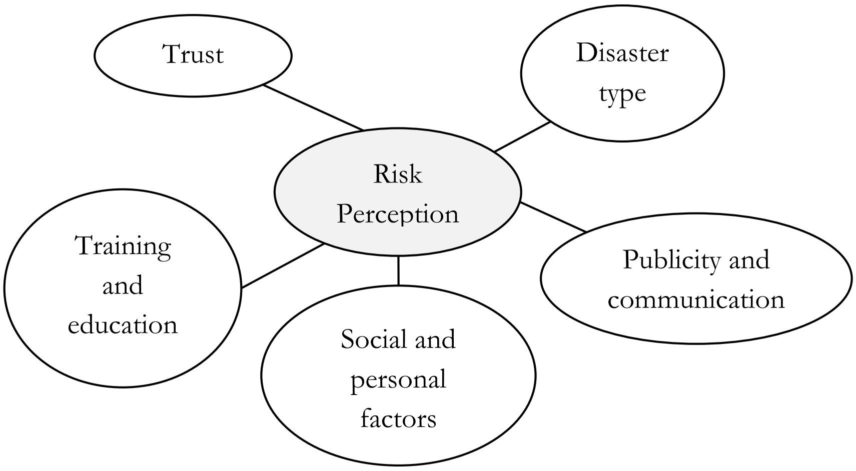


Figure 3 Different determinants of risk perception
Source: (Hofer & Hamann, 2016)

2.5. Conceptual Framework

To link the identified concepts and their linkages, a conceptual framework is proposed, figure 4. The framework presents the two main concepts: urban form and risk perception at community level. Here the primary focus is the relation between urban form and risk perception. The aim of the study is to understand how different aspects of urban form may or may not influence risk perception of individuals from different communities. Community is considered an important factor which binds the two concepts as distinct characteristics of urban form can be observed in two different communities. This in turn influences many factors which are deemed important determinants of risk perception. In this study only the influence of urban form on risk perception is studied and not vice versa. But it should be kept in mind that the relation flows both ways. Urban form is understood by its six determinants as learned from the literature. Risk perception is characterized by 5 major determinants where type of disaster is omitted because this research is specific to earthquakes as shown in figure 4.

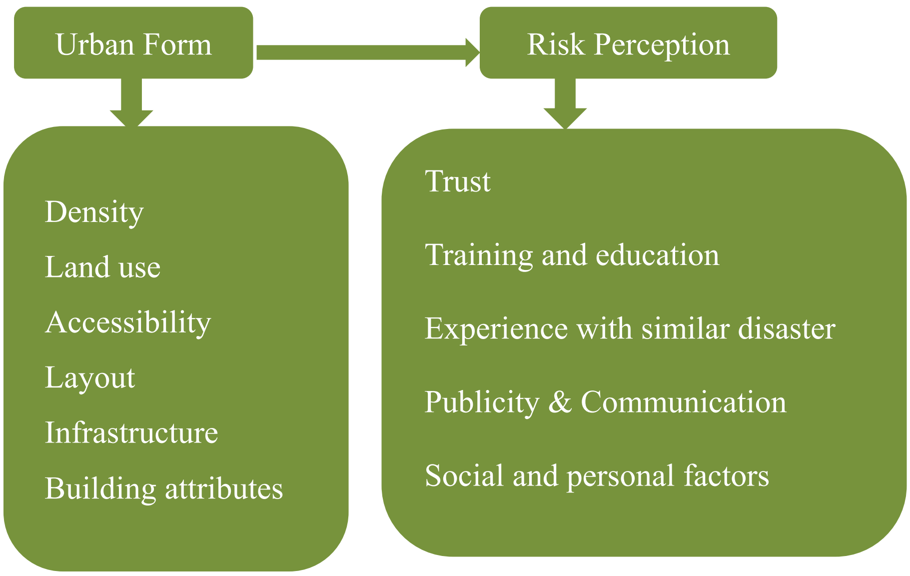


Figure 4 Conceptual Framework showing determinants of both urban form and risk perception

3. RESEARCH METHODOLOGY

This chapter explains the methodological approach followed during this research. The research is exploratory in nature. The primary goal was to explore potential relationships urban form and seismic risk perception. In this regard community is viewed as an important catalyst that allows and perpetuates such a relationship. Thus a comparative case-study approach was carried out at community level. Both qualitative and quantitative methods were used. Data requirement varied for the analyses of urban form as methods of analyses differ from each dimensions. GIS based data, i.e. building footprints and roads along with open spaces were vital for analyses. The data regarding risk perception of individuals was primarily gathered from household surveys. Qualitative research design facilitates investigation of subjective experiences enabling an in-depth understanding of risk perception. Expert interviews with various stakeholders such as local authorities, academicians, professionals and international partners were conducted to gain expert insights on this topic.

3.1. Selection of sites

Two communities within Kathmandu valley were selected as case study sites. The chosen sites were viewed as distinct communities as per the definition provided earlier. These communities were selected based on the observed differences in their urban form and socio-economic attributes. It is assumed that the potential relationship between urban form and seismic risk perception will be highlighted due to their distinct urban form and socio-cultural differences. Both of these sites suffered from physical damage and human casualties during the earthquake in 2015. Although the extent of damage incurred is different, the intensity of the earthquake felt by the people is assumed to be the same for both sites. This is because the distance from each sites to the epicentres of the two major earthquakes is similar and relatively very high than the distance of one site to the other. The distance from the epicentres is 173 km and 183 km for the first and second earthquake respectively and the distance between the two sites is 8km. The relative position of the two communities from the city centre of Kathmandu can be seen in figure 5.

Figure 5 Relative position of Panga & Nayabazar to the city centre

3.1.1. Panga

Panga is a small satellite town which is at a distance of around 6 km from Kathmandu city centre. It falls under Kirtipur Municipality. It was known in ancient times as Shankhapur because it was shaped as a *Shankha* (a sea shell). Historical evidence suggests that the town was established by King Ratna Malla with 300 Newar citizens in 1509 AD (Maharjan, 2008). It is a typical Newari settlement where the majority of the population are still Newar. The culture and traditions of its people can be witnessed in yearly festivals and many temples and shrines it hosts. This cultural influences can also be seen in its urban form. Its urban form developed organically, composed of courtyards of varying sizes interconnected by mostly narrow streets paved with stones or bricks. Most of the houses are traditional Newari houses made up of brick, mud mortar and wood via load bearing construction technology[1] (see figure 7a). However, due to modernization, changes in urban form can be observed in forms of concrete houses of higher number of floors. Although the changes have been more and more prominent in recent years, the core area of Panga still embodies a community rich in culture and traditions with distinct urban form and sense of homogeneity within its people. As such the only the core area of Panga is studied for this research. The area is initially defined based on google maps which is checked for compact built density. The demarcation of area is later verified with the locals of Panga. Figure 6, shows the tentative boundary of the core area of Panga which is around 8.5 Ha. Panga was one of the critically hit area during the earthquake, figure 7b. Figure Ta & 7b shows the type of building construction and building materials used and how the earthquake affected it.

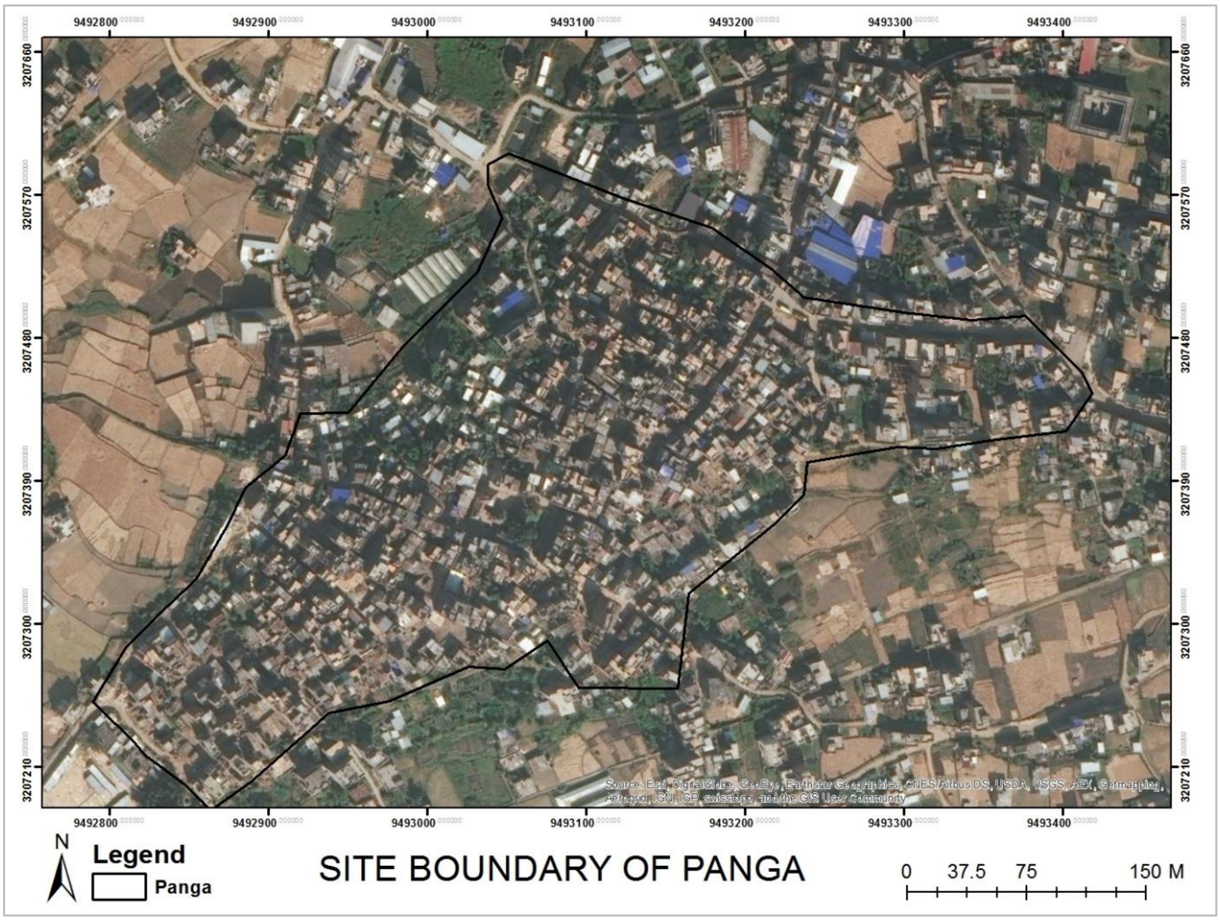


Figure 6 Aerial view of Panga, Kathmandu, Nepal
Source: Google maps

<u>*Footnote</u>

1: In load bearing technology, the weight of the building is transferred through walls thus making walls part of the structural that holds the building. The thickness of such walls is higher, usually equal to or greater than 45cm.

Figure 7a) Panga before the earthquake 7b) Panga after the earthquake

Source 7a: https://hiveminer.com/Tags/panga,temple

7b: http://andersryman.photoshelter.com/image/I0000_T9NcVSdGGw

3.1.2. Nayabazar

Nayabazar is a relatively new area just 1.5 km from the city centre. It was originally agriculture land along the Bishnumati River. It was initially developed to connect with Guided land Development (GLD) roads within this area, figure 9, and also the site boundary of the site. While doing so, land was readjusted in collaboration with the locals for a planned and well managed town with basic infrastructure (Pradhan, 2008) where in locals would lose part of their land proportionate to the total land area. The total project area was around 42 ha under two different wards. The project completed in 2000. The urban form of this area is characterized by hierarchical roads with plots on either side. Initially, the type of development in these plots was mostly housing. There are many houses which are mixed with shops in ground floor, some commercial activities. There are also few industries and recreational buildings. There was a huge influx of emigrants in this area thus there is a diversity in the socio-economic demographics of the place. Some of its roads are established as routes for public vehicles as seen in figure 6a. It also provides an overview of the urban character of the whole area. Figure 6b shows one of the collapsed concrete buildings after the earthquake. Due to the heaviness of the concrete structures, it was impossible for locals to rescue people trapped inside the buildings. In such cases, they had to wait for emergency rescue services, or police forces with necessary tools and equipment to rescue them.

Figure 8a) Nayabazar before the earthquake 8b) collapsed house due to earthquake in Nayabazar

Source 8a: http://www.panoramio.com/photo/87973057

8b: http://www.alamy.com/stock-photo/quake.html?pe=001&so=20&page=6

Figure 9 Aerial view of Nayabazar
(Source: Google maps)

3.2. Research Design

As mentioned before, a mixed method approach for analysis is used. The primary approach is qualitative, wherein, household surveys and expert interviews are used to understand the various determinants of urban form and risk perception at community level. It is then critically analysed to identify potential relationship between these concepts and synthesize the role of community to instigate such a relationship. The quantitative approach was used to observe the spatial relationship. The aim was to gain insights on implications of quantitative attributes of urban form into the subjective perception of risk. The data required for both qualitative and quantitative analysis were collected during fieldwork. The following diagram 8 gives an overview of the methodology followed in this research.

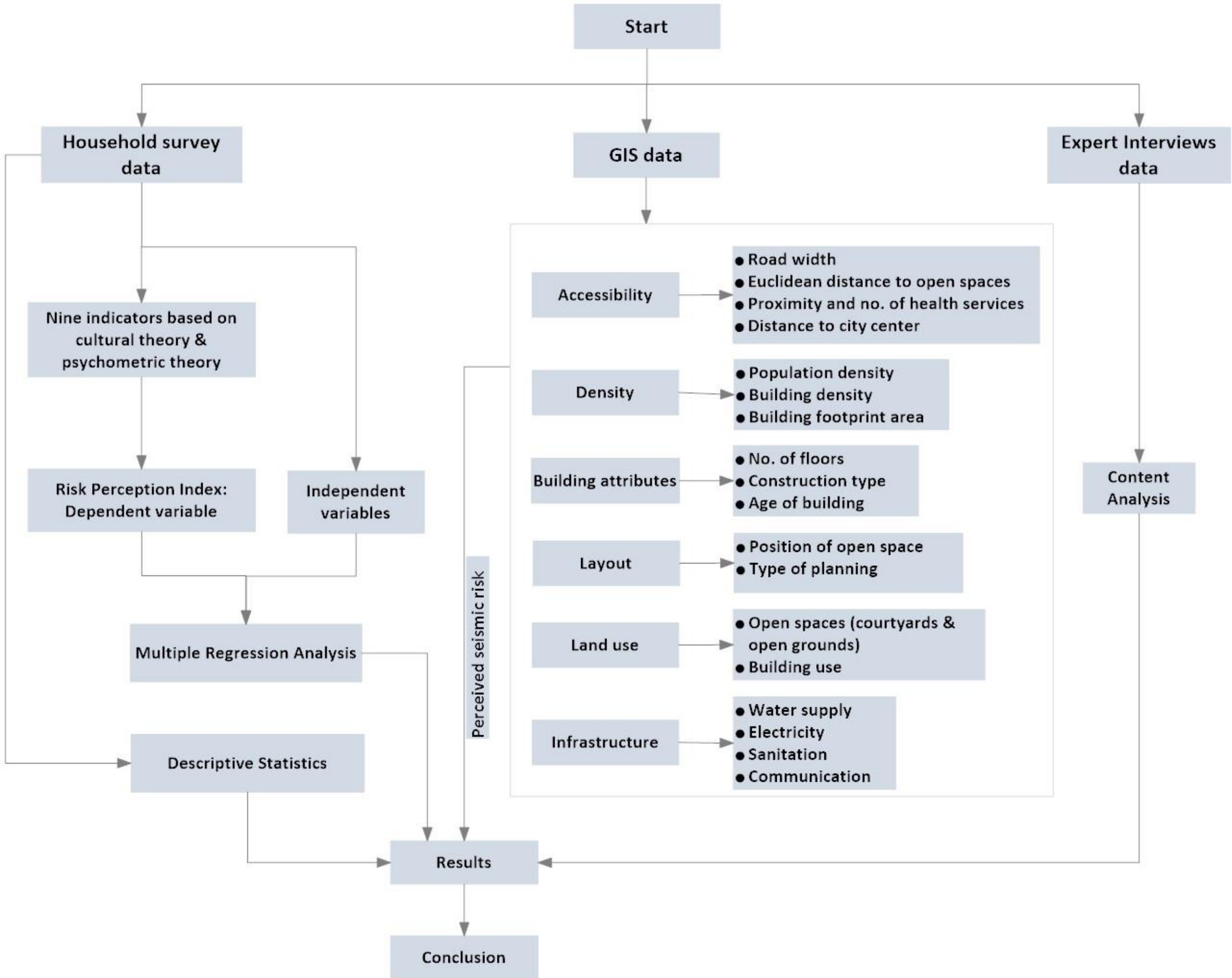


Figure 10 Overview of the general methodology followed in the research

3.2.1. Indicators

To operationalize urban form and risk perception specific indicators were developed based on literature as well as logical rationale (table 1). Some of the indicators used were context based such as member of a religious/cultural institutions. Nepal is country where cultural practices and rituals are an important of daily life and influences people's perception. Cultural institutions have existed for centuries and are highly revered and trusted. For example, most Newar families are part of a *Guthi* organization. *Guthi* is a religious and socio-culture based organizations in which you become member based on your blood line. These organizations play a vital role in cultural and religious sides of way of life and govern what to do and what not to do during a given religious/cultural functions. Some of the indicators used for risk perception required information that are very subjective and thus are presented in the form of degree value. These indicators were based on Likert scale responses in the questionnaire. Likert scales are capable to measure variation in attitudes and are easy for the respondents to express their perception (Subedi, 2016).

