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Open spaces and risk perception in post-earthquake Kathmandu city

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ABSTRACT

Perceptions of seismic risks, among other factors, are influenced by urban environments. This relationship is investigated in this paper, in relation to open spaces. A comparative study of two communities in Kathmandu, Nepal with the context of 2015 earthquake was conducted using data gathered from household surveys and expert interviews. Escape behaviour in relation to open spaces was examined by analysing the correlation with a risk perception index (RPI) which is a novel approach in seismic risk perception studies. Additionally, point density analysis of surveyed houses and visualization of escape routes and destination followed by the respondents offer insights into the spatial relationship with perceived risk. Furthermore, expert interviews were used to validate the findings and highlight the important relationship between perceived risks and open spaces. The findings suggest that open spaces are a key component of disaster response as they are safe locations and offer spaces for community that enables mutual coping among its members. As such it directly or indirectly affect people's perception of seismic risk. It was found that medium sized communal spaces are preferred within a distance of 200 m as immediate safe destinations. The choices for such spaces are dependent on the built environment of the site given by its layout, landmarks, building density and building height. The choices of open spaces as shelter locations are influenced by duration of stay such as availability of drinking water, public lavatory and electricity are crucial for short term stay where as ownership and economic capabilities are vital for long term stay.

1. Introduction

The number of natural hazards and their impact on communities have steadily increased over recent decades. Earthquakes have been among the most catastrophic natural disaster (Nasreen, 2014) in part due to rapid urbanization and population growth in earthquake prone cities, especially in developing countries. The devastating impacts of earthquakes is evident in recent seismic events in China (2008), Haiti (2010) Japan (2011) and Nepal (2015) (EM-DAT, 2017). The unpredictable but inevitable nature of earthquakes means that communities and stakeholders alike must be prepared to resist and cope with their occurrences as well as adapt to the subsequent consequences. To this end, early research and policy considerations focused mainly on structural strength of buildings against seismic risks (Spence, 2007). However, current risk reduction strategies irrespective of the type of disaster encompasses a broader areas of concern (UNISDR, 2005) including issues of risk perception.

1.1. Risk and risk perception

Risk is the probability of consequences (loss or damage) due to adverse events (Slovic & Weber, 2002). Any risk associated with earthquakes can be considered as seismic risk. In seismic risk studies, the importance of understanding risk perceptions of people is gaining momentum (Ainuddin, Kumar Routray, & Ainuddin, 2014; Armaş, 2006; Paul & Bhuiyan, 2010), as such studies provide insights into the probable responses of people. An improved understanding of risk ultimately leads to improved risk communication among the general public, experts and policy makers (Slovic, Fischhoff, & Lichtenstein, 1982). Risk perception also affects people's preparedness for, responses to and recovery from natural disasters (Bradford et al., 2012) and could be an important factor for community resilience.

Risk perception can be understood as a person's intuitive risk judgments (Slovic, 1987) which influence their reaction to risk (Hofer, 2016). There are primarily two theories that explain perception of risk, psychometric theory and cultural theory. Psychometric theory is rooted in disciplines of psychology and decision science (Sjöberg, Moen, & Rundmo, 2004). It uses psychophysical scaling and factor analysis to generate quantitative representations or "cognitive maps" of risk perception (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, Fischhoff, & Lichtenstein, 1980). Cultural theory was developed by anthropologists and sociologists and is based on the principle that a

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person's perception of risk owes to systematic cultural biases that are not homogenous (Olczyk, 2005). Perception of risk is manifested through social and cultural constructs which do not adhere just to an individual but also reflects a community's values, symbols, history, and ideology (Weinstein & D., 1989). It focuses on the importance of culture, society and community on shaping human attitude towards risk. Mileti (1999), for example, found that when people observe an increase in seismic adjustments of their neighbours, they tend to follow.

Before, during and after natural hazards, the interaction of psychological processes, cultural processes and institutional factors may alter perceptions of risk. In terms of earthquake hazards, understanding how seismic risks are perceived by individuals within a community is an important first step for assessing the community's seismic vulnerability (Armaş & Avram, 2008; Armaş, 2006). It also provides an indication towards the potential response of individuals and the community before, during and after a seismic event. This information can be crucial to experts and policy makers in devising mitigation strategies, preparing evacuation guidelines and implementing effective disaster response.

1.2. Urban environment, open spaces and perception of seismic risk

Cities have become the focal point of human ecology (McMichael, 2000) evidenced by the growing number of urban population and urban centres around the world. People are rapidly changing their natural surroundings into complex urban environments with little or no regards for sustainability. By doing so, humans have compounded the negative impacts of increased urbanization. This is further exacerbated by the onset of a natural disaster. Literature on the role of urban environments in post disaster scenarios are limited, however, they are growing in number. Among them, Allan and Bryant (2011) through their case study of post-earthquake scenario in San Francisco (1906) and Concepción, Chile (2010) discussed the role of urban design and planning in disaster response and recovery.

The role of open spaces in particular for improving disaster response and recovery has been discussed(see Allan, Bryant, Wirsching, Garcia, & Teresa Rodriguez, 2013; Anhorn & Khazai, 2015; Villagra, Rojas, Ohno, Xue, & Gómez, 2014a), especially in relation to earthquakes. Open spaces are an integral part of any city plan: it can have a variety of land use such as parks, playgrounds, courtyards, agricultural land, squares, (plaza) and even streets. Their contribution to the overall enhancement of the city and its people across various fields has been widely discussed in literature (see Chiesura, 2004; McMichael, 2000; Wu & Plantinga, 2003).

Sufficient and adaptable open spaces are incredibly valuable during and after an earthquake (Godschalk, 2003) as the immediate evacuation locations. They are locations for shelters (both long term and short term), may also accommodate the distribution of goods, health services, commerce and become sites for communal activities which enables the recovery process (Allan et al., 2013). However, Bernardini, D'Orazio, and Quagliarini (2016) argue that most studies overlook the human aspect of disaster response. The approach to disaster risk should be more people oriented and should focus on preventive methods (UNISDR, 2015, pp. 2015–2030). Thus behavioural aspects should also be considered a part of risk reduction strategies for earthquake hazards.

This paper attempts to fill that void. The main aim is to investigate if individual's perception of seismic risk is correlated with the availability of open spaces, their attributes and its surroundings. Two communities in the post 2015 earthquake city of Kathmandu, Nepal were chosen as the case studies. The actual reaction of individuals to the seismic event provides valuable insights into how perceived risk manifests into behavioural response in regards to open spaces.

2. Methodology

A comparative approach was taken to highlight the differences in perceived risk, if any, between two communities and reveal the underlying links between open spaces and perceptions of risk. Both qualitative and quantitative, data and methods were used.

2.1. Study site

In 2015, Nepal was struck by two powerful earthquakes measuring 7.8 M_w and 7.3 M_w respectively in a span of two weeks with subsequent aftershocks felt for more than a month. More than 8800 people lost their lives, more than 22000 people were injured and the earthquake affected more than 8 million people. Kathmandu was one of the worst hit cities, with many communities witnessing immense damage to the people and their properties. This paper looks into two of these communities: *Panga and Nayabazar* which were selected based on observed differences in their built environments, type and functions of open spaces as well as socio-economic and cultural peculiarities. Both communities suffered from physical damage and human casualties. The distance from each site to the epicentres of the first and second major earthquakes is similar (173 km and 183 km respectively). The distance between the two sites is 8 km and their relative position to the city centre is shown in Fig. 1c.

Nayabazar is a relatively new area developed over agricultural land along the Bishnumati River just 1.5 km from the city centre (Fig. 1a). It was developed under Guided Land Development (GLD) where land was readjusted in collaboration with the locals for a planned neighbourhood with basic infrastructure (Pradhan, 2008). The total project area is around 42 ha spread over two wards. The project completed in 2000. The site is characterized by hierarchical roads with plots on either side. Five major open spaces had been designed during its inception. Additional open spaces are given by vacant plots designated for housing and cross-sections of wider roads.

Panga is a small satellite town around 6 km from Kathmandu city centre. Historical evidence suggests that the town was established by King Ratna Malla with 300 Newar[1] citizens in 1509 AD (Maharjan, 2008). It is a typical *Newari* settlement which developed organically and its built form is characterized by a compact arrangement of row and courtyard houses that define streets and open spaces. Its core area is composed of courtyards of varying sizes interconnected by mostly narrow streets paved with stones or bricks. Other open spaces are large agricultural fields that surround the core area. Fig. 1b, shows the boundary of the core area of Panga which is around 8.5 Ha.