Table 1 Determinants and their possible indicators

	Determinants	Indicators	Rationale/References
Risk perception	Trust	Degree of community bond	A strong bond among people in a community leads to increased trust among people.
		Location of stay after the earthquakes	People will prefer to stay with community members who they trust during disaster period.
		Degree of perceived safety in a given community	This will show the degree of perceived risk they feel within a community
		Member of a Religious/Cultural institution	Religious/Cultural institutions are highly respected and trusted by most people in Nepal
	Training and education	Awareness of earthquake safety (pre-disaster0	It shows the inclination of people to take measures against seismic risk.
		Degree of perceived preparedness (pre-disaster)	It explains the perceived severity of a seismic risks. If people perceive risk to be real then it is more likely that they will act on it (Slovic, 2000).
		Education level of people	Buckle, 2000; (Armaş, 2006)
	Publicity and communication	Number of awareness programs in the community (pre-disaster)	Higher the number of awareness programs higher the chances of publicity and communication
	Experience of similar disaster	Number of earthquake events that affected Kathmandu in last 10 years (above 6 Richter scale)	This gives an approximation of experience of earthquake. To ensure people's remembrance of the experience, magnitude 6 and 10 year period is chosen as threshold values.
	Social and personal factors	Age	(Armaş, 2006), (see table 2). Older people are usually the most vulnerable which can influence their perception.
		Gender	(see table 2), (Armaş, 2006). There are often distinct differences in how women and men perceive things.
		Income	(Armaş, 2006), see table 2. Higher income means increased ability to cope against disasters and vice versa.
		Employment	(Victorian Government, 2000); (Armaş, 2006). It can offer insights into the adaptive ability of a person.
		Caste	Nepal is a caste based society, as such it can influence people's behaviour.
	Proxies	Willingness to move	(Armaş & Avram, 2008). This shows how people view riskiness of a given area.
		Perceived damage of houses	Damage to the house is a clear visual reminder of the risks imposed by an earthquake
		Perceived effects to personal life	(Armaş & Avram, 2008). Effect to personal life is likely to influence perception of risks.
		Ownership of building	(Armaş & Avram, 2008). Ownership hints at socio-economic attributes of the respondents

Urban Form	Density	Number of buildings per ha	(Mike Jenks et al., 2008), (Forsyth, 2003). It gives a simple overview of compactness of the area.
		Number of people per ha	(Roberts, 2007), (Forsyth, 2003), (Mike Jenks et al., 2008). It gives a simple overview of compactness of people
	Land use	Use of building (residential, commercial etc.)	Use of building can offer insights into functionality of the building.
		Number of public open spaces	Open spaces are vital for people for immediate safety and shelter. It could also include schools with big playgrounds.
		Location of open spaces	The closer the open spaces, easier it is to get there during an earthquake.
		Size of open spaces	Larger open spaces accommodate more people. They have enough space for movement and can allow space for collapsing buildings, if any.
	Accessibility	Distance to open spaces	Open spaces are vital for people for immediate safety and shelter.
		Distance to hospitals	Hospitals are one of the prominent emergency service required during a disaster.
		Width of roads	Large emergency vehicles are inaccessible in small roads, especially due to high possibility of debris.
		Proximity to city centre	Proximity to city centre suggests higher potential of immediate response during a disaster as city centre is easily accessible and considered valuable.
	Layout	Ratio of streets to open spaces	This will show the accessibility of open spaces in a community.
		Type of layout design	It gives the overview of patterns of street and open spaces
	Infrastructure (post disaster)	Availability of water	Water is one of the basic requirement for survival
		Availability of power (electricity)	Electricity is necessary variety of functions such as for light, heating, communication
		Availability of sanitation (sewerage and drainage)	Sanitary situations determine the health of people which are especially important after a disasters as people live together in groups.
	Housing & Building attributes	Construction type	Different types of construction technology react differently to the effects of earthquake.
		Age of building	Buildings have a life span. Older the buildings, it is more likely to have structural problems.
		Damage incurred	This is relevant in case of disasters as it directly shows the effects of a seismic event.
		Number of floors	(Armaş, 2006), taller buildings can be psychologically intimidating during earthquake

3.2.2. Primary data collection and methods: Household survey

The primary data was collected through house hold surveys. A questionnaire was developed based on the indicators for each concepts. The questionnaire was then translated into local language. The questionnaire contained questions in both languages. It was tested among Nepalese students at ITC before leaving for fieldwork. The indicators used for the survey were classified into four categories: general information, urban form, risk perception and communities. The classification was done so as to facilitate the interviewers asking the questions in a structured manner and to prepare the respondents to setup a frame of mind for a given class of questions. Four interviewers were selected for the survey. All of them were architecture students (finished school, waiting for final results) who had related experience in household survey after the earthquake in April, 2015. They were trained in group by demonstrating correct methods for recording each type of data for all the questions. Each surveyor was then tested by asking them to conduct the survey with the author as a dummy respondent. The sampling strategy used for the household survey was spatial random method i.e. each location was first divided into 4 parts such that the resulting areas were similar in size and density of buildings. This was achieved using major streets and roads where possible. Then the interviewers were asked to conduct the survey such that after one household survey they would skip two houses and conduct the survey on the third house. In case the respondents were unwilling or absent, the survey would be carried out from the next house and then followed the initial pattern of one in every three house. Each surveyor would give a unique household id for the surveyed house and mark the house in the map so that later on GIS analysis could be carried out. The classified areas for Panga and Nayabazar is shown in fig 11.

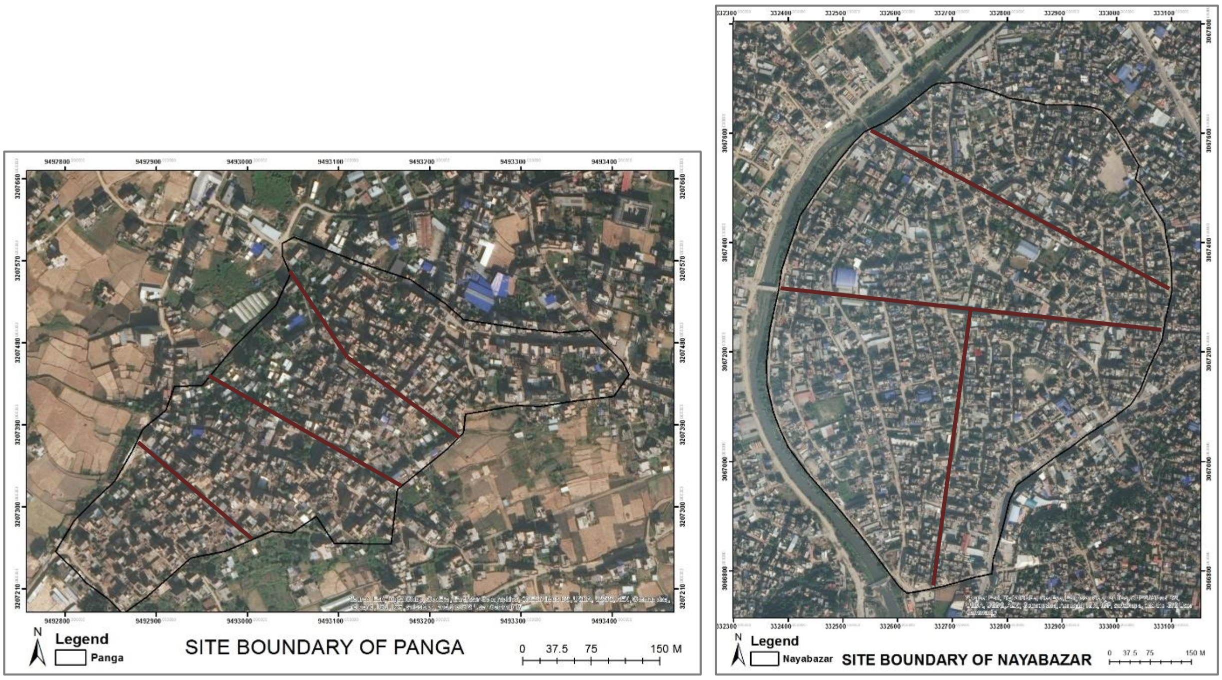


Figure 11 Demarcation of boundaries for stratified sampling in Panga (left) and Nayabazar (right)
Source: Google Maps

The first category in the household survey is about general information where indicators such as age, income, employment, gender, caste, education and profession were included. These indicators were insightful to know about the person and should explain some of the behavioural traits inherent in them. Previous studies have shown gender, income are important determinants of how people perceive risk (see table 2). Caste as an indicator was chosen to highlight the distinct differences in the socio-cultural attributes of the two community and also provide information about the cultural aspect of the respondents.

Table 2 General indicators for socio-economic attributes and their references

S.N.	Indicators	References
1.	Age	Davidson, 1997; Granger et al., 1999; King and MacGregor, 2000; Pelling, 2003; (Armaş, 2006)
2.	Gender	Granger et al., 1999; Fordham, 2000; (Armaş, 2006)
3.	Income	Granger et al., 1999; Dwyer et al., 2004; (Armaş, 2006)
4.	Residence type	Bolin and Stanford, 1991; Dwyer et al., 2004; (Armaş, 2006)
5.	Employment	Buckle, 2000; (Armaş, 2006)
6.	Education	Buckle, 2000; (Armaş, 2006)

Source: (Armaş, 2006)

The second category is regarding urban form. Here indicators such as ownership, construction type, building use, age of building, number of floors were included. Furthermore, people were also asked to indicate the perceived damage of their house. This was determined through a 5 point Likert scale which had options from no damage to complete destruction. These indicators provided an overview of the physical and non-physical aspects. In addition to this, the questionnaire also included maps where respondents pointed the location they went after the two major earthquakes. The routes to these locations were also pointed out in the maps (Figure 12). Red colour was used for first escape route and green colour was used for second escape route. The aim was to see the spatial characteristics of reaction of people during the earthquake.

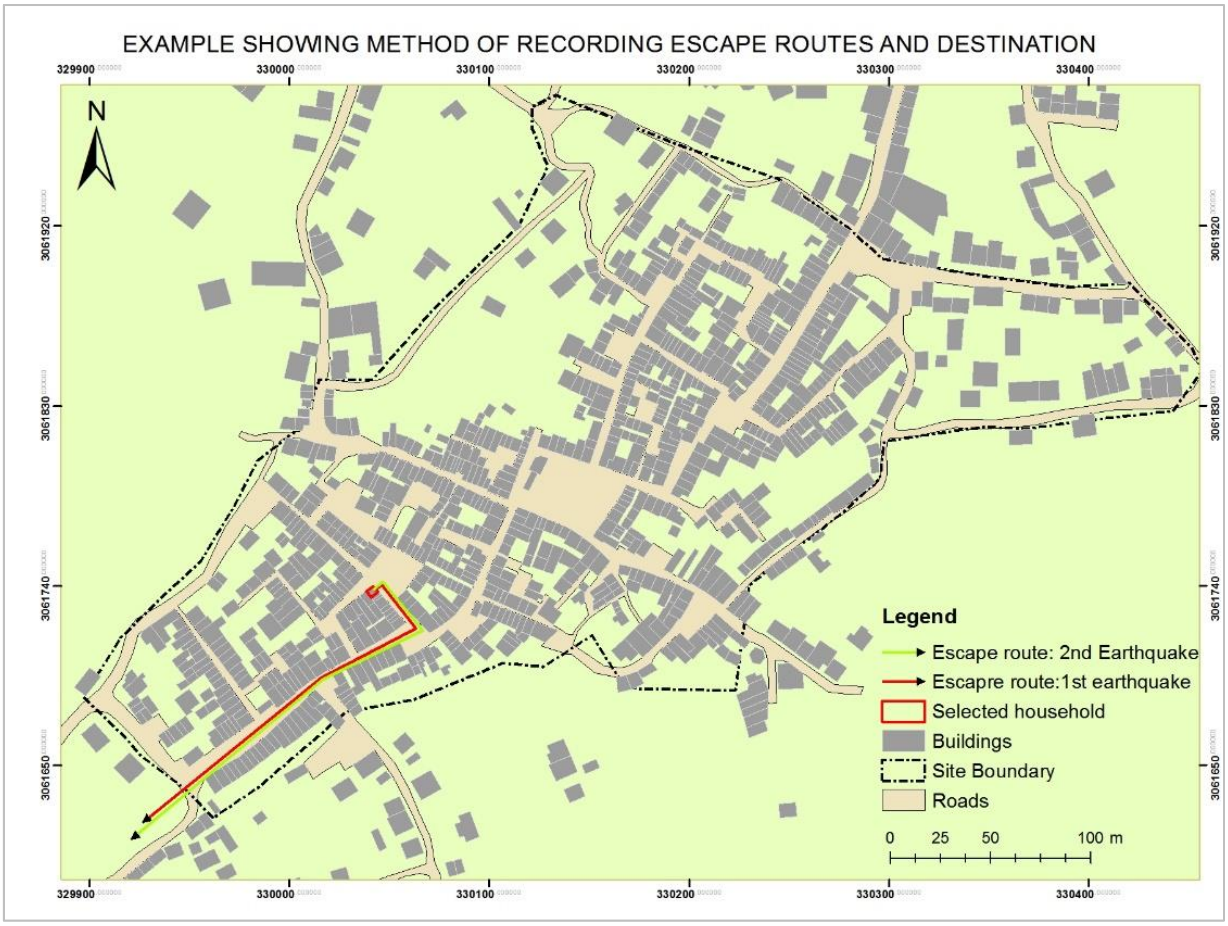


Figure 12 example of method used to record escape routes during fieldwork

Third category of questionnaire is related to risk perception. Here the indicators were divided into pre-earthquake, during earthquake and post-earthquake scenarios. This classification provides insights on how people perceived risk independent of the disaster event and thus would be beneficial in deriving the underlying reasons of perceived risk. The pre-earthquake indicators used were predictability of a major earthquake, preparedness against a major earthquake and awareness of safety measures against a major earthquake. The 'during earthquake' indicator was a structured question divided in two parts based on the location of the respondent during the earthquake. The respondents were classified based on whether they were inside a building or in an open space during the first major earthquake. The post-earthquake indicators assessed the effect on personal life, desire to change current residency and opinion on important factors to reduce seismic risks. The effect on personal life was noted in a five point Likert scale to better capture the perception of the individuals. For the other two questions audio recording was envisaged so that a comprehensive answer could be obtained. However, many respondents were hesitant to be recorded although they were assured their identity are kept private. As such, key words were noted so that they could be used for analysis later.

The final section contained questions pertaining to community and attempted to see how respondents see the community and people within them. The first two questions asked the respondents if they stayed within the community after each the 2 major earthquakes for at least three nights. The three night period was chosen because the government had issued notice deeming this period as risk sensitive period. The next question queried about how safe felt within the community during the disaster period in a 5 point Likert scale, from strongly agree to strongly disagree. Similar scale was used for the final question which queried about social bond of that individual with other people in the community. These questions are envisaged to explain social cohesion and trust among people within communities.

The number of household data gathered through survey in Panga and Nayabazar is 83 (out of 943) and 90 (out of 1282) respectively. The questionnaire for household survey is attached in Appendix 1.

3.2.3. Expert interviews

For the purpose of expert interviews, the sampling method used was snowball sampling where participants were determined through chain of recommendations from the interviewee. In total, 7 such interviews were recorded. To get a complete overview the experts were included from diverse backgrounds. Due to lack of time and unwillingness of some of the recommended people more interviews were not possible. However, due to diversity of profession, knowledge and work experience, the number of expert interview sufficiently add to the household survey (see table 3). For the purpose of the interview a separate semi structured questionnaire was prepared. The experts were first asked to give a general overview of their field of work and experience in either or both of the two main concepts. Most of the experts have been either working in disaster risk reduction (DRR) in Nepal or adhere to urban planning (academicians, professionals). The questionnaire was primarily focused on influence of urban form on risk perception as such questions pertaining to all the six dimensions of urban form were included separately. The interview was based on a set of fixed questions (see Appendix 2) but depending on the conversations, the sequence of questions were changed. Additional questions were also asked where applicable. The findings of the interview were then visualized in a matrix for risk perception across different phases of disaster. For perceived risk, the matrix is based on relevance of each determinant with respect to disaster phase i.e. pre-disaster, during disaster (up to 2 weeks) and post disaster (up to 8 weeks). The relevance is given by number of '+' sign in a scale of 1-3, where one '+' means low relevance, two '+' means medium relevance and three '+' sign means high relevance. The relevance was based on the number of times each determinant was discussed in reference to the three time scale by the experts. Emphasis on a given determinant in relation to the phases were also taken into consideration but this was subjectively done by the author.

Table 3 Interviewee, their respective professions and organizations

S.N.	Profession	Organizations/Location
1.	Civil Engineer, Program manager, Disaster Risk Reduction/CCA programme,	OXFAM, Lalitpur
2	Disaster Management Expert, DRR unit	ENPHO, Kathmandu
3	Architect-Urban Planner, academician	Institute of Engineering (IOE), Lalitpur
4	Civil Engineer-Urban Planner, private consultant	WeLINK Associates Pvt. Ltd.
5	Architect, private consultant and academician	Morphogenesis Consultant Pvt Ltd.
6	Municipal officer, Civil engineer	Kirtipur Municipality, Kirtipur
7	Trained volunteers (Various DRR trainings from Red Cross)	Locals, Panga

3.2.4. Secondary data collection and methods

The household surveys consisted of many questions regarding the urban form. However, it did not include some of the aspects of urban form such as density, land use and accessibility. This is because it is difficult to make people understand of these concepts and then probe if they affect their risk perception. As such specific questions were raised in the expert interviews. To support the qualitative analysis and to present an objective view of the results quantitative analyses were also conducted. For simple quantitative analyses GIS data was required (table 4) such as building footprints and road networks which were obtained from GENESIS, a private consultant based in Kathmandu which specializes in GIS and remote sensing operations. The data obtained is from 2013 for both towns. The data is quite rich as it includes information about building height, construction type, building use and type, street name and size among others. However, the data is only available for a sample of the total household units. In addition to that additional data set for Panga was obtained from a PhD student who did some research after the earthquake. This data also includes the damage assessment of the buildings after the earthquake. However, similar data with damage assessment was not available for Nayabazar.

Table 4 Overview of spatial data used during the research

Data Type	Description	Acquisition date	Data source
Road (Panga)	Road network of Panga (core area)	2016	PhD. student
Buildings (Panga)	Buildings footprints of Panga with damage assessment data (core area)	2016	PhD. student
Buildings (Panga)	Building footprints of Panga (core area)	2013	Genesis Pvt. Ltd.
Buildings(Nayabazar)	Building footprints of Nayabazar	2013	Genesis Pvt. Ltd.
Roads (Nayabazar)	Road network of Nayabazar	2017	Open street Map
Escape routes (Panga & Nayabazar)	Escape routes followed by respondents immediately after earthquake of 25th April	2016	Survey
Open Spaces (Panga & Nayabazar)	Designated open spaces based on information from locals & visual assessment.	2017	Survey

3.2.5. Digitization and coding of data

The data collected from fieldwork was first digitized and compiled in MS Excel. Initially this was done separately for each of the case study sites. The obtained data was then classified where necessary. For example, the answers to the open question regarding risk reduction measures had varied answers. The opinions of the respondents were grouped under three broad categories, related to urban form, unrelated to urban form and no idea. Education was broadly classified into no formal education, up to high school and graduate or above. For occupation and building use a small group of varied responses was grouped as others. This classification provided a better overview of collected response in the context of this study and was helpful for effective analysis of the data. The survey data was then coded into numeric values for each of the gathered response except for caste of the people. This simple coding of data into numeric values was carried out for ease of statistical analysis later on. Initially, simple comparative descriptive statistics was carried out to gain an insight into the similarities and differences that exists between the two sites. The results are explained in chapter 4. This coded data was also added to the GIS database for each community. This was done by first, exporting the Excel file into a .csv format. Then based on the household ID of the survey, the GIS data was assigned a matching ID for each households so that the .csv files for each site could be joined with the respective buildings data for each community.

3.3. Analysing Urban Form

The analysis methods for each element of urban form varied considerably. But one of the most prominent and recurring aspect across all the elements was open spaces. While analysing the determinants of urban form, they were assessed in relation to open spaces where applicable. In addition to this, other analyses were also carried out which are described in detail in the following sections.

3.3.1. Accessibility

Accessibility to open spaces was analysed through the length of escape routes followed immediately after the earthquake struck. The routes followed and the end destination of the escape routes form each community were also analysed and compared. The data required for this analysis was obtained from the survey. Maps of the respective areas were provided during the survey and people were ask to draw their escape routes and locate their final destination. This was done to understand the behaviour of people during the disaster. It provided insights into how people perceived the immediate risks and since these are spatial attributes, they were analysed to look for patterns of behaviour. Escape routes only after the first major earthquake were used for analysis although escape routes after the second major earthquake had also been recorded in the household interview because most people were in open spaces during the second major earthquake. The routes were first drafted in GIS software using the respective houses as the starting point. Although in some cases where the residents were outside the building, they were close by so they pointed the escape routes from their own house. After completing the drafting process for both Nayabazar and Panga, the escape routes were classified into 3 groups, <100m, 100-200m, >200m. This was done so as to see if there are distinct patterns of escape distance values that people travel when a disaster strikes. This classification, if significant in displaying patterns of escape route behaviour could later be used as guidelines for design and policy making. Then the median values were calculated and compared between the two sites along with the classified distance values. The results were then visualized as maps displaying the escape routes with an end destination pointed via an arrow head. The collapsed buildings (for Panga) were also visualized to search for influences on the escape behaviour. Other indicators such as width of the road, proximity to the city centre were simply calculated by measuring the distances in GIS files and in goggle earth respectively. Distances to health services were not calculated as both sites did not host any big health services within its boundary and data for smaller health clinics was not available. This data was not available in open street map as well. However, discussions with locals were held to have an overview of the availability of health services in the both sites. The obtained results are presented in chapter 4.