2.2. Data collection and digitization

Three different types of data were collected. *First,* a household survey was conducted with the help four architecture students who had experience in post-earthquake survey in Kathmandu. For sampling, each location was first divided into four parts (one per each surveyor) of similar size and building density (Fig. 1a and b). The surveyors marked each respondent's house and gave it a unique household ID. The initial approach was to skip two houses after every complete survey but due to unwillingness and/or absence of people in homes, the pattern was discarded by the surveyors where necessary. In total 83 (out of 943) and 90 (out of 1282) household surveys were conducted for Panga and Nayabazar respectively. The questionnaire was structured according to three main areas of investigation.

1) Questions related to demography such as age, sex, caste, education level, income level, occupation.
2) Questions related to respondent's own built urban environment. It included questions on building use, ownership, no. of floors, construction technology and age of the building etc.
3) Questions about risk perception in relation to the earthquake of

[1] Newar is a sub-caste in Nepalese caste based society.

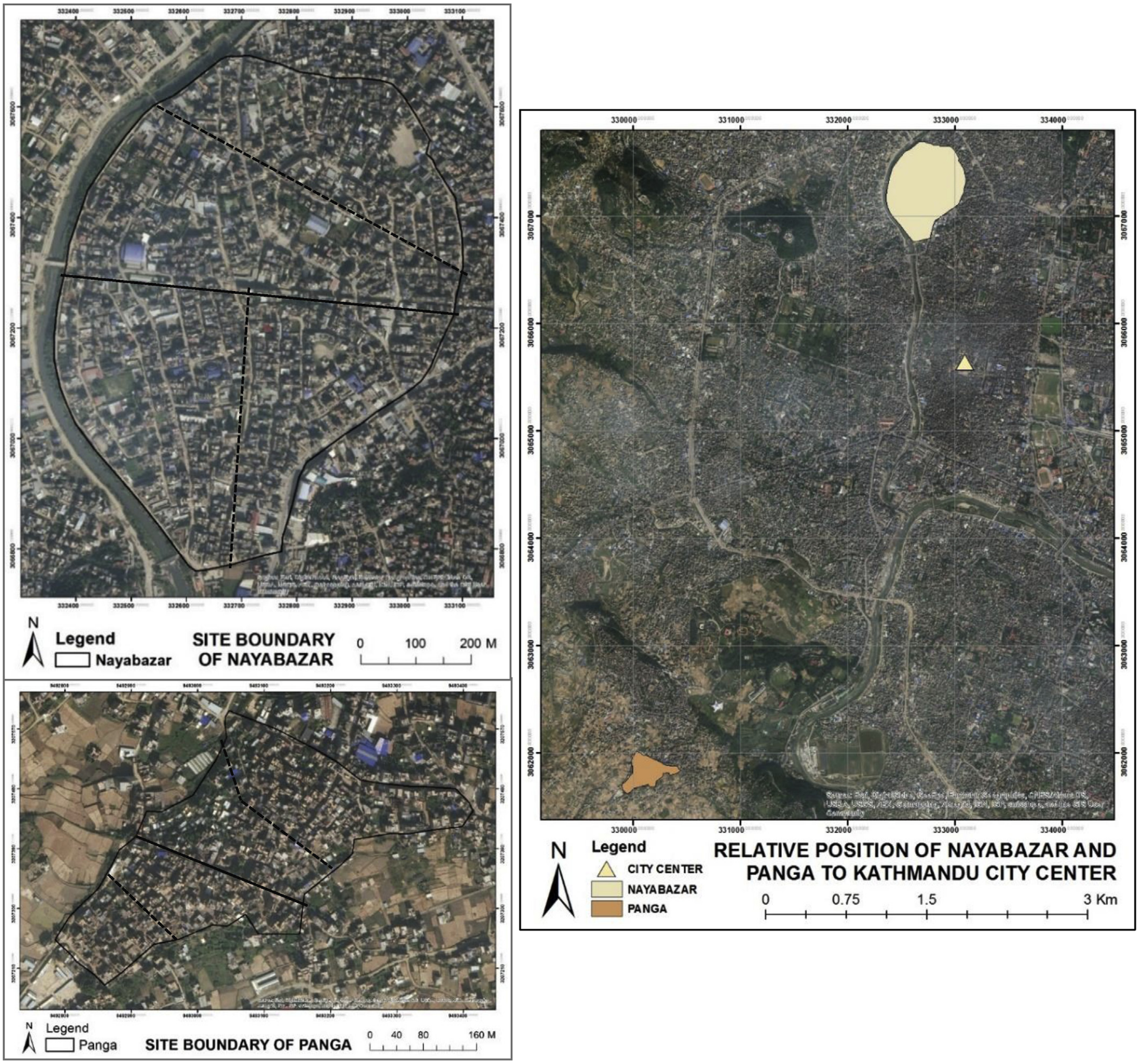

Fig. 1. 1a Aerial view of Nayabazar, 1b, aerial view of Panga, 1c, locations of Panga & Nayabazar and the city centre (From top left and then anti-clockwise).

Table 1
Overview of acquired spatial data.

Data Type	Description	Acquisition date	Data source
Road (Panga)	Road network of Panga (core area)	2016	PhD. student
Buildings (Panga)	Buildings footprints of Panga (core area)	2016	PhD. student
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

2015 were divided into pre-earthquake, during earthquake (1–2 week) and post-earthquake (3–4 week) phase. Perceived awareness level, perceived preparedness level and anticipation of earthquake focused on the pre-earthquake phase. ‘During the earthquake’ phase included respondent's location during the earthquake, their immediate escape location and routes followed and shelter locations for the first three days (at least). The immediate escape route and destination after the earthquake were marked in the map. Post disaster phase included questions such as, perceived damage to the house, willingness to move from the area, perceived safety within the community, effect to personal life due to earthquake, perceived factors that could lead to reduced seismic risk.

Second, semi-structured expert interviews were conducted through snowball sampling where participants were determined through chain of recommendations from the interviewee. In total, seven interviews were recorded in the local language and later transcribed into English. The experts had diverse backgrounds such as DRR, urban planning, academics, government authorities and architecture. The interview focused on the relation between the built environment and observed perception of risk.

Third, GIS data for building footprints and road networks were obtained from varying sources (Table 1). It should be noted that the damage assessment data after the earthquake was only available for Panga.

The data collected from fieldwork was first digitized and compiled separately for each case study site and, where necessary, further classified. For example, risk reduction methods as mentioned by the respondents were grouped under three broad categories: related to the built environment, unrelated to the built environment and none. Similarly, education level was grouped into *no formal education* (NFE), *up to high school* (HS) and *graduate or above* (G). The escape routes and destinations used by sampled households were also digitized.

2.3. Defining urban parameters

Open spaces were classified into five broad groups: courtyards, parks/playgrounds, agricultural lands (open fields), street (road) networks and others (vacant land, private gardens etc.). Open spaces were assessed against three attributes: number of open spaces, size of open spaces and built density around the open spaces. The size of the open areas was categorized into four classes: 50–100 m^2, 101–500 m^2, 501–1500 m^2 and > 1500 m^2. Larger agricultural lands were assigned values as 3000 m^2 to signify > 1500 m^2 for Panga. The chosen classes are smaller than in other studies (see Villagra, Rojas, Ohno, Xue, & Gómez, 2014b) due to the neighbourhood scale of this research. To control for irregular shapes and high length to breadth ratio (which would reduce the sense of openness), areas larger than 50 m^2 with each side at least 7 m was taken as threshold for open spaces. The area of road as an open space is taken as $A^2 \times 1.5$, where A is the width of the road. It is multiplied by 1.5 to account for added area coverage it allows in either direction of the road.

Building density was calculated via two approaches, number of buildings per Ha and point density of buildings for each community. Additionally, total building footprint area was also calculated. The point density was calculated using a radius of 50 m and was visualised using five classes (using natural breaks). The extent of the analysis was based on the farthest escape destination of the locals in each community.

2.4. Escape routes and destinations

It was assumed that during and immediately after the earthquake, people tried to reach those locations that they perceived to be safe which was most likely to be some form of open spaces. The escape destinations and the paths followed to reach them provided an actual account of behavioural response after the earthquake. Thus it provides insights into the relationship between the perceived risk and open spaces. These escape destinations were thus analysed against their size and proximity from the respective sampled house, their use and the surrounding density. These calculations were made only for the first earthquake as many respondents were not within the community during the second earthquake.