3.3.2. Density

The demand and supply of open spaces for shelter is dependent on population density of that area (Anhorn & Khazai, 2015) and the compactness of its built structures. So, two types of density calculations were done and compared for each site. First, building density was calculated which is given by the number of buildings per hectare (equation 1). This is a measure of compactness of the urban built form. Next, population density was calculated for each site. The population density of Panga was calculated from the data (767 houses) obtained from a PhD student which gives number of people per house as 6 on average (see equation 2). This value was applied to all the houses within the site boundary. Population data was not available for Nayabazar, however informal talks with locals reveal that most houses host 3 or more families. Since Nayabazar is a modern town with nuclear families, the average household is assumed to be 4 people per family which is used for calculating the population density. The results are presented in chapter 4.

$$\textit{Building density} = \frac{\textit{Number of individual building footprints within the site boundary}}{\textit{Total area within site boundary in Hectare}} \qquad \textit{(equation 1)}$$

Similarly, Population density is given by number of people per hectare (equation 2).

$$\textit{Population density} = \frac{\textit{Number of individuals per family} \times \textit{number of houses within the site boundary}}{\textit{Total area within site boundary in Hectare}} \qquad \textit{(equation 2)}$$

3.3.3. Housing attributes

The data required for analysing housing attributes were based on its indicators which were included in the household survey questions. These data are later used for multiple regression analysis. The data obtained from the survey are presented in chapter 4.

3.3.4. Infrastructures

The assessment of infrastructure was done through information provided with the locals as well as the experts since no GIS data was available. Based on literature and the interviews with the locals, four main infrastructure services were considered: water supply, sewerage system (access to bathrooms), and infrastructure of electricity and telecommunication infrastructure.

3.3.5. Layout

The overall planning of the two communities is very different in terms of layout design as well as composition of buildings, open spaces and road networks. Simple visual analysis was carried out outlining the type of layout patterns of streets and open spaces by comparing the two sites.

3.3.6. Land use

Land use was assessed in two aspects: the use of building i.e. residential, commercial, institutional etc. and open spaces. The data for building use was collected through the household surveys whereas open spaces (courtyards and open grounds) are taken based on information provided by the locals and also with the help of google maps. The use of building was later used in multiple regression models. The attributes of open spaces are one of the most crucial aspect of immediate disaster response for shelter needs (Anhorn & Khazai, 2015). These spaces provide immediate refuge and are potential sites for temporary housing. The distinct public open spaces for each site w presented in the form of maps. In Nayabazar, there are 5 open spaces which were planned during the land pooling project along with empty plots of land scattered around the site. In Panga, the open spaces are primarily given by courtyards of varying sizes. In Panga, it was not possible to consider them all as some of them are as small as 10sq. m. Also, if we just look at the map (figure 20, right), it is unclear which areas are used as common courtyards. So, for simplicity, only those courtyards with areas 100 sq. m or higher with each side at least 8m were considered. The selection was done manually. Further, some aspects of urban form such as accessibility, layout etc. were assessed in relation to open spaces.

3.4. Risk perception Index (RPI)

The RPI is an aggregated value which was developed for this research to conduct further statistical analysis to seek potential relationships between urban form and seismic risk perception. Other research have also employed index as a means to understand people's risk perception, albeit it is calculated differently (see Ainuddin, Kumar Routray, & Ainuddin, 2014). It was calculated for each household based on nine indicators (table 5). To ensure soundness of the developed index, indicators that represent both psychometric and cultural theory of risk perception were used. These indicators were given values, based on rationale, from 0 to 1, where, 0 represents lowest perceived risk and 1 represents highest perceived risk. For those indicators which are based on Likert scale data, the value was assigned in equal division to the data. This means for 5 point Likert scale data, the values were assigned as 0, 0.25, 0.5, 0.75 and 1 in order based on the rationale.

Table 5 Selected indicators for developing RPI, their weights and rationale

S.N.	Indicators	Denotation of value	Rationale
1	Awareness of earthquake safety before the event	Yes: 0 No: 1	Awareness of earthquake safety enables people prepare for a seismic event and also helps them for a safe response during an actual event thus reducing their perception of risk.
2	Perceived preparedness against earthquake before the event	Strongly agree: 1 Agree: 0.75 Neutral: 0.5 Disagree: 0.25 Strongly disagree: 0	People who view risks to be real are more like to act on it (Slovic, 2000). Thus a negative relation can be established between preparedness and perceived risk.
3	Perceived effect to personal life	Strongly disagree: 0 Disagree: 0.25 Neutral: 0.5 Agree: 0.75 Strongly agree: 1	People who have been strongly affected by the earthquake will perceive the risk to be higher as they will have the realization of the risks
4	Willingness to move away from the community	No: 0 Yes: 1 Unsure: 0.5	People's desire to move suggests perception of risk to be higher for that location. For people who are unsure, the value is taken at the middle.
5	Anticipation of earthquake event in near future	No: 0 Yes: 1 Don't remember: 0.5	People who did not anticipate an earthquake means they were either in denial or did not expect it to happen a near future. This suggests they were also aloof of the risk and thus perceive it to be less. For people who don't remember, the value is taken at the middle.
6	Location of stay after 1st earthquake	Within community: 0 Outside community: 1	People will stay where they feel the safest during the disaster.
7	Location of stay after 2nd earthquake	Within community: 0 Outside community: 1	People would stay in locations where they feel the safest during the disaster.
8	Perceived safety within the community (safer)	Strongly disagree: 1 Disagree: 0.75 Neutral: 0.5 Agree: 0.25 Strongly agree: 0	People who felt safe within the community means they perceive the risk to be less within the community.
9	Perceived community bond (high)	Strongly disagree: 1 Disagree: 0.75 Neutral: 0.5 Agree: 0.25 Strongly agree: 0	People who share a strong similar community bond will perceive the risk to be lower because they have trust among themselves.

Then values for all the 9 indicators were assigned and then summed to obtain the RPI value. The RPI value can range from 0-9, where, 0 is the lowest and 9 gives the highest perceived risk. The RPI was calculated for each community separately. For each of the indicators data was derived based on the household surveys. The RPI was first correlated with socio-economic indicators to identify significant indicators, if any, for each community. 2-tailed Pearson correlation was conducted in SPSS. The obtained RPI value was then visualized through maps for both communities to investigate spatial patterns which may not be apparent just looking at the numbers. To achieve this, the resultant RPI value was first classified into three groups: low RPI, medium RPI and high RPI. This classification was based on the average RPI value obtained for each community. The average value was calculated by subtracting the highest RPI value with the lowest RPI value and dividing it by three (equation 3) which gave a value, say X. Then based on this value three classes are developed whose threshold values are given by table 6. This approach of classification was based on the resultant RPI values rather than the possible range of RPI value. The aim of this approach was to present a true representation of degree of perceived risks for a given community.

$$X = \frac{\text{Highest RPI value} - \text{Lowest RPI value}}{\text{Number of desired classes}} \qquad \textit{(Equation 3)}$$

Table 6 Threshold values of three classes of RPI

Low RPI class		**Medium RPI class**		**High RPI class**	
Lower threshold	Upper threshold	Lower threshold	Upper threshold	Lower threshold	Upper threshold
Lowest obtained RPI	Lowest obtained RPI + X, say **A**	(A+0.1)	A+X, say **B**	(B+0.1)	Highest obtained RPI

3.5. Multiple Regression Analysis (MRA)

Regression analysis is a statistical tool which is used to examine the relationships between variable (Sykes, 2007). When there are more than one variable, multiple regression analysis is used. According to Field (2013), multiple regression analysis is used to predict the outcome variables (dependent variable) based on a linear model when there are more than one predictor variable (independent variable). The model is given by the equation 4 where $\mathbf{Y_i}$ is the dependent variable, b_1, b_2 & b_n are correlation coefficients of first, second and n^{th} predictor respectively. E_i is the error of the ith participant. The parameter b_0 gives the value of the outcome when the predictor is 0.

$$Y_i = (b_0 + b_1X_{1i} + b_2X_{2i} + \ldots\ldots\ldots + b_nX_{ni}) + E_i \qquad \textit{(Equation 4)}$$

MRA was used in this research to identify if there are statistically significant relationship between RPI value (dependent variable) and the parameters of urban form (independent variables). Additionally, general parameters were also included in the model so as to control for them in the analysis. The list of indicators chosen are given in table 7. All of the variables were chosen based on criteria, first, availability of data at household level was checked since the RPI value is at household level. Thus, Density, number and size of open spaces, infrastructures etc. could not be used in this analysis. Second, the data could be converted in numeric value though coding. As such, caste as an independent variable was not used since it is string data and could not be coded into numeric data. This short-listing of variables was carried out to simplify the analysis process. Also, lesser number of variables would enable MRA to be carried out for each community separately which could be beneficial to synthesize and understand the results of the analysis. The minimum sample size for MRA is given by 10-15 times the number of variables (Field, 2013) i.e. if there are 5 independent variables, the sample size should be 50-75. The RPI is a scale type data but the independent variables differ in their type, i.e. ordinal, nominal or scale (as presented in SPSS). Before running MRA, these data were appropriately coded where applicable. For categorical parameters with more than two category, the number of output dummy variable for *n* number of category is given by *n-1*(Skrivanek, 2009). This is because the resulting output variable are created in reference to one of the categories eliminating the need to create the dummy variable for the reference category. For example, there were three category in the variable education (no education, up to high school and graduate or above) which had the output dummy variable for only two of the categories, up to high school and graduate or more. Similar dummy variable was created for perceived damage.

After MRA, correlation coefficients were checked through correlation matrix and variance infiltration factor (VIF) values. VIF value identifies multicollinearity among variables, if any, which is important because it influences the truthfulness of the obtained results as well as alter R^2 value (Field, 2013). If the variables are highly correlated i.e. 0.8 or higher up to 1 (1 being the highest value of correlation) then the output is less trustworthy and it only explains negligible amount of variance in the R^2 value. Additionally, VIF tests inquire about the linear relationship between predicators. Values between 0.2 (Menard, 2002)and 10 (Myers, 1990)represent non-multicollinearity. SPSS software was used to conduct the MRA. The type of MRA used is 'forced entry' where the variable with the least significance is manually removed from the list of variables and next round of MRA is carried out. This was continued until all the variables had a significant value i.e. $p < 0.001$. Finally, the R^2 and Adjusted R^2 are reported and discussed. R^2 indicates the variance in the outcome explained by the model and adjusted R2 indicates the loss of predictive power of the model (Field, 2013). Normal distribution and heteroscedasticity was also checked through residual plots to validate the statistical significance and reliability of the model. Since each community has only 80-90 variable, MRA is first carried out only using variables under urban form for each community. In total 4 variables were used (see table 7, dimensions). The results of MRA for each community is valuable in providing insights into how the influences of urban form are manifested in each community. After that, the data of the two communities was combined and MRA was conducted again using additional variables related to personal factors. The addition of these variable controlled for personal factors to explanation the model. The results are reported and analysed for individual community first and then for the combined data.

Table 7 Selected variables for MRA

S.N	Independent variable	Data type	Dimension	Coding applied
1	Age	Scale	Personal factor	None
2	Gender	Nominal	Personal factor	0=Female, 1=Male
3	Education Level	Nominal	Personal factor	No education=reference variable High school=dummy variable Graduate or above=dummy variable
4	Ownership	Nominal	Personal factor	0=owner, 1=tenant
5	Perceived damage	Ordinal	Urban form /personal factor	No damage= reference variable Slight damage= dummy variable Moderate damage=dummy variable High damage=dummy variable
6	Construction type	Nominal	Urban form	0=Load bearing structures 1=RCC structures
7	Number of floors	Scale	Urban form	None
8	Age of buildings	Scale	Urban form	None
9	Building use	Nominal	Urban form	Residence only= reference variable Residence/commercial=dummy variable Residence/others= dummy variable

4. RESULTS

The following chapter explains the obtained results from the survey and interviews as well as from the conducted analyses. The household surveys are firstly described through descriptive statistics and the expert interviews are summarized. After that, results of the index and regression analyses are explained.

4.1. Description of household survey

This paragraph explains the general attributes of the data collected from the household survey. The description of the collected data is comparative to facilitate the clear understanding of similarities and differences between Panga and Nayabazar. This comparison is useful in identifying the similarities and differences across all the collected variables for the two sites. It provides an initial analysis of the data that can already highlight some of the links between the general attributes, urban form and seismic risk perception. The total number of household survey conducted in Panga and Nayabazar is 83 (out of 943 household within the site boundary) and 90 (out of 1282) respectively. The table 8 below gives an overview of the findings obtained from the household survey. Most of the presented data is in aggregated form which highlights the distinct values found in the obtained results.

Table 8 Results of the household survey

	Indicators	**Panga**	**Nayabazar**
Personal traits	Median Age	50 years	36 years
	Gender	61% female, 39% male	53% female, 47% male
	Occupation	Business (35%)	Business (59%)
	Formal education	67%	92%
	Prevalent Caste	95% Newar	Diverse castes without a strong prevalence of any
	Income	Incomplete data set	Incomplete data set
Urban form	Ownership	Owner, 95%& tenant 5%	Owners, 34% & tenant 66%
	Construction type	Load bearing, 64%	RCC frame structure, 91%
	Building use	Residential only, 75%	Residence/commercial, 83%
	Median Age buildings	25 years	13 years
	Median. number of floors	4 floors	4 floors
Risk perception	Possibility of earthquake in near future (pre-earthquake)	80% agreed	84% disagreed
	Awareness about earthquake safety (pre earthquake)	40% aware,	51% aware
	degree of preparedness (pre-earthquake)	10% prepared	9% prepared
	Effect on personal life	59% agreed,	41% agreed
	Move away from community in regards to earthquake safety	57% would not move	71% would not move
	Risk reduction measures	57% urban form related , 35% no idea	68% urban form related, 17% others, 15% no idea
Community	Location of stay after first earthquake	75% stayed in Panga	92% stayed in Nayabazar
	Location of stay after 2nd earthquake	73% stayed in Panga	83% stayed in Nayabazar
	Strong community bond	66% agreed, 27% neutral	50% agreed, 41% neutral
	Safety in community	47% agreed, 38% neutral	45% agreed, 31% neutral

In Panga, there are more female respondents where as in Nayabazar the spread is well distributed. There are also higher number of housewives in Panga than in Nayabazar. One of the potential reason for this is lower education level in Panga (9.6% of people with a graduate degree). This is partly because educational facilities were not accessible in older times, especially for women due to social reasons. Also, Panga used to be a farming community, thus a formal education was not a pre-requisite for survival and day to day living. Business is the primary occupation in Nayabazar. Panga too boasts business as the main occupation, but the total number of business person are far less compared to Nayabazar. The respondents of Panga are much older than their counterparts from Nayabazar (see table 7) with a difference of 14 years observed in the median age. One of the distinct contrast between the two communities can be observed in the caste of the respondents. Panga is culturally homogenous, 95% of the respondents were 'Newars' among which 83% of them have the same caste "Maharjan" as seen in figure 13. They follow same cultural practices and traditions and have many religious and cultural events all around the year where most people of the community take part. However, Nayabazar is culturally very diverse. There are 29 different castes in this community with a fairly balanced frequency distribution. In both the communities, Panga (71%) and Nayabazar (59%), the income data has a lot of missing values due to reluctance of the respondent to express their income.

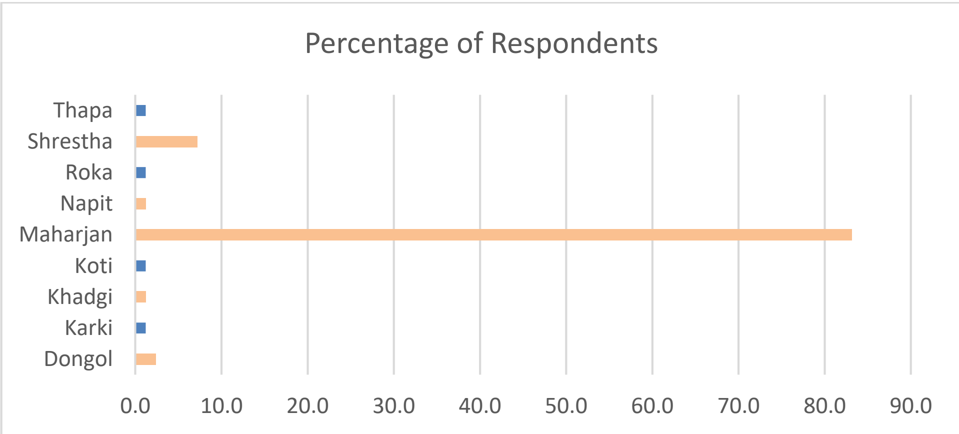


Figure 13 Percentage of respondents based on caste colour coded to differentiate Newars and non-Newars

The second section of the household survey deals with urban form. Most respondents in Panga are owners of the house which is expected of that community as it is farther from the city centre and lacks ample economic opportunities. Most of the buildings here are load bearing structures made of brick, mud mortar and wood (see table 8). This is typical of an old Newari settlement. A higher than expected number of concrete houses (34%) is observed in Panga, although the chosen site is the core area of the settlement. This hints at growing trend of building modern houses perhaps due to high number of practical issues inherent in the older houses. Older houses usually have low ceiling height (around 2.5m) and have narrow steep staircases which encourage people to build modern houses. The median age of the buildings in Panga is 25 years old which is lower than initially expected given the community is quite old. In Nayabazar, most of the houses are newer (median age 13 years) and built through frame structures of RCC. There are much more tenants here (see table 8) than in Panga because Nayabazar is closer to the city centre and has better access to health and education facilities as well as more economic opportunities. These economic opportunities are evident in the building use found in Nayabazar. Here, most residential units also support commercial activities (figure 14). This is often characterized by residential use in the upper floors and shops in the ground floor which are facing the streets. In Panga, most of the houses are residential because many of the houses are not connected to streets. Even the connected streets are often restricted to have commercial spaces as it is not recommended to make large openings in load bearing houses to maintain its structural strength. In both sites, the median floor level is 4 storey.

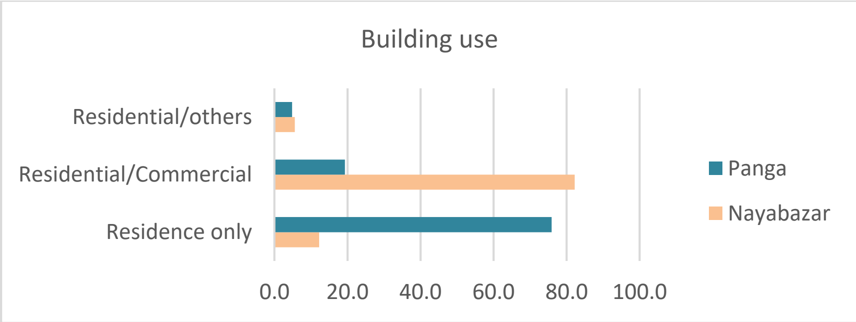


Figure 14 Percentage of building use type in Panga and Nayabazar

The perception of damage to the house is in important factor which shapes how people view risk. There is a clear distinction in the two sites in this regard. People in Panga have a fairly evenly spread views of perceived damage whereas in Nayabazar most people perceived the damage to be negligible or non-existent (figure 15). This corresponds to the fact that there were more old buildings which were damaged partially or completely by the earthquake event (as stated by the experts). However, the number of deaths per building is higher in concrete buildings as it is impossible for locals without equipment to lift heavy concrete slabs and save the trapped people. In older, load bearing houses, even if a house is completely damaged it is possible to save the trapped people due to the lightness of the materials used in the construction. The number of collapsed buildings in Panga is 85. Similar data was not available for Nayabazar.