2.5. Risk perception index (RPI)

The RPI is an aggregated value developed to conduct statistical analysis to seek potential relationships between open spaces and seismic risk perception. It was calculated for each household based on nine indicators (Table 2) which combined aspects of the psychometric and the cultural theories of risk perception. Its conceptualization is primarily based on two previous studies (see Armaş & Avram, 2008; Hofer & Hamann, 2016). These indicators were given values based on the rationale and insights from literature which ranged from 0 to 1, from lowest to highest perceived risk. For indicators based on 5 point Likert scale data, the value was assigned in equal divisions of the data i.e. 0, 0.25, 0.5, 0.75 and 1 sequentially. To calculate the RPI value for each individual, the scores for each of the indicators is obtained based on survey answers and then they are summed. The range of RPI value for an individual is, thus, 0–9. Each individual score is then correlated against selected demographic indicators and parameters related to open spaces.

3. Results

3.1. Descriptive statistics

There is a distinct contrast between the cultural setup of the two communities (see distribution of caste, Table 3). Panga is culturally homogenous: community members follow the same traditional practices and also organize annual religious events. However, the culturally more diverse Nayabazar community does not host and organize cultural/communal events. Additionally, Panga is a residential neighbourhood with very high native home ownership where as Nayabazar host many tenants who have migrated into the area in search of economic opportunities and access to health and education services. In both communities, most respondents were reluctant to express their income. Similarly, members from both communities show similar responses regarding perceived risk across all indicators except one. In Panga the perception of damage is quiet varied where as in Nayabazar most people perceived the damage to be slight or non-existent (Fig. 2) which reflects the higher damage levels in Panga. However, members from both communities agreed that factors related to the built environment are crucial for reducing seismic risks, Fig. 3. Among these, open spaces was mentioned by 22% and 25% of respondents in Panga and Nayabazar respectively.

3.2. Urban parameters

The overall *building density* of Nayabazar is 30.5 buildings per ha which is considerably lower than 111 buildings per ha in Panga. The total building footprint area in Nayabazar amounts to 36% of the total site area compared to 40% of total area in Panga. It should be noted that Panga is much more compact due to the arrangement of its buildings and street networks (Figs. 8 and 9).

In regard to *open spaces*, Panga hosts 36 distinct open spaces of varying sizes and uses that are well distributed across the site, primarily in the form of internal and external courtyards (Fig. 4). The external courtyards are part of the street network whereas internal courtyards are semi-private spaces, although without any restrictions to public access. Most open spaces are smaller than 500 m^2. Larger open areas are mostly peripheral agricultural lands except one big school playground, Fig. 4. In contrast, the smallest designated open space in Nayabazar is 1950 m^2, however, there are additional smaller open spaces within the site (Fig. 9) which are still relatively bigger compared to Panga. The detailed information regarding the use and demarcation of boundaries

[2] Guthi is a religious and socio-culture organization of Newar community where membership is based on patriarchal blood line. These organizations play a vital role in cultural and religious aspects of way of life and usually govern what to do and what not to do during communal religious/cultural functions.

Table 2
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 helps them for a safe response during an actual event
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 them (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 the risks have been realized and experienced.
4	Willingness to move away from the community (specifically asked in relation to the earthquake)	No: 0 Yes: 1 Unsure: 0.5	People's desire to move suggests an increase in perception of risk. 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 do not anticipate an earthquake means they were either in denial or did not expect one in the near future. This suggests they were also aloof of the risk and thus perceive it to be low. For people who do not 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. Availability of water, food, shelter, electricity, toilets and community support are also some of the factors that affects this decision.
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. Availability of water, food, shelter, electricity, toilets and community support are also some of the factors that affects this decision.
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 or acceptable there.
9	Perception of community bond to be high	Strongly disagree: 1 Disagree: 0.75 Neutral: 0.5 Agree: 0.25 Strongly agree: 0	Strong community bonds will have a positive influence to risk perception because people have more trust among themselves.

Table 3
Results of the household survey for Panga and Nayabazar