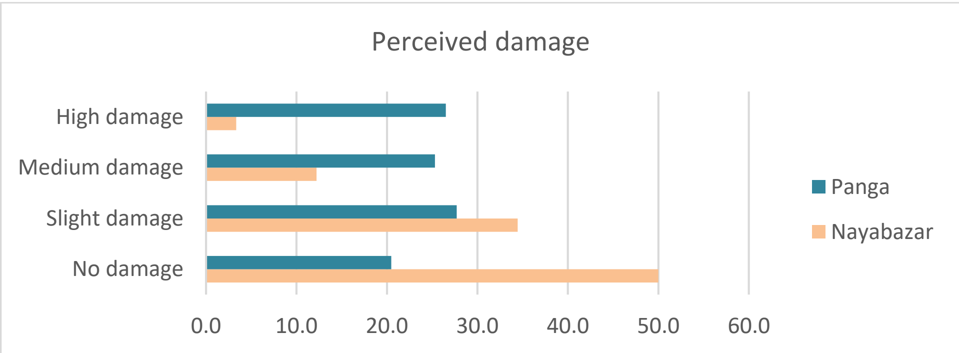


Figure 15 Perception of damage to the houses in Panga and Nayabazar

The third section deals with perceived risk. The first three indicators refer to the pre-disaster context. Most residents in both Nayabazar and Panga denied the possibility of a big earthquake before the event in 2015. This is surprising because it is common knowledge that Kathmandu city is an earthquake prone city especially in Panga because the Kirtipur Municipality under which Panga falls under even has a disaster management committee. Further, numerous awareness and communications programs have been conducted in that area over the years. However, in both communities, many people said they were aware about earthquake safety but lacked the preparedness against a big earthquake event as seen in figure 16.

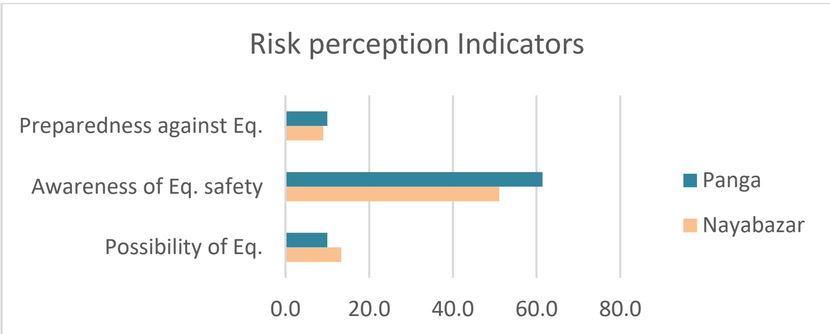
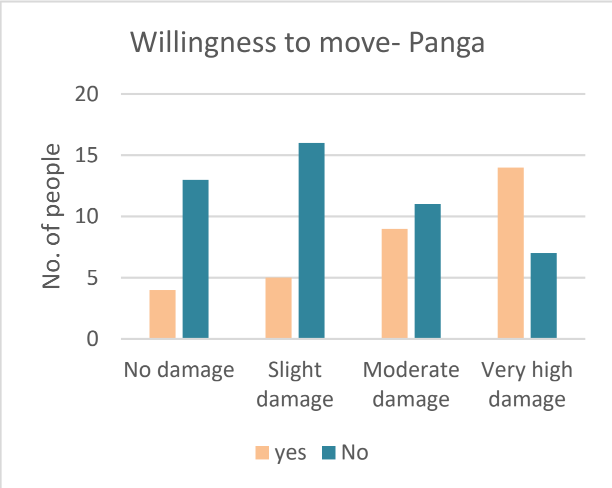


Figure 16 Risk perception indicators for pre-disaster

The effect that earthquake had on their personal life is an important relationship which can explain how people perceive risks (Armaş & Avram, 2008). More people in Panga (59%) indicated that the earthquake affected their personal than in Nayabazar (45%). This is possibly due to higher number of damaged houses in Panga. Also it can be assumed that since the community is very tight knit, the effect on one person also, at least, partially affects others. When asked if they would move away from the community in relation to earthquake safety, 57% and 71% said they would not in Panga and Nayabazar respectively. It shows that both communities feel quite safe in their own neighborhood. This results corroborates with the results of perceived damage to the house.



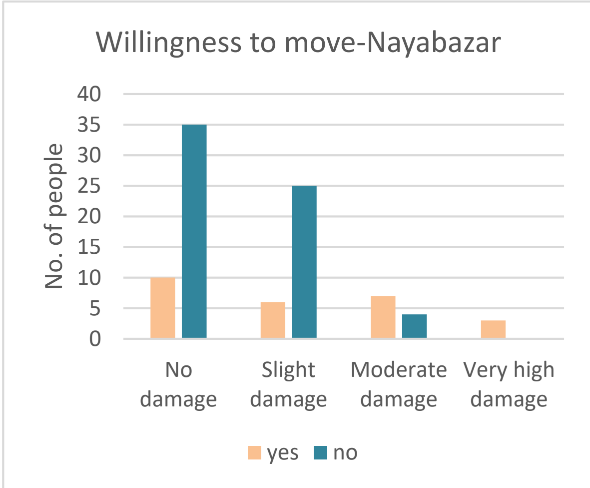


Figure 17 a) Willingness of people to move away from Panga, b) willingness of people to move away from Nayabazar

As seen in figure 17a, residents in Panga who perceived the damage to be high wanted to move from the community. Similar trend is evident in Nayabazar, figure 17b, where people who perceived the damage to the house as non-existent or low did not want to move away from the community. In response to what risk reduction measures do you think are important (an open question), most people in Panga (35%) said they had no idea. However, 27% people believed in structural measures, 22% said open spaces and 8% wanted reduced floor heights. Only 8% people opted for other measures such as awareness and building bye laws. Similar results can be observed for Nayabazar. 24% people believed in structural measures, 25% said open spaces and 15% wanted reduced floor heights and 4% accessibility. Only 17% people opted for other measures such as awareness and building bye laws where as 15% had no idea. This shows that 68% and 57% of people think factors pertaining to urban characteristic are important for seismic risk reduction in Nayabazar and Panga respectively, figure 18. It is again interesting to see that even though there are awareness campaigns run in Panga over the years, comparatively there is higher percentage of people who have no idea regarding seismic risk reduction measures.

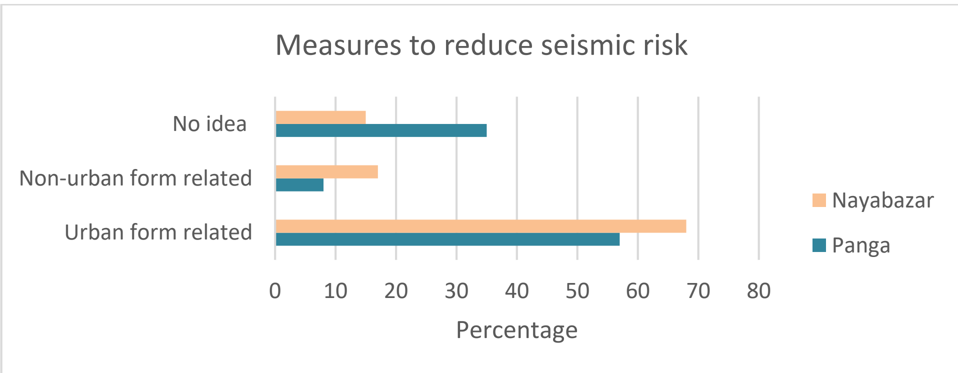


Figure 18 measures of reducing risks as stated by the respondents

The final section consisted of questions relating to community. The residents of Nayabazar stayed within the community for at least three nights after both earthquake which is 92% and 83% respectively for the first and the second big earthquake. In Panga too, most people stayed within the community 75% and 73% respectively. This shows the bond they have with other members of the community and the sense of safety it enables within the community in both the case study sites. Furthermore, if we visualize this in the form of a matrix of strong community bond against perception of safety within the community (table 9), the number of people who either agree or strongly agree is much higher than the ones who disagree or strongly disagree. This pattern is evident in both the communities There are a lot of respondents who have opted to be neutral in both perceived safety and community bond. This further shows a strong relation between the two constructs of perception.

Table 9 Matrix representing Perception of safety against perception of community bond

			Perception of community bond				
			SA	A	N	D	SD
Perception of safety within community	**Panga**	**SA**	**3**	**2**	1	0	0
		A	**11**	**7**	12	2	0
		N	1	5	**19**	1	0
		D	5	4	2	1	1
		SD	3	1	0	0	2
	SA: Strongly agree, **A:** agree, **N:** Neutral, **D:** Disagree, **SD:** Strongly disagree						
	Nayabazar	**SA**	**20**	**2**	2	3	1
		A	**9**	**2**	1	2	0
		N	10	5	**19**	0	0
		D	5	2	2	1	0
		SD	4	0	0	0	0

4.2. Urban form

For each element of the urban form, the results of the analyses are given below. However, certain results are explained through combination of elements of urban form which are explained after the individual results for each element.

4.2.1. Accessibility

The road width is higher in Nayabazar which ranges from 6m-10m where as in Panga streets are narrower which is mostly around 4-6m. In some locations the street width is as low as 1.5m whereas at rare locations it is up to 9m. In Panga, the difference in road widths even in the same road segment restricts the movement of larger vehicles in most locations i.e. fire trucks, dozers cannot access many locations. In terms of accessibility to health services, locals informed that the relative number of smaller health services is higher within and in close proximity to Nayabazar than in Panga. Similarly, there are higher number of well facilitated hospitals near Nayabazar than in Panga. Exact number and location of these health services were not available. Open street map (OSM) was also checked for data, but the data was incomplete. Additionally, Panga is farther from the city centre than Nayabazar (see figure 5). Furthermore, the analysis of escape routes has shed light on some interesting discoveries. First, it is seen that most people would travel distances of less than 100m in both Panga and Nayabazar (74% & 59% respectively) as seen in figure 19b. If we extend this threshold to 200m then the percentiles become 88% and 86%. This shows a clear pattern of distance travelled by the people during the disaster. Another interesting find is that the median distance travelled in Nayabazar is almost half the median distance travelled in Panga (figure 19a) although Panga has a lot of small open spaces in form of courtyards.

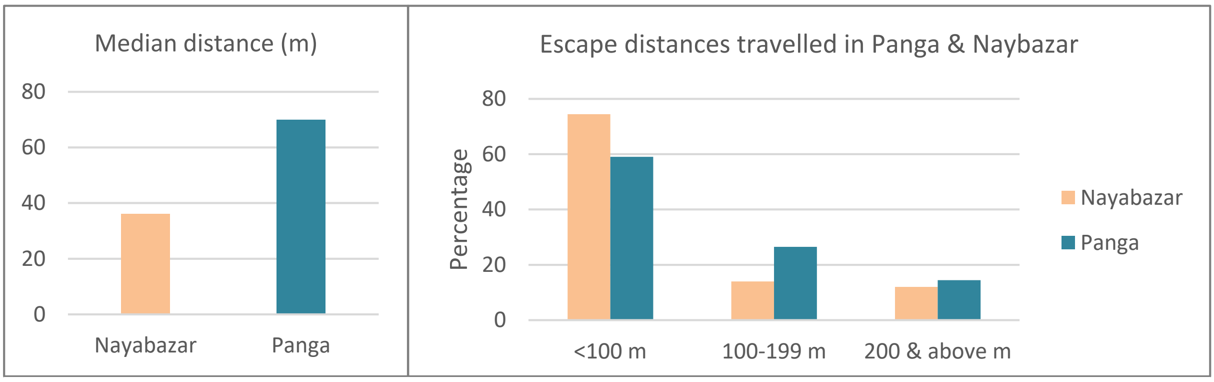


Figure 19a) Median distance travelled during escape in Panga and Nayabazar 18b) Escape distances travelled based on thresholds in both Panga and Nayabazar

4.2.2. Density

The building density of Nayabazar was calculated to be 30.5 buildings per ha which is considerably lower than for Panga which was 111 buildings per ha. The total area of building footprint in Nayabazar is 15.42 ha amounting to 36% of the total site area. The total area covered by building footprint in Panga is 3.39 Ha which is approximately 40% of the total area. Although there is not difference in percentage of area covered, it should be noted that buildings in Panga is much more tightly arranged than in Nayabazar. The population density of Panga was calculated as 666 people per Ha. Based on the assumptions, the population density of Nayabazar is calculated as 366 per ha. This means both built density and population density is much more compact in Panga than in Nayabazar.

4.2.3. Infrastructure

Four major infrastructure for utility services were assessed: Water supply systems, sewerage systems and infrastructure for electricity and communication. Water supply system and sewerage systems were not disturbed by the earthquake in either of the sites. However, it was noted in Panga that single storey communal bathrooms were really useful during the disaster as residents were reluctant to enter their houses because of frequent small tremors. It was also important for people whose houses were destroyed during the earthquake. In both sites, electric lines were down initially but in Nayabazar they were working from the next day. However in Panga, the main lines of the houses were cut intentionally so that there are no short circuits. But there was electricity from the second day in the common areas. The immediate power supply calmed the people and created a sense of safety within the communities. The telecommunications infrastructures only had slight damages, so it was functional in most part of Kathmandu valley and in Nayabazar and Panga.

4.2.4. Housing attributes

The results of survey data for housing attributes are discussed through descriptive statistics (see table 7) in the earlier section. Additionally, it is discussed through results of MRA in later section.

4.2.5. Layout

The primary difference in layout of streets between Panga and Nayabazar stems from the development of these areas. Panga evolved organically without a fixed plan over the course of centuries. The buildings are either courtyard houses or row houses which creates a distinct pattern of streets and courtyards. Here narrow streets connect to hierarchy of courtyards and join the road network which surrounds the area. There is no direct street connection to many of the houses and there are less number of nodes and intersections (figure 19, right). However, Nayabazar was developed through a land pooling project. There are considerably more nodes and intersection of streets (figure 19, left) which allows for access to each house through a road of at least 6m width. The houses are mostly detached units.

4.2.6. Land use

The building use has been presented in earlier section through descriptive statistics. There are 5 distinct public open spaces for Nayabazar which were planned during the land pooling project which were listed by the locals (figure 20, left). The smallest open space is around 1950 sq. meters. However, it is clear from the image that there are lot more open spaces well distributed within the site which is most likely private property. In case of Panga, most of the distinct open spaces is given by 22 courtyards of various sizes (figure 20, right). The smallest courtyard based on the selection criteria (A>100 sq. m, L&B >8m) is 103 sq. m. Except the largest central courtyard (A=1365 sq. m) all the other courtyards are under 500 sq. m. These courtyards are semi-private i.e. all the buildings adjoining the courtyards claim partial ownership but it is open for anyone to go into the courtyard in most cases. Additionally, there are many smaller courtyards within the densely built core area and larger open spaces in the peripheral areas of the site.

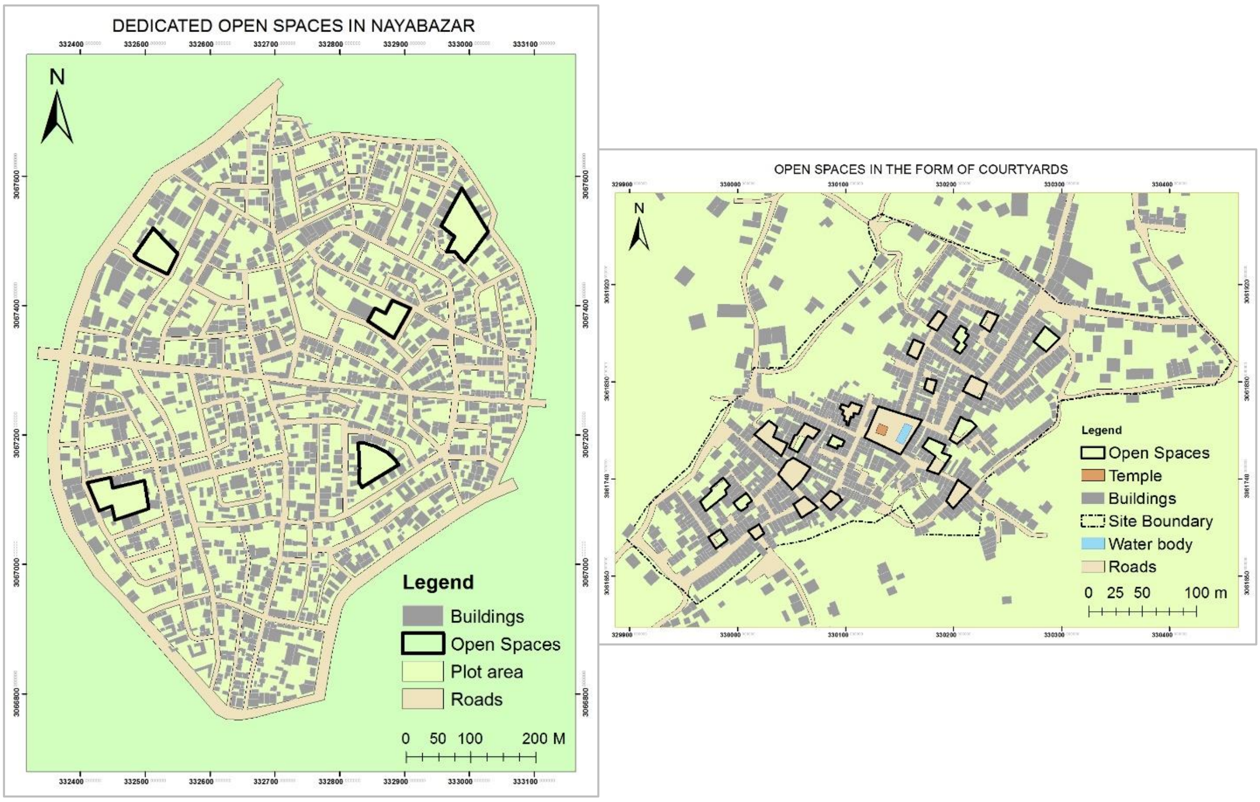


Figure 20 Dedicated open spaces in Nayabazar (left) & Panga (right)

4.3. Urban form & Risk perception

The different elements of urban form interact with each other to influence human behaviour and their perception of risk. People's first response to the disaster is to find a safe open place. If we look at the map of Panga (figure 22), we can observe that people have travelled further to larger open spaces than going to the smaller courtyards nearby. If we draw a diagonal line dissecting the total site into two halves as seen in figure 22 we can see that in the northern half of the site, people have travelled lesser distances (100<), figure 21. The number of collapsed buildings in the southern side is 56, almost twice as much than the northern side with 29 buildings collapsed. This suggests that there is a relation between the collapsed buildings and the distance travelled. Although concrete conclusions cannot be drawn, it can be logically assumed that people who were closer to collapsed buildings feared that other buildings might collapse as well and thus travelled longer distances to safer location. This travel behaviour is further influenced by size of open spaces. If we look at map, figure 22, carefully we can see that in northern part of the site, buildings are relatively loosely based allowing for larger uncluttered open spaces nearby. In the southern part however, buildings are more compact (higher built density) and courtyards are smaller. Few respondents tend to choose enclosed courtyards which were bigger in area. This is indicative of a relation between floor height and size of open space. It should be noted that most people opted for open fields rather than closed courtyards even though there were relatively farther. The combined effects of damage to buildings, size of open areas, floor heights and compactness of built structure is likely to have influenced people's escape behaviour and destination. This also corroborates with the comments from experts on how people avoided damaged houses, taller buildings and opted for clear fields.

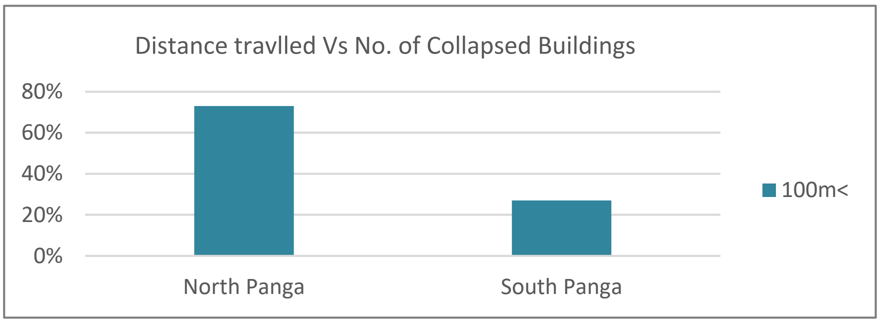


Figure 21 Comparison of escape distance travelled & collapsed houses in Panga

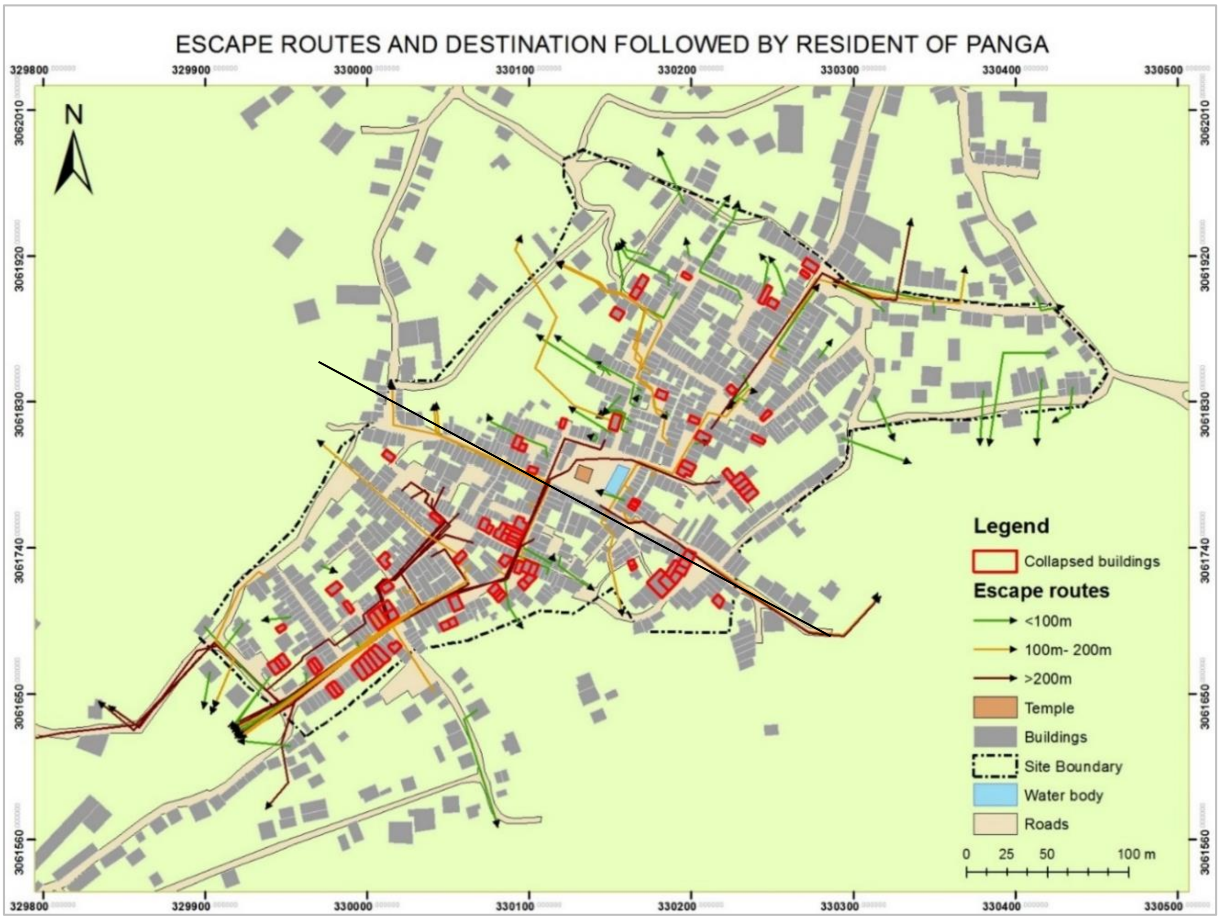


Figure 22 Escape routes and final destination immediately after the earthquake in Panga

In case of Nayabazar, the streets are wider and many open space exist in the form of vacant plots. Thus many people opted to travel shorter distances rather than going to larger open areas. But even these open plots are bigger than most of the open spaces in Panga. Since a clear pattern of escape behaviour was absent in Nayabazar, those open areas where three or more people escaped to is presented (figure 23). All of these spaces are larger than 1950 sq. m. which is calculated including the adjoining road areas. It is thus clear that people prefer larger open areas where the potential impact of a collapsed building is minimum or non-existent.

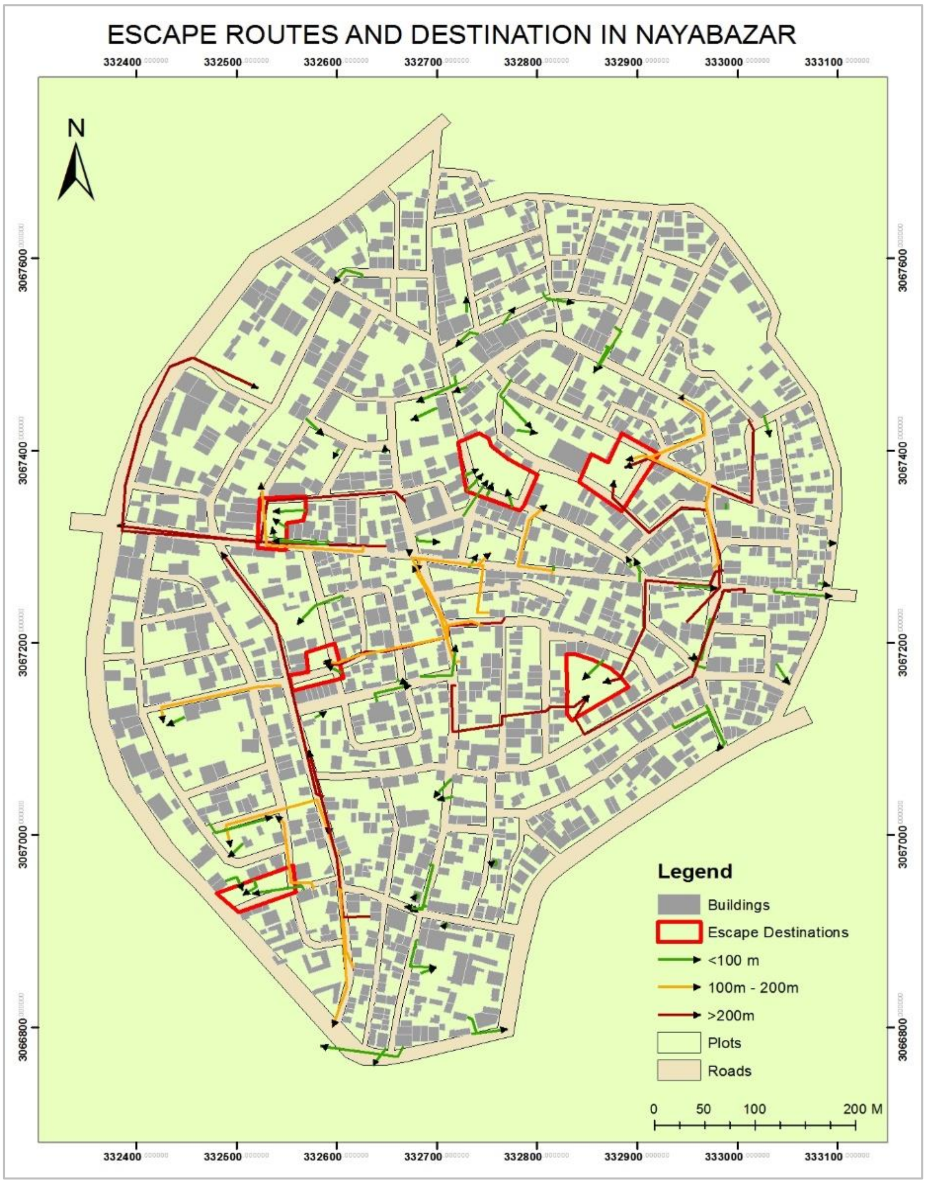


Figure 23 Escape routes & highlighted escape destinations with at least three people

4.4. Risk Perception Index (RPI)

The median value for both of the communities is 3. The values range as well as distribution of it is quite similar for both communities (table 11) which means the overall seismic risk perception is also similar. The obtained threshold values for each class which is used for visual analysis of spatial component of RPI is given in appendix 3. In both communities, there are higher number of respondents in the medium RPI category uniformly distributed around the site. The frequency of high RPI values in both communities is quite low and hints towards a spatial pattern. In Nayabazar, if the area is divided into two halves based on the central horizontal road then higher RPI values are only observed in upper half and low RPI values are primarily observed in the lower half (figure 24). Similarly, if Panga is divided into two halves (given by the black line), then it is observed that the high RPI value are concentrated mostly on the upper half and low RPI value is concentrated mostly in the lower half (25). The correlation of RPI with socio-economic indicator show that Age has a positive correlation with RPI in Panga whereas none of the other indicators show significance, table 10. In Nayabazar, gender shows positive correlation whereas education level shows negative correlation (table 10).

Table 10 correlation results of socio-economic indicators with RPI in Panga and Nayabazar

			RPI	Age	Gender	Education	Ownership
Panga	Pearson Correlation	RPI	1	.229*	-.022	.016	-.130
Nayabazar	Pearson Correlation	RPI	1	-.101	.226*	-.238*	.045

Table 11 Descriptive statistics of Risk perception index for Panga and Nayabazar

	N	Minimum	Maximum	Mean	Median	Std. Deviation
RPI (Panga)	83	.75	6.25	3.1807	3.0	1.24163
RPI (Nayabazar)	90	.50	6.50	3.1361	3.0	1.16549

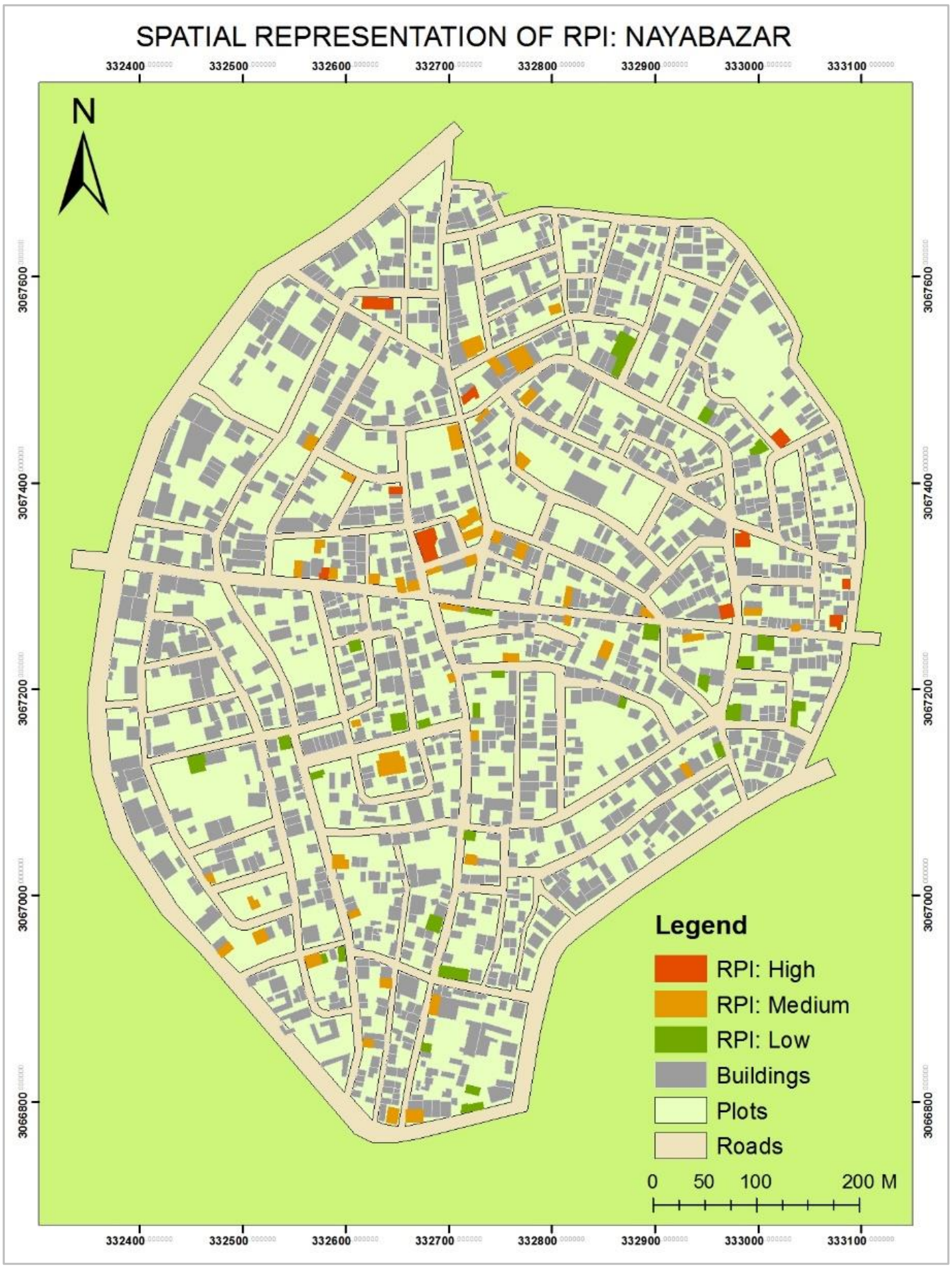


Figure 24 Spatial representation showing different classes of RPI in Nayabazar for the surveyed households

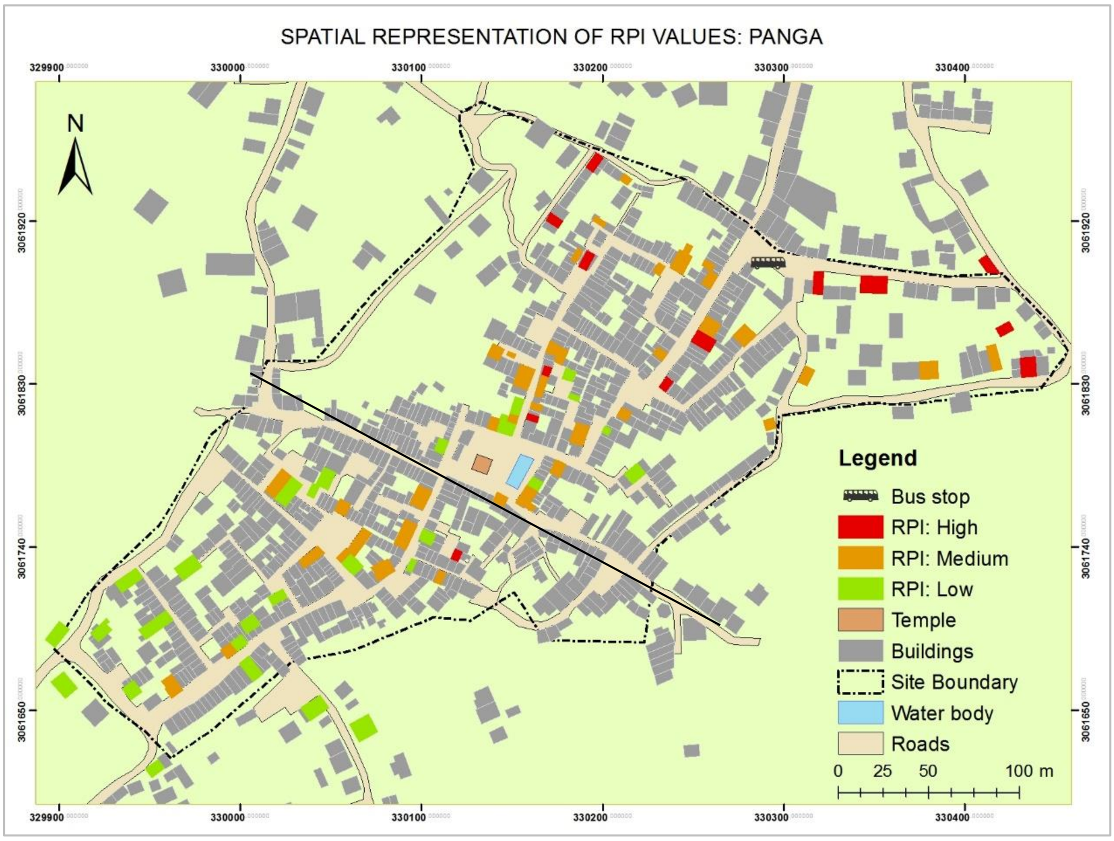


Figure 25 Spatial representation showing different classes of RPI in Panga for the surveyed households.

4.5. Multiple Regression Analysis (MRA)

The MRA for Nayabazar yielded in a significant model, i.e. $p<0.001$ for the four indicators on the first calculation. Here building use variable was insignificant and thus removed for the next MRA. On the second run, construction type variable was removed for insignificance. However, for the final two variable, number of floors and building age showed statistical significance. The model summary for each subsequent removal of variable shows the changes R^2 and adjusted R^2 values (table 12). The R^2 value of 0.24 means that the model can explain 24% of the variance observed in the outcome. This value is significant as the model attempts to explain human emotions which are harder to predict than physical processes (Frost, 2013). The adjusted R2 value improved after removing building use as independent variable. The adjusted R^2 value for the final is given at 0.219 which means the predictive power of the model is approximately 22%. The F value of the model is 11.52 and $p<0.001$ (table 13). Among the two significant variables of the final model, number of floor has the higher significance (table 14). The VIF value are within the range of 0.8-10. However, if we look at the Durbin-Watson value, it is quite low which means the model cannot be generalized. Further, the scatter plot of residuals and predicted value is indicative of heteroscedasticity as the points are not as evenly spread to form a rectangle as desired (figure 26). This means the variance of error is increasing with the value of independent variables and the R^2 value is not as reliable.

Table 12 Summary of model for each subsequent removal of the he least significant variable-Nayabazar

Model Summary[b]					
Predictors	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Building use, Const_type, Built_age, Floors,	.503[a]	.253	.199	1.09240	1.134
Const_type, Built_age, Floors	.502[a]	.252	.220	1.07794	1.123
Built_age, Floors	.490[a]	.240	.219	1.08450	1.073

Table 13 ANOVA table showing the F value and the significance of the final model-Nayabazar

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.827.079	2	13.540	11.51	.000[b]
Residual	85.858	73	1.176		
Total	112.938	75			
Dependent Variable: RPI					
Predictors: (Constant), Built age, Floors					

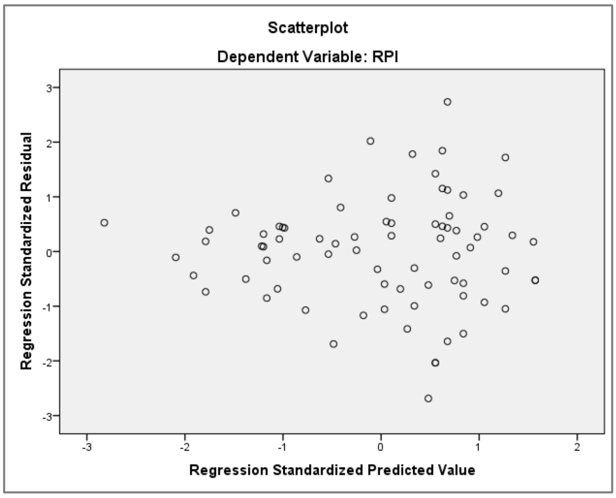


Figure 26 Scatter plot of predictor vs residual values

Table 14 Significance of each variable, their coefficients and collinearity statistics –Nayabazar

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower	Upper	Tolerance	VIF
1	(Constant)	2.113	.490		4.310	.000	1.136	3.090		
	Floors	.398	.105	.385	3.773	.000	.188	608	1.000	1.000
	Built age	-.043	.015	-.295	-2.891	.005	-.073	-.013	1.000	1.000

The MRA is then conducted for Nayabazar. Here $p>0.001$ in the first run (table 14), i.e. the model is statistically not significant (table 16). The R^2 and adjusted R^2 values are also very low (table 14), so the process of removing the least significant variable and re-running the model is not continued. For the combined data, additional variables related to personal factors were included in the MRA. Similar to Panga, the model was not statistically significant (table 15). R^2 and adjusted R^2 value is slightly higher (table 16) than in Panga, but still statistically insignificant.

Table 15 ANOVA table showing the F value and the significance of the final model-Panga & combined data

ANOVA										
	Sum of Squares		df		Mean Square		F		Sig.	
	Panga	Combined	Panga	Combined	Panga	Combined	Panga	Combined	Panga	Combined
Regression	15.289	34.305	5	10	3.058	3.430	2.119	2.467	.072[b]	.009[b]
Residual	111.125	204.450	77	147	1.443	1.391				
Total	126.414	238.755	82	157						
Dependent Variable: RPI										
Predictors: (Constant), Building use Other, Const_type, Building use_Commercail, Floors, Built age										

Table 16 Summary of model for each subsequent removal of the least significant variable-Panga & combined data

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Panga	.348[a]	.121	.064	1.20133
Combined data	.379[a]	.144	.085	1.17933

4.6. Expert Interviews

The expert interviews were carried out so that wide array of relevant qualitative data could be collected. This was useful to have an overview of the disaster response of people after the earthquake. The interviews provide deeper insights into the possible links between urban form, seismic risk perception and communities which was helpful in explaining the underlying results of the household survey and provide a holistic understanding of the given concepts. Snowball sampling of choosing the experts has enabled in interviews from diverse fields of profession which facilitated in abundance of unique opinion and perspectives. The 7 interviews were conducted in the local language (Nepali) which were then translated in English and transcribed. In the following paragraphs, the interviews has been summarized.

The interviewee were first asked to express their opinion on the factors affecting risk perception based on literature. These factors are trust, training and education, experience with similar disaster, publicity and communication, social and personal factors. Based on the responses, it can be inferred that the factors influencing perception of risk is partly determined by the temporal aspect of disaster i.e. pre-disaster, during disaster (1-2 week after the disaster) and post disaster phase (After a month of the event). In pre-disaster context, **awareness and training programs** are the most important aspect to shape people's perception of risk. Before the disaster many people were either unaware or in denial that a large earthquake would occur in Kathmandu. Even government officials were sceptic of a high magnitude earthquake although it is common knowledge that Nepal lies in an earthquake prone area and medium scale (5-6.5 magnitude) have occurred in the last decade.

> *"Awareness programs are necessary and we conducted mock drills (in Panga) which was the first in the country with the help of Red Cross. At that we were called crazy because they were not aware of the risks and they actually scolded us for doing it. But we still did another mock drill and again conducted one more around 2 years back with the help of Lumanti and OXFAM. There was another huge earthquake awareness program in Kirtipur couple of years back." -**Volunteers, Panga***

This shows the lack of awareness among the people regarding the risks of earthquake. But it also highlights the impact of awareness and training programs have over the years. In Panga, Kirtipur, over the course of a decade people turned from highly sceptical and even resisting information of earthquake risks to hosting part of the biggest earthquake awareness program in the country. The positive effect of training and education programs were also evident after the disaster as the youths in Panga were actively worked to support the whole community. They were able to manage community shelters, conduct rescue operations, clear debris as well as distribute necessary relief supplies. They were able to co-ordinate with the locals and institutions to keep them safe and provided for during the earthquake. Even though such programs have had an impact, the impact to the perceived risk of the general people has been shaped by the actual experience of the earthquake itself as one expert emphasized

"Seeing is believing" ***–DRR expert, OXFAM***

Many of the interviewee stressed that the actual **experience of earthquake** has had a huge impact on how people view the seismic risks now. People have become much more aware of the risks and how to tackle it. People's perception of risk and mitigation measures have changed significantly after the earthquake. But during the immediate aftermath of the earthquake, most of the interviewee stressed on importance of social and personal factors and trust among people. They opined that during a disaster, people will stay in groups and seek safety in number.

> *"I think trust is very important and social and personal factors are very important. They should go hand in hand. When there is trust, then there is willingness to help each other and only then other social factors come into play. When I know there are people who will support me and act as my backbone, then perceived risk becomes lower." **–Urban Planner, IOE***

As such, **trust** among fellow community members becomes very important and it helps them to cope through the situation collectively. This was further heightened because there was no official statement from the government even after few days, there were no advertisements and publicity of what to do. This created confusion among the people and added to the existing stress. As such, the communal institutions become more relevant and people helped each other by themselves. But few of the interviewee also opined that during a disaster the tendency to help is natural and a strong community bond is not a pre-requisite to support those in need. They stressed that people in different communities, even if they did not speak to each other before stayed together, slept in communal areas and ate together. But few of them also pointed out that this was unique to Nepal as completely different scenario can be observed in other disaster hit nations such as Haiti where there were civil conflicts after the disaster. As one interviewee explained

> *"You can say that the Nepalipan (a stereotype of Nepalese people which suggests brotherhood and the willingness to help others) shined through in our context. I live in Gaushala and there is a courtyard for parking in our neighbourhood. This worked as an open space which is enough to park 3-4 cars. In this space many people, some known faces and other strangers, came to reside after the quake. We offered them tea and biscuits, coke from the freezer and so on. So in that way I supported them. Similarly other people in the house supported people in the streets. When someone was crying to know their kids whereabouts immediately after the earthquake, when the phone lines were dead, we consoled them and offered our help. So in that sense the Nepalipan is still alive within us."* ***–DRR expert, OXFAM***

However, all of the interviewee agreed that this tendency to help each other must be stronger in communities which have a strong **cultural and social bond**. The fact that most people know each other in the community automatically increases the trust factor and the willingness to help each other. Most of the interviewee acknowledged the importance of proper communication needed during the disaster period. During such a chaotic time, many people were willing to help but did not have idea where to go and what to provide in the initial days. This lack of information was evident in responses from the government, NGOs and INGOs, as well as in individuals and independent groups.

> *"There is a huge difference in providing relief in the right time or providing them very late. It is imperative that relief funds and supplies are provided as soon as possible to save lives."* ***-Municipal Officer, Kirtipur***

There were also instances where relief supplies were consistently been provided to one area because many people heard about those locations and went there oblivious to the facts that relief material had already reached those locations. These communities who had excess supplies did not accept it or forwarded it to other communities in need. The lack of credible information was a hindrance in effective and efficient disaster response. Those communities who were able to acquire these materials in time and in ample amount are likely to perceive the risks to be lower compared to those communities who got little too late.

In the post disaster scenario, the perception of risks shifts primarily towards rebuilding and **economic capabilities** of the people. People cannot live in temporary shelters for ever, that too in public open spaces or properties of other. They want to rebuild as soon as possible and move on with life. But this becomes a huge problem as economic limitations force people to live in unsafe and unhygienic conditions.

> *"Only yesterday I went to a house which had external support and there were cracks in the house. He knows that it is not safe to stay in the safe but he does not have a choice. He and his wife stay there in the cold because there is no option. So economic factor is also important. To respond to the perceived risk, he has to have added source of income or backup, or a resilient plan. Without that even if he knows then that risk becomes acceptable risk."* ***–DRR expert, OXFAM***

Furthermore, after few months of the event, there are disputes among people on various issues of receiving money, cleaning house debris etc. The immediate danger has passed and it is no longer possible nor desirable to live in groups. With time individual preferences are more important than communal benefits and people slowly start to rebuild their own houses and support their own families. This is natural. But it also invites conflicts. These conflicts are often incited by weak government policies such as providing money based on the house unit. This particular policy created a lot of confusion and arguments among community members because a single house unit can host multiple families of brothers who have separate kitchens and thus are separate households but the **ownership** is combined. All the families are in need of relief funds and a meagre amount of around 140 Euro is not enough to be shared. These kind of conflicts were mostly observed in older settlements as such a setup of multiple families living in the same house is prevalent there. In modern towns, families are often nuclear. Even though a single house unit house may host multiple families, the ownership of the house remains to just one of the family.

During such scenarios **cultural institutions** such as Guthi were able to play an important role. In Panga, such an issue was resolved with help from the Guthi. Whenever a family of brothers split their households they have to register as separate families in the Guthi although they are not registered separately in the municipality. Because Guthis have existed for centuries and are highly respected institutions with high perceived morality, locals were able to convince the local municipality to provide relief funds based on their registration in the Guthi. This was an important contribution among others from the cultural institution which assisted people in mitigating the impacts of the disaster.

The importance of different elements based on the interviews during different phase of the disaster can be visualized in a matrix. Here the degree of importance is given by number of '+' signs from 1-5, 5 being the highest. It is clear that social and personal factors are the most crucial aspect that could alter perception of risk in all phases of disaster. This is further heightened though trust among people during the disaster period but has lesser impact in other phases. Experience with similar disaster is more effective than training and awareness programs immediately after the disaster. But this effect gradually declines over time. Before the event, awareness and training programs are the most important determinants that can influence perceived risks (table 17). Publicity and communication support the awareness and training programs. Their impact is further increased during the disaster period as people are wary and desire information to plan their response accordingly.

Table 17 Matrix of determinants of risk perception over different phases of disaster

		Time line		
		Pre-disaster	During disaster (Week 1-2 after the disaster)	Post disaster s(Week 3-8)
Determinants of Risk	Training and education	+++	++	+
	Experience with similar disaster	+	+	+++
	Social and personal factors	++	+++	+++
	Trust	+	+++	+
	Publicity and communication	++	+++	+

The experts were then inquired about potential relationship of perception of risks, community and each elements of urban form. All of the interviewee agree that either some or all of the elements of urban form influence risks and how people perceive them to varying degree. Opinions based on each elements of urban form are summarized below.

Density, both buildings and people has an indirect effect on risk. Higher the density of people and buildings, higher the vulnerability as most areas in Kathmandu city are not planned properly. This means the potential of fire hazards and epidemics become higher after the disaster. Unplanned higher density of buildings suggests that there is a lack of open spaces proportionally and at appropriate locations. It also becomes highly costly and difficult to provide basic infrastructure in these areas.

> *"The lack of open spaces means even if the houses have not collapsed, people would not go there which is a psychological response." –**DRR expert, ENPHO***

The experts stated that if proper planning is done, then having higher density of people and buildings do not pose a problem even during disasters. As the population and building densities increase, the density of open spaces should also increase and proper escape routes should be planned. However, a direct relation to people's perception of risk because of higher density for example through perceived crowding was not mentioned by anyone.

The experts who opined about **land use** stressed on the importance of risk sensitive land use planning. This particular factor influences all the other factors. They also stressed about need of policy guidelines to address the issues of land use. The effect of land use in people's behaviour is shaped through factors influenced by it such as accessibility, availability of open spaces, density of buildings etc.

> *"The needs and requirements of people and settlement is constantly changing and increasing. For e.g. before, in old settlements people wouldn't have dreamed of vehicle running in that area so a small road may have been made for walking only but now since vehicle is available for easy mode of transportation, people need that facility but the accessibility for vehicle is not sufficient and congested through that road, so the houses need to be destroyed." **–Urban Planner, WeLink Pvt. Ltd.***

Open spaces is one of the most recurring theme in the interviews. Most of the interviewee stressed the need of communal open spaces so that access to them is easy. It was mentioned several times that the government had designated large open spaces as safe zones in an event of a huge disaster but very few people went to these locations. People preferred to stay in closer open spaces because they wanted to protect their belongings in their homes even if it collapsed as they still have their valuables inside the house which was all they had left.

> *"For example, 83 open spaces which were designated as safe place, no one went there. Only in Tudikhel (a large open space, centrally located in the city) people stayed in large numbers because it was close to the communities. What we learned from that is, even if the house is completely damaged and is now a pile of rubbles, people valuable their possessions such as gold and silver which was still there. Bed and wood is still there, relatives are near the houses so people didn't want to stay farther from their homes. So we understood that small open spaces at community level is necessary." -**DRR expert, ENPHO***

Accessibility was considered an important factor which shapes people's perception. However, very few roads were damaged during the earthquake which means accessibility to open spaces and important services such as hospitals were not hindered after the earthquake. Many of the experts pointed out that people were lucky as the damage to roads was almost non-existent compared to the predicted 60% damage.

> *"What truly matters in terms of accessibility if we talk about Panga is within 2 minutes the residents can flee the core area to an open space where they can be safe during an earthquake. But to make things more accessible a belt around the core city area which will cater to the emergency evacuations or helps must be considered. Rather than expanding the roads and lanes of the city, roads on the periphery area to cater ambulances, fire engines etc. will be feasible and relevant." **Architect, Morphogenesis Consultant Pvt Ltd.***

Accessibility was also considered important in terms of width of the roads such that emergency vehicles such as ambulance and fire brigades could reach the desired locations. Need of multiple access roads were also mentioned in case one of the route is blocked, then other routes could be utilized. It should be considered in respect to its influence to other elements of urban form such open spaces, infrastructure such as hospitals, layout and design etc.

> *"To have proper accessibility it is not just the width of the roads but also its geometric design, its layout is also important. It doesn't serve well if the roads are wide enough but there are bottlenecks in many areas which will hamper accessibility."* ***Urban Planner, WeLink Pvt. Ltd.***

Building type and building attributes were important factor to determine risks. In terms of building technology, most experts opined that it does not matter if the house is load bearing or frame structures. If the materials used and workmanship is good and if the buildings have been well maintained then both type of structures are able to withstand the earthquake quite effectively. However, in Panga it was observed that many load bearing buildings with concrete slab roofs had collapsed and caused a lot of deaths. This type was later considered unsafe by the state authorities as well as the local people.

> *"Just before the earthquake, we from Kirtipur Municipality executed building codes; pillar must be of 12" x 12" (30cm x30cm). Likewise other building codes, which are there, in theory, must be implemented. Initially, it was a challenge to us. But after the earthquake, it was not necessary for us to keep telling people to follow the building codes. People, themselves would ask if they could add to safety factor than required by the building code."* - ***Municipal Officer, Kirtipur***

Number of floors was directly connected with perceived risk as people sought to decrease the floor heights of their existing buildings after the earthquake. The tall structure created a sense of fear among the people. Damage to buildings was the most significant factor that influenced people's perception of risk which further heightened when combined with tall buildings.

> *"People actually were afraid to go by damaged houses, for example one of the houses which had suffered heavily was not demolished for a long time. In that area, there were more death casualties too, so a lot of people were really scared to go to that area for a long time (2-3 month)."* ***– Volunteers, Panga***

> *"Psychologically it affected students the most. In Janasewa and Panga School the number of students decreased considerably as the houses were not earthquake resistant and they had to travel through the streets where there were damaged houses."* ***– Volunteers, Panga***

Infrastructure of basic services significantly affected people's perception of risk. One of the most important infrastructure was electricity which was available in most locations in the next day after the earthquake. This was important as people did not have to stay in the dark while there is recurring aftershocks frequently. This made them feel safer. People could charge their electronic devices and communicate with their loved ones which gave them sense of relief as telephone towers were functional too.

> *"Availability of electricity gives a lot of psychological peace to people because they don't have to stay in the dark. Darkness also incites crimes which was quite low in Nepal compared to other countries during disasters."*
> ***Urban Planner, IOE***

There were very few instances of disruption of water supply but Kathmandu has water shortage problem in normal conditions as well. So this was not a major concern, however, the disaster experts expressed the importance of water supply for drinking as well as for sanitary purposes. In terms of infrastructure of sanitation, public bathrooms were considered a must near the open spaces as many people were afraid to go inside their homes and some would even defecated in open spaces increasing the risks of epidemics.

Street and open spaces **layouts** were discussed in unison with accessibility aspects such as connectivity of roads. In times of disaster one street may be blocked due to collapsed buildings so an alternative route becomes necessary. The hierarchical courtyard systems of older settlements were preferred by most of the interviewee as they provide easy access to open spaces. Street layouts could also instigate sense of identity and work as landmarks in themselves such that during disaster period people can easily follow the routes towards a safe place. Patterns of streets and open spaces could also enforce sense of ownership, improve security as well as promote social interactions and bonds.

> *"Talking about street patterns, similar to our chowks (courtyards), in Europe you can find cul-de-sac at the dead end. So that dead end road is of the people who are connected to it similar to our chowks. So the cleaning of that space is also the responsibility of those people. The area is secluded and thus unnecessary access of strangers is avoided which enhances the security of the area. In our chowk systems too where there are bahal and bahil were surrounded by houses. If you look at the planned neighborhood of today there is actually too much access."* ***DRR expert, OXFAM***

The layout influenced by grid iron patterns of streets were commended for easy and multiple access to a given area. However, if not designed properly, its repetitive design could incite confusion during a disaster especially when the people are new in the community and could result in loss of valuable space in form of too many roads.

It is clear from the interviews that the elements of urban form directly or indirectly influence the risk perception of people. But these elements are complimentary to each other so many of the perception are based on a combination of factors and not just a single one. It is also clear that these elements have varying degree of influence on how people behave and are subject to differences with time. Combination of multiple elements seems to influence how people perceive and behave during disaster situation.

5. DISCUSSION

This chapter provides a detailed discussion on the obtained results in relation to the literature. It attempts to present a critical review of the methodological approaches, obtained results and also reflects on the limitation of this study.

5.1. Urban form

In this research, urban form is broadly described by its six elements: accessibility, density, infrastructures, land use, layout and building attributes. This generalized view of urban form was adopted to simplify its understanding by dividing the whole into smaller distinct elements. Because of this generalized view, urban form should be approached considering its response to external factors (Bostenaru Dan, Armaş, & Goretti, 2014), i.e. in this study, in relation to the impact of earthquake. The specificities of each element is studied carefully for comprehensive understanding of its peculiar attributes. This allows for precise delineation of risk factors that shapes particular decisions depending on the context (Florescu and Ionita 1999). Since these elements are characterized by diverse attributes, its analyses also required diverse approaches. However, it should be noted that none of the urban elements exist in isolation. These elements constantly interact with each other and through these interactions, each element develops certain attributes which are subject to change over time. For a given time frame, each element boasts a static value of its attributes, which in this research, is used to investigate its potential influence on perceived seismic risk. The reference time frame for this research is given by the earthquake in Nepal, 25th April, 2015. The urban form is studied at community scale through comparison of its attributes against two urban communities with varying urban form and character. Community is viewed as an important catalyst that influences human behaviour as well as deemed appropriate scale for effective disaster mitigation and response (see Bruneau et al., 2003).

5.2. Comparison: Panga Vs Nayabazar

The main objective of this research is to link perceived seismic risk and urban form through comparative study of two communities. In this regard, it is necessary to understand the urban form of the two communities. The comparative study has revealed that, indeed, the two communities differ considerably in terms of their urban form. The descriptive statistics demonstrated some of these differences observed in building use, construction type as well as age of the buildings which is provides an initial understanding of the urban character of the two sites.

The compact arrangement of row and courtyard houses define the street and open spaces of Panga. This organic form can be journeyed through a well-defined path that stretches from its one end to the other through hierarchical courtyards which guide the passage and act as landmarks, for example, the large central courtyard (fig 19, right). Thus, anyone can traverse through the streets without the feeling of being lost. Most of its open courtyards host temples relative to the size of the courtyard which demonstrates its cultural peculiarities and significance. It also facilitates sense of place (Lynch, 1981). The inner courtyards link with the streets through seemingly concealed passages which are small openings in ground floor of some of the houses adjoining the inner courtyards. These courtyards are accessible to all but can be considered as semi private spaces. They allows privacy to the residents but also functions as a mental barrier that reduces public access. The access to large emergency vehicles is compromised which increases the vulnerability of the area against disaster risks. Over the last few years, haphazard development of built structures on pre-dominantly agricultural land is observed. Furthermore. Before the earthquake there was a tendency to adapt traditional slope roof homes into RCC slab roofs within the core area along with addition of floors. According to the locals infrastructure for services such as water, sanitation, electricity and communication has been steadily improving over the years along with better access to health services and educational institutions.

Nayabazar is a modern town based on a land readjustment project. Its road layout is inspired by grid patterns but do not consist of strict parallel and rectangular streets. This is because of existing organically developed roads and the obligation (of the project) to provide proper access to every plot which came in all shapes and sizes. The considerably higher number of intersections points encourage long succession of turnings are disturbing to the human brain (Lynch, 1981). Additionally, it lacks distinct landmarks which combined with similarly built buildings often confuse the orientation of newcomers. These landmarks are important factors in that influence urban perceptions of a given area (Lynch, 1981). The pre-dominantly RCC built structures of Nayabazar usually host residential spaces for owners in the upper floors whereas lower spaces are rentable. These rentable spaces invite many tenants from all over the country and also facilitate multiple uses such as shops, garages, offices etc. Thus there is a great diversity in culture and also in functions depending upon the attributes of the adjoining roads. In addition to the planned five open spaces there are several other open spaces in the form of empty plots scattered all around the site. The basic infrastructure service is planned, while abundant health and education services are available within and in close proximity to the area. The area is developing into a dense community with the number of buildings and population increasing steadily over the years.

5.3. Open spaces and perception of risk

Based on the findings of this research, the most crucial aspect of urban form in regards to disaster response and perceived risk is given by open spaces. Open spaces are destinations for safety immediately after the event as well as suitable sites for temporary shelter which could further develop into long term shelters. Land use influences the number, location and sizes of open spaces in the form of parks and play grounds. It also determines its relation with the built structures. Land use is considered one of the most effective approaches to reduce disaster risk (EMI, 2014). Most of the interviewed experts agree with this notion of risk sensitive land use planning, especially because Nepal is an earthquake prone country with haphazard urban development. The importance of open spaces are also highlighted in this research. The household survey results show that people perceived open spaces to be the most prominent factor for reducing seismic risks. All the experts, too, discussed the importance of open spaces in relation to its various attributes such as number, size, location and availability of services.

In the aftermath of disaster the attributes of and in relation to open spaces influenced evacuation behaviour of people. Significant percentage of respondents (>85%) from either case-study site preferred open spaces which is less than 200m for immediate refuge. Additional analysis revealed that median distance travelled during this immediate escape is twice as much in Panga than in Nayabazar. At first look, this is surprising because Panga boasts considerably higher number of distinct open spaces (courtyards) of varying shape and sizes which are in closer proximity to the built forms. But closer inspection of choices of escape destinations suggests that most people preferred uncluttered open spaces which are visually clear of built structures even if it is relatively farther. Additionally, a ratio of building height to size of the open space seems to exist which people find psychologically safe. The ratio of the open courtyards to the building height of the buildings should be such that, that even if a building collapses, it does not impact the person in the adjoining open space. This is further supported by the influence of collapsed buildings on choice of open spaces as safe refuge which was observed in Panga. Respondents in the southern part of Panga travelled longer distances than their northern neighbours where the number of collapsed building is twice as high.

Open spaces (especially public ones) are temporary shelter locations after a disaster. The unpredictable nature of earthquake means planned evacuation is not possible thus emergency shelters are positioned mostly after the event (Wright & Johnston, 2010). The disaster shelter response is especially challenging in urban setting than in rural areas (Global Communities, 2012). Even if the open spaces are pre-determined, the choice of safe location during such a chaotic period is dependent in several other factors. This was also evident in Nepal. Although the government had pre-assigned 83 open spaces for evacuation and temporary shelters, most of the people stayed closer to their homes. The primary reason was to protect their properties which were still inside the buildings. Even if the buildings had collapsed, people still guarded the house because the remaining belongings and valuables were necessary for sustaining their future. Secondly, it owes to a sense of place and social bonds within the community, whereby people chose to stay closer to people they know and trust. They feel safer in their own neighbourhood and find it easier to co-exist harmoniously among known faces which encourages shared coping mechanisms through joint efforts towards survival. This was observed in both Panga and Nayabazar. Similar behaviour have been evident in other countries as well during disaster period (see Allan et al., 2013).

Experts also stated that lifelines such as drinking water supply and sanitation near the open spaces influence people's choice of shelter locations. Open spaces with functioning services are much more attractive as shelter locations. These services can attract people to public shelters even if their house is otherwise intact but lacks the functioning of these services (Anhorn & Khazai, 2015). Even when the services are still intact access to these services can be vital as many people still find it risky to go inside the buildings for as long as 2-3 weeks. Many people preferred public restrooms or even defecate in open spaces rather than enter a house. This is due to frequent aftershocks that continuously remind people of the risks posed by earthquake. These aftershocks could be smaller in magnitude (3.5-4 Mw) but are still felt as people anticipate these tremors and a weakened structure may also collapse as a result of such aftershocks.

While considering open spaces, it is thus necessary to take into account qualitative attributes along with the quantitative aspects. The consideration of open spaces should take into account all possible functions that is imminent due to variability of its purpose which could be risk mitigation, immediate response as well as disaster recovery. Allan et al., (2013) support this notion of need to incorporate both qualitative and quantitative aspects of open spaces. Although they discuss it at a city scale, the underlying essence remains relevant at community level too.

5.4. Infrastructures and perception of risk

The importance of basic utilities such as water, electricity and sanitation is general and not limited to its relation with open spaces. They are crucial service which should be accessible in sufficient amount and in continuous supply after a disaster (Fema, 2011). Water supply and sanitation are basic utilities that relates to core needs for survival. Electricity could also be a core need, especially in a developed nation where most actions are dependent on electrical appliances. However, a developing country like Nepal (which suffered up to 12 hours blackouts every day until last year during winter season) is less reliant on continuous supply of electricity for its day to day life. But the availability of electricity after the disaster was important to reduce perceived risks as it meant not to live in the dark which heightens the fear among people. Further, it allowed people to charge their phones which enabled them to communicate to their loved ones. The internet could still be used which allowed for communication with the whole world. The volunteers from Panga setup a website within 2-3 days of the disaster where they documented the destruction caused by earthquake in their community. This resulted in flow of necessary supplies soon after from different quarters which supported the people to cope with and adapt to the situation. The limited damage to all the basic infrastructure after the earthquake was a key aspect which helped in reducing the overall risks as well as lowered perceived risks of people.

Besides infrastructure for utilities, other physical infrastructure such as hospitals are critical to reduce the impacts of disasters on people. Major hospitals within Kathmandu were reported to be functional. However, more than a 1000 smaller health clinics pre-dominantly in village areas were reported to be damaged (WHO, 2015). However, in relation to Panga and Nayabazar, discussions from locals and experts suggest that access to health services did not hold a significant influence on how people perceived risk. It can be logically assumed that, because the health services were functional and accessible, impacts on perceived risk were low. Due to lack of data concerning the number, location and capacity of the health services for both of the case-study sites, quantitative analyses could not be conducted to see its potential relationship with the developed RPI. Nonetheless, it is certain that they play an important role to provide physical and psychological relief to people immediately after a disaster. In longer term scenario, proximity to health services are considered necessary to determine the suitability of shelter sites as well (Sphere Project, 2011).

5.5. Accessibility and perception of risk

Proximity to open spaces and critical services are key part of assessing accessibility but are not limited to these. The inherent attributes of physical means that allow access, i.e. roads, train tracks etc. also influence the degree of accessibility. The narrow streets of Panga as well as closed courtyard planning obstructed access to larger vehicles to certain locations of the sites. For the people who live in these locations, actual risk as well as perceived risk becomes higher as valuable time could be lost to reach them which could be a matter of life and death during a disaster event. However, in Nayabazar wider streets were even used as escape destinations (see figure 22, pg. 41). These roads added surface area to adjoining empty plots creating large enough open spaces which were perceived to be safer. Multiple access points meant easy access even if one entry point is disturbed by a collapsed building. This adaptability to access is given by its street layout.

5.6. Layout and perception of risk

The layout of streets, open spaces and the built environment determines the movement of people and vehicles. This influence is hinted at through the movement of people as they escaped during and immediately after the earthquake. In Panga, repetitive patterns of movement was observed (escape distance >100m) guided by the limited options of streets that reach distinct open spaces (figure x, pg. 41). In stark contrast, the escape routes followed (those >100m) in Nayabazar are random (figure x, pg. 42). It could be due to higher number of streets and scattered open spaces that is evident here that did not encourage any order to the travel behaviour. However, concrete conclusions cannot be drawn given the sample size is quite small. A review of this possible relationship can be potentially studied though network analysis of the street patterns of each communities comparing them with the escape routes followed and destinations reached. The social influences of street networks have been well documented through approaches such as 'space syntax' (see Hillier, 1997, 2004; Hillier & Hanson, 1984) and 'multiple centrality assessment' (Porta et al., 2006a, 2006b). The initial idea was to use one of these approaches in this research to assess the street layouts, but due to complexity of the approaches and the requirement to develop a suitable methodology specific to this research meant, the process would take a lot of time. Due to limitation of time it was discarded, but it could be an effective approach to understand the link between influences of street layouts on perceived risk.

5.7. Density and perception of risk

Higher built density does not in itself indicate higher risk, as mentioned by several experts. They stressed that a well-planned area with high built and population density can actually mitigate risk as DRM needs and activities are concentrated efforts at a single location. This means the impact of an earthquake is most likely concentrated at a given area which makes emergency rescue operations and distribution of necessary supplies efficient. This means perception of risks could be indirectly lowered through swift and effective response. However, high built density with poorly built buildings means the area is susceptible to the effect of an earthquake causing mass destruction. This could increase the perceived risk considerably. Population density was deemed insignificant as a factor to influence an individual's perception of risk by locals and experts. Most people preferred living in groups which functioned as a coping mechanism. In both communities overcrowdings was not seen as an issue. However, it should be noted that community factors could have been influential in this circumstance. It is much more likely that people do not mind sharing spaces with other community members than strangers. Although the experts pointed out that the inherent nature of Nepalese people to help those in trouble shone through after the disaster, it is still unclear how it affected their perception of risk. Also, a given space can only accommodate a certain number of population based on standard area requirements per person. This means in densely populated urban areas, where shelter demands may well exceed the supply of open spaces, conflicts could arise among people for space which would influence perceived risks. Although such incidents were not evident in both the sites or reported in general it is unknown how they would affect people's behaviour.

Density of buildings in unison with other factors such as size and proximity of open space and height of the built structure (given by number of floors) influenced the choice of open spaces for immediate refuge. People perceived uncluttered open spaces to be safer than enclosed open spaces (see figure 20, pg. 40) even if there were smaller confined spaces nearby. This is indicative of a potential influence of ratio of building height to the size of the open spaces.

5.8. Building attributes and perception of risk

Building height had a significant influence on the perceived risk of people. It not only influenced immediate shelter locations, but also altered travel behaviour of people for a long time. Its effect was repeatedly mentioned by the experts. It was also one of the important determinants of reducing seismic risk as shown by the household survey. This was also given by the statistical analysis (in Nayabazar only) to be significant in determining the variation in perceived risk. Although the model is not as reliable as it could be, it still points at its potential influence which is supported by findings from the interviews and household surveys. The statistical analysis also shows building age as a significant indicator. This could be potentially due to the dread factor associated with modern buildings. The dread factor is caused by the potential imminent death and low possibility of rescue (even if one survives the initial impact) that collapsed modern concrete houses present. Although the statistical analysis of data from Panga was not concurrent with statistical findings of Nayabazar. However, locals and experts of Panga did express that older masonry buildings with adapted RCC roofs suffered the most damage and were the cause of most of the fatalities there. They also indicated that there is now a general consensus to avoid and ban such building practice. This shows a clear influence on perceived risk.

5.9. Making sense of Multiple regression analysis

It is interesting that the MRA analyses resulted in a significant model only for Nayabazar and not for Panga or for the combined data. This variability in results is surprising because the obtained results have been supported by claims from experts as well as locals from both sites. This inconsistency is perhaps explained by two reasons. First, it is possible that the RPI developed for this research is not representative of the actual perception of risk of people. Risk perception is affected by multitude of factors such as uncertainty, dread, catastrophic potential, controllability, equity and much more (Slovic, 1987) which is only part of the psychometric paradigm. Additionally there are cultural and social influences that influence perceived risks. It is possible that the developed RPI did not fully represent the actual perceived risk. The factor, damage to buildings which was found to have influenced the perceived risk were not included. This primarily owes to limitation of sample size. However, statistical significance of the regression model with observed significant variables is supported by findings from survey and expert interviews which validates the reliability of RPI to a certain degree.

Secondly, it is possible that the influences of cultural and community factors played a pivotal role in influencing perceived risk of respondents in Panga which overshadowed the influences of urban form. Cultural constructs have shown to be influential in shaping seismic risk perception by earlier studies which stresses that culture differs tremendously across different location and should be considered as a determinant of perceived risk due to earthquakes(Palm, 1998). Panga is a culturally homogenous community which has been evolving through collective development for centuries. The influences of cultural institutions (Guthi) after the disaster have been repeatedly mentioned by the locals and the experts. The community bond was evidently higher in this community than in Nayabazar which was clear from the interviews with the local volunteers. Old traditions and cultural practices are intact and still remain vital to the locals, especially the older population. It is also possible that the age was a factor which perpetuated this effect. This is supported by the positive correlation observed between age and RPI (see table 10, pg. 43). Previous research has also shown age a strong indicator of seismic risk perception (Ainuddin et al., 2014; Armaş & Avram, 2008; Wachinger, Renn, Begg, & Kuhlicke, 2013). Respondents of Panga are old (median age: 50) which suggests that they are dependent on others for support, which is given by their family, community and cultural institutions. In contrast, Nayabazar was a young community both in its development and in the age of its members (median age 36). Although the perceived community bond was high based on the survey data, the actual overall community bond was observed to be considerably less than in Panga. This high perceived bond is possibly because respondents in Nayabazar were referring to their immediate neighbours and not the whole community. This doubt arose as there were no community institutions which were active during the disaster period nor a mention of collective community response to the disaster that would hint at a strong community bond.

The results of measures to reduce risk (figure 17, pg. 37) also hint at the probability of second notion in explaining the statistical inconsistency, albeit a minor one. It shows that respondents in Nayabazar found factors related to urban form more relevant to reduce seismic risk than their counterparts in Panga. This is indicative of the factors that influence the perceived risk of the respondents which is related to urban form at a higher degree in Nayabazar than in Panga.

5.10. Limitations

The initial approach of the research was focused on identifying relationships between urban form and seismic risk perception for a given time frame i.e. the disaster period (up to 2 weeks from the event). However, during the interviews it was realized that the perception of risk differs in different phases of disaster. The degree of influence of given factors changed over time which was most apparent in the acceptability of risk in the post disaster phase due to limited income capabilities of people. An attempt was made to express these findings (see table 15, pg. 47) but the method used to obtained the results owes to subjective judgement of the author. However, it is now understood that perception of risk changes over time and the degree of impact of a given determining factor is highly dependent on it.

The survey could not yield income data at household level due to reluctance of people to express their earnings. This information could have provided further insights into how risk perception manifests in people as higher income suggests increased adaptability against the risks and subsequently lower perceived risk. Additionally, experience with similar disaster has not been properly addressed by this research. Although an indicator was developed, it was realized after the fieldwork that the indicator did not capture the essence of perceived risk. A question in the household survey could have been a 'yes' or 'no' question related to their personal experience of earthquake. However, some of the disaster experts pointed out that the effect of such experience on perceived risk lasts for a shorter period of time especially if the magnitude of the earthquake is not that high. This was already evident in Kathmandu and that too after the biggest earthquake in around 80 years.

In this research, the site selection was based on their urban form and origin of their development which did not align with the administrative boundaries. Since, only the core area of Panga is considered and Nayabazar is part of two different wards, official data could not be used. These data could have had specified aggregated income levels and damage data observed after the earthquake that would have been valuable to the research. This is particularly true for Nayabazar as damage data was only lacking for this site which hindered the comparative analysis. Attempts were made to contact the municipal officers of the two wards of Nayabazar for expert interviews as well as for obtaining the data but it was unsuccessful. Damage data for one of wards for Nayabazar was obtained (through personal channels) but were deemed useless for this research as it only specified number and lacked spatial information.

A larger sample size could potentially provide insights into the underlying reasons of inconsistent regression results. It would have also allowed for adding variables related to personal factors in MRA conducted for each site and broaden the scope of comparison. This study also does not incorporate the influences of institutional factors in detail. Detail information regarding issues such as lack of communication from government authorities, delay in providing necessary supplies, problems with distribution of funds etc. could have improved the understanding of perceived risk of people.

5.11. Ethical considerations

Disasters create a chaotic environment for the affected people. In an instant, people could lose their lives, their family members and valuable physical properties. This is a traumatic period and remains a sensitive issue for a long time for those who have endured great human and physical loss. During social research like this it is possible that conversations during the survey in the affected areas may rekindle subdued feeling of loss and sorrow. It is thus important that the surveyors are well trained who should handle the interactions with the people with utmost consideration of their loss. First, the purpose of the study should be clearly mentioned and people should not be harried to respond to the survey if they do not wish to. This is true for all types of survey done for scientific study. But disaster study should go one step further and encourage disaster preparedness through awareness while conducting the survey. The implications of the potential results should also be mentioned if possible but cautioned should be undertaken not to give false hopes.

Before carrying out the survey, the surveyors were made aware of these considerations. Since all of the surveyors had participated in disaster related survey after the earthquake of 2015, the task was made easier. Additionally, all the surveyors themselves experienced the earthquake which provided them context and also facilitated empathy to the respondents. In Panga, one of the respondents started crying during the survey process. She had loss a family member, but the surveyor was able to carefully handle the situation by sharing her own experiences and empathizing with the old lady. There were some family who were still living in the temporary shelters in the school backyard in Panga in vicinity of which surveyors had to conduct the survey. At such locations, it is necessary that surveyor respect the privacy of the people which could be have been compromised depending upon the type of shelter.

While conducting the research, full names were recorded as surveyors opined that asking just the caste could provoke negative emotion as Nepal is a caste based society and it is not socially prevalent to call people, especially strangers by their caste. Although the first names were also recorded, they are not presented to protect the privacy of the respondents. This is a small consideration applied in this research but such considerations should be taken into account while conducting proper scientific research.

6. CONCLUSION

This research adds to the growing body of literature which aims to understand perception of seismic risk and factors that influence it. The main objective was to identify potential relationship between urban form and seismic risk perception. In this regard, it is evident that urban form may indeed influences seismic risk perception but the degree of influence vary and are dependent on additional factors such as time, socio-economic factors and cultural peculiarities. Furthermore, three sub-objectives were established in this research, 1) to identify the dimensions of urban form at community level, 2) To analyse seismic risk perception of people and 3) To identify and analyse aspects of urban form that could influence seismic risk perception of people.

The elements of urban form exist in interdependency where one or more elements are in constant interactions and any attempt to modify the property of one element impacts the attributes of other elements. This holds true for both case study sites but the level of interactions and influence in one another among these elements differ with respect to differences in their attributes. Open spaces is the link which is part of or influences all the other elements of urban form. This understanding is key to critically analyse its impacts on perceived seismic risk. Size of open spaces and floor height were two of the most significant factor that influenced perceived risk which was consistent across all the results (of survey, interviews, maps and statistical analysis) and corroborates with existing literature. However, it should be noted that proximity of open spaces and built density are also important considerations. Thus, the observed influence on perceived risk is not a consequence of an isolated element of urban form but a resultant of a combination of attributes of multiple elements.

The importance of context while analysing perception of risk was highlighted in the form of cultural influences in Panga. Communities where culture and traditions are an integral part of day to day life respond to the disaster in unity and harmony which reduces the perceived risk of individuals through increased adaptive abilities and strong coping mechanisms based on trust, respect and mutual co-operation. Cultural institutions in Panga facilitated communal response, resolved conflicts as well as provided basis for receiving funds which had crucial impacts on reducing perceived risk. Proxies such as perceived damage seems to affect perceived risk but ownership is deemed insignificant.

The research also shed light into the variability of perceived risk depending on different phases of disaster. Factors which are more relevant during pre-disaster such as awareness and training programs might be overshadowed by trust and personal factors during the disaster phase and economic limitations in the post disaster period. The elements of urban form are affected by time factor too. Floor heights were reduced and ban on risky construction practices were widely discussed after the earthquake but as experts argued, the effect is already fading away.

The findings of this research can guide policy makers and urban planners to develop safer communities. The importance of designing open spaces of appropriate sizes with due consideration of proximity to buildings has been highlighted in this research. These consideration can be included to develop risk-sensitive land use plans which facilitates adaptive responses and which caters to the need and perception of people. Furthermore, building codes could address problems of unsafe constructions such as load bearing houses with adapted concrete roof to minimize the risks. Contextual realities of communities should be considered to account for variability in needs of people and their response which changes over time. One of the approach to facilitate this considerations could be incorporation of existing communal and cultural institutions in disaster risk management mechanisms where applicable. In communities, where such institutions do not exist, new ones could be formed.

6.1. Recommendation for future research

This research has laid the ground works for understanding relationship of perceived seismic risk and urban form. This could be furthered through, first, conducting similar research in multiple communities for cross cultural comparisons. A bigger sample size is recommended. Also, future research should take into account the different phases of disaster while developing a framework. After that, further research could be carried specific to significant elements of urban form to have a deeper understanding of their influence and its manifestation over time. More complex analyses could be carried out for these specific analyses such as use of network analysis through space syntax or multiple centrality assessment. Further research could also look into the inconsistencies observed in the statistical analyses and find the underlying reasons for it.

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APPENDIX I – THE HOUSEHOLD SURVEY TEMPLATE

शैक्षिक सर्वेक्षण

नमस्कार, म ………………………………………………………………. (आफ्नो नाम) । म नेदरल्यान्डसमा अर्बन प्लान्निङमा स्नाकोत्तर्को गरिरख्नु भएको दाईको तर्फबाट आएको हुँ। वहाँको थेसिस को निम्ती जानकारी चाहिएको हुँदा तपाईंको समय लिदैछु । यो सर्वेक्षणको औचित्य चाहिँ हाम्रो वरिपरीको बस्ति, सडक, घरहरु, त्यस्को त्यस्को सँरचना तथा घरको निर्माण सामाग्री ले मान्छेको जोखिमको बुझाइमा असर गर्छ कि गर्दैन भनेर पत्ता लगाउन हो । यस्ले तपाईंको २०-३० मिनेत समय लिने छ ।
सबैभन्दा पहिला यो सर्वेक्षणकोलाई तपाईंको अनुमती लिना चाहन्छु । तपाईंले दिनु भएको जानकारी पढाईको सिल्सिलामा मात्र प्रयोग हुनेछ ।
Good afternoon, I am ……………………………………………… (Name of interviewer). I am here on behalf of a Master's student (urban planning and management), University of Twente, Netherlands). I would like to request you for your time for a short survey. The questionnaire is aimed to get information regarding disaster risk perception and how urban form may impact it. This survey will be based on the earthquake that happened in April and May 2015. The interview will take around 20-30 minutes of your time. Firstly I would to like to ask you for your consent for the survey. I assure you that your identity and the data provided by you will be private and only used for research purposes.

साक्षात्कारदाता (*Interviewer*): ……………………………………………………………….. (आफ्नो नाम)
मिति (Date):
ठाउँ (Neighbourhood location):
सडक (Street name):
घर आइ दि (House ID):
जहाँ उचित हुन्छ, कृपया (√) गर्नु होला । जहाँ खाली छ, त्यहाँ उत्तर भर्नु होला ।

Instruction: Please tick (√) the right/possible answer where applicable. Fill in the space with appropriate answer where required.
साक्षात्कारदाता :यो सर्वे १८ बर्ष भन्दा माथि उमेर को मान्छेहरुको निम्ती बनाएको हो । भूकम्पको बेला घरको ठुलाबदाले सबै थोक हेर्ने भएको हुँदा १८ बर्ष भन्दा बढी उमेर को मान्छे खोजेको हो । घरमा १८ बर्ष भन्दा ठुलो अरु कोही हुनु हुन्छ भने वहाँलाई सर्वे को लाई सोध्नु ।

Interviewer: The interview is meant for residents above 18 years old. If the respondent is younger than 18, explain the age selection criterion. Then, ask if the respondent was living in this neighbourhood during the earthquake. If not, thank the respondent for their willingness to participate and ask if there are others in their household over 18 years old who might be able to participate.

1. समान्य जानकारी **General Information**	
1.1	तपाईंको उमेर? What is your age?
	…………….
1.2	तपाईंको लिङ्ग? Are you?

	☐ महिला (Male) ☐ पुरुष (Female) ☐ अन्य (Others)
1.3	तपाईंको शैक्षिक योग्यता के हो? What is your level of education?
	☐ औपचारिक शिक्षा छैन (No formal education) ☐ प्राथमिक तह (Primary level) ☐ माध्यमिक तह (Secondary level) ☐ एसएलसी तह (SLC level) ☐ उच्च माध्यमिक तह (Intermediate level) ☐ स्नातक वा माथि (Graduate or above)
1.4	तपाईंको थर के हो? What is your caste?
	…………………………………………..
1.5	तपाईंको पेशा के हो ? What is your profession?
	☐ ब्यवसाय (Business) ☐ किसान् (Farmer) ☐ मजदुर् (Laborer) ☐ सेवा (सरकारी अथवा निजि) (Government or Private service) ☐ बेरोज्गार /छैन (Unemployed or not working) ☐ अन्य (स्पष्ट गर्नुस्) (Others, please specify) ………………………………………………………..
1.6	तपाईंको घरको बार्षिक आम्दनी कती छ ? What is the total income per year of your household in NRs.
	☐ <100,000 ☐ 100,000-300,000 ☐ 300,001-500,000 ☐ 500,001-700,000 ☐ >700,000
2. शहरको बनोट **Urban form**	
2.1	तपाईं स्वामित्व यो घरमा के हो ? What is your ownership status of this building?
	☐ घर-धनी (Owner) ☐ बाल-वाला (Tenant)
2.2	घरको निर्माण कुन प्रकारको हो ? What is the construction type?
	☐ लोड बेरिङ्ग (Load bearing) ☐ फ्रेम स्ट्रक्चर (Frame structure) ☐ मिश्रृत (Mixed)
2.3	घरको प्रयोग के को निम्ती हुन्छ ? What is the building used for?
	☐ आवासिय मात्र (Residential only) ☐ आवासिय तथा ब्यवसाय (Residential/Commercial)

	□ आवासिय तथा अफिस (Residential/ Institution (office)) □ आवासिय तथा उधोग (Residential/Industry) □ आवासिय तथा भन्डार (Residence/warehouse or storage) □ अन्य (स्पष्ट गर्नुस्) (Others, please specify)
2.4	घरको निर्माण कुन साल सम्पन्न भएको थियो? On which year did the building construction finish?
	…………………………………………………………………………….. (घरमा तल्ला पछी थप भएमा कहिले भनेर उल्लेख गर्नु होला) (If there was further addition later, please specify when?)
2.5	घर कती तल्ला छ? What is the number of storeys of the house?
	……………………………………………………………………………………… (घर मिश्रृत प्रायोजन को लाई प्रयोग हुन्छ भने कुन तल्ला क को लाई प्रयोग हुन्चा उल्लेख गर्नु होला) (Please specify which floor is assigned for which purpose if the building has multiple use)
2.6	गएको भूकम्पमा यो घरमा कुन हद्सम्म्को क्षति भएको थियो ? What was the extent of damage to the house?
	□ क्षति थिएन (No Damage) □ निम्न क्षति (Negligible/slight damage) □ मध्यम क्षति (Moderate damage) □ अत्यधिक क्षति (Very high damage) □ पूर्ण बिनाश (Destruction damage)
2.7	पहिलो भूकम्प गएपछी तपाईं कुन स्थानमा जानु भयो ? To which location did you go to immediately after the first major earthquake?
	(नक्सामा देखाउनुहोस) (Show in map)
2.8	दोश्रो भूकम्प गएपछी तपाईं कुन स्थानमा जानु भयो ? To which location did you go immediately after the second major earthquake?
	(नक्सामा देखाउनुहोस) Show in map)
2.9	तपाईं बसेको स्थान बाट त्यो स्थान जने कुन बाटो प्रयोग गर्नु भयो ? Which route did you take to get to that location?
	नक्सामा देखाउनुहोस) Show in map)
3. जोखिमको बुझाई **Risk Perception**	
3.1	बैशाख १२ को महभूकम्प जानु अघी, के तपाईंले ठुलो भूकम्प निकत भविश्य मा जान्छ भन्ने सोच्नु भएको थियो? Before earthquake in Baiskh 12 (April 25), did you think a major earthquake would occur in near future?
	□ सोचेको थिएँ (Yes) □ सोचेको थिएँन (No) □ याद छैन (Don't remember)

3.2	बैशाख १२ को महभूकम्प जानु अघी, के तपाईंलाई भूकम्प विरुद्धको सुरक्षाको जानकारी थियो ? Were you aware about earthquake safety before April 25th earthquake?
	☐ थियो (Yes) ☐ थिएन (No)
3.3	बैशाख १२ को महभूकम्प जानु अघी, मैले ठुलो भूकम्प लागि पहिले नै तयारी गरेको थिएँ I was prepared for a major earthquake before the April 25th earthquake?
	☐ एकदम सहमती छ (Strongly agree) ☐ सहमती छ (Agree) ☐ तथस्त (Neutral) ☐ सहमती छैन (Disagree) ☐ एकदम सहमती छैन (Strongly disagree)
3.4	भूकम्पको समयमा के गर्नु भयो ? What did you do during the earthquake?
	यदी घर भित्र भए (If inside the house) ☐ घर भित्रै बसेँ (Stayed within the house) ☐ घर बाहिर निस्कैं (सडक वा खुल्ला ठाउँ) (Went outside to an open area or street) यदी घर बाहिर भए (if outside the house) ☐ त्यही ठाउँमा बसेँ (Stayed in the same place) ☐ नजिकैको खुल्ला ठाउँमा गएँ (Went to the nearby open place) ☐ घर भित्र गएँ (Went back inside the house)
3.5	यदी घर भित्र भए, बैशाख १२ (अप्रिल २५)को भूकम्प जादाँ तपाईं कुन तल्लामा हुनुहुन्थ्यो ? If inside the house, which floor were you at during the Baisakh 12th (April 25th) earthquake?
3.6	भूकम्पले मेरो व्यक्तिगत जिवन म असर गर्‍यो The earthquake affected my personal life
	☐ एकदम सहमती छ (Strongly agree) ☐ सहमती छ (Agree) ☐ तथस्त (Neutral) ☐ सहमती छैन (Disagree) ☐ एकदम सहमती छैन (Strongly disagree)
3.7	यदी तपाईं सँग विकल्प भए अर्को ठाउँमा सर्नु हुन्छ? किन? If you had a choice will you move to a different place ? Why?
	(मुख्य बुन्दा हरु तिप्रे अनि अडियो रेकोर्ड गर्ने । अडियोमा घरको नँ आफैले तिप्रे)
3.8	In your opinion, what is the most important thing to reduce the risk of earthquake?
	……………………………………………………….. *(मुख्य बुन्दा हरु तिप्रे अनि अडियो रेकोर्ड गर्ने । अडियोमा घरको नँ आफैले तिप्रे)* (*Record audio. write key words. Record household number yourself before recording answer*)
4. समुदाय **Community**	
4.1	बैशाख १२ को भूकम्प पछी कता बस्नु भयो ? (कमसेकम ३ रात) Where did you spend your nights after the Baisakh 12 earthquake (April 25) At least, the next 3 nights after the earthquake
	☐ यही बस्तिमा, घर भित्र (In this neighborhood, inside the house) ☐ यही बस्तिमा, खुल्ला ठाउँमा (In this neighborhood, in an open area)

	□ अर्को बस्तिमा, घर भित्र (In a different neighborhood, inside the house) □ अर्को बस्तिम, खुल्ला ठाउँमा (In a different neighborhood, in an open area)
4.2	बैशाख 29 को भूकम्प पछी कता बस्नु भयो ? (कमसेकम ३ रात) Where did you spend your nights after the Baisakh 29 earthquake (May 12) At least, the next 3 nights after the earthquake
	□ यही बस्तिमा, घर भित्र (In this neighborhood, inside the house) □ यही बस्तिमा, खुल्ला ठाउँमा (In this neighborhood, in an open area) □ अर्को बस्तिमा, घर भित्र (In a different neighborhood, inside the house) □ अर्को बस्तिमा,, खुल्ला ठाउँमा (In a different neighborhood, in an open area)
4.3	म यो बस्तिमा सुरक्षित महशुस गर्छु I felt safe in this neighborhood after the earthquake
	□ एकदम सहमती छ (Strongly agree) □ सहमती छ (Agree) □ तथस्त (Neutral) □ सहमती छैन (Disagree) □ एकदम सहमती छैन (Strongly disagree)
4.4	मेरो यो समुदाय को मान्छेहरु सँग निकै राम्रो सम्बन्ध छ I have a strong social/communal bond with people in this neighborhood
	□ एकदम सहमती छ (Strongly agree) □ सहमती छ (Agree) □ तथस्त (Neutral) □ सहमती छैन (Disagree) □ एकदम सहमती छैन (Strongly disagree)

*तपाईंको*सहभागिता *को लागि धेरै धेरै धन्यवाद। तपाईंले दिनुभएको जानकारी निकै सहयोग गर्नेछ ।*
अन्तमा, तपाईंलाई यो सर्वेक्षणबारे केहि प्रश्नहरु छ भने सोध्नुस ।

Thank you for your participation. If you have any questions or remarks about the things that we just discuss, please share.
……
………………………………….

APPENDIX II – EXPERT INTERVIEW TEMPLATE

Good afternoon, I am Shakti Raj Shrestha, a Master's student at ITC, University of Twente, Netherlands. Thank you for participating in this short interview. This interview is aimed at extracting information about how people in the community perceived the disaster and how urban form may impact it. This interview will help me get an expert overview of what happened during the earthquake on April and May 2015. The interview will take around 20-30 minutes of your time.

Interviewer: Shakti Raj Shrestha

Date :

Neighborhood :

Respondent's name :

1.1	What is your professional background?
	……………
1.2	Do you have any experience in DRR?
	……………
1.3	In literature, the following are the important factors that influence risk perception, which one do you think is the most important?
	Trust Training and education Experience with similar disaster Publicity and communication Social and personal factors
1.4	In your opinion, are there any other important factors that could affect risk perception?
1.4	In your opinion, what are the most important aspects to reduce risks associated with earthquake?
1.5	In your opinion, does density of buildings and/or people in a neighbourhood affect how people perceive risks?
1.6	In your opinion, does accessibility to important services such as hospitals, schools and fire department affect how people perceive risks?
1.7	In your opinion, does infrastructure for water, road etc. affect how people perceive risks? If yes, how?
1.8	In your opinion, does building type affect how people perceive risks? If yes, how?
1.9	In your opinion, does land use type a neighbourhood affect how people perceive risks? If yes how?
1.10	In your opinion, does layout (street patterns and open spaces) of neighbourhood affect how people perceive risks? If yes how?

1.11	Was there a difference in how different communities behaved after the Baisakh 12 and consequent earthquakes?
1.12	If yes, what were the differences and why do you think this happened?

Read: Thank you very much for your participation. The information you provided would be extremely helpful for our research. We are now at the end of the interview. Do you have any questions or would like to add something that you find is crucial to what we have discussed today?

……

APPENDIX III – RESULTS OF CORRELATIONS

Correlations: Panga

		RPI	Age	Ownership	Education	Gender
RPI	Pearson Correlation	1	.229*	-.022	.016	-.130
	Sig. (2-tailed)		.037	.847	.886	.243
	N	83	83	83	83	83
Age	Pearson Correlation	.229*	1	-.120	-.470**	-.096
	Sig. (2-tailed)	.037		.279	.000	.390
	N	83	83	83	83	83
Ownership	Pearson Correlation	-.022	-.120	1	.118	-.284**
	Sig. (2-tailed)	.847	.279		.289	.009
	N	83	83	83	83	83
Education	Pearson Correlation	.016	-.470**	.118	1	-.337**
	Sig. (2-tailed)	.886	.000	.289		.002
	N	83	83	83	83	83
Gender	Pearson Correlation	-.130	-.096	-.284**	-.337**	1
	Sig. (2-tailed)	.243	.390	.009	.002	
	N	83	83	83	83	83

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations: Nayabazar

		RPI	Age	Gender	Education	Ownership
RPI	Pearson Correlation	1	-.101	.226*	-.238*	.045
	Sig. (2-tailed)		.344	.032	.024	.675
	N	90	90	90	90	90
Age	Pearson Correlation	-.101	1	-.324**	-.006	-.385**
	Sig. (2-tailed)	.344		.002	.953	.000
	N	90	90	90	90	90
Gender	Pearson Correlation	.226*	-.324**	1	.012	.069
	Sig. (2-tailed)	.032	.002		.910	.520
	N	90	90	90	90	90
Education	Pearson Correlation	-.238*	-.006	.012	1	.155
	Sig. (2-tailed)	.024	.953	.910		.145
	N	90	90	90	90	90
Ownership	Pearson Correlation	.045	-.385**	.069	.155	1
	Sig. (2-tailed)	.675	.000	.520	.145	
	N	90	90	90	90	90

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX IV –THRESHOLD VALUES OF RPI

	Low RPI class		Medium RPI class		High RPI class	
	Lower threshold	Upper threshold	Lower threshold	Upper threshold	Lower threshold	Upper threshold
Panga	.75	2.5	2.6	4.4	4.5	6.25
Nayabazar	.5	2.5	2.6	4.6	4.7	6.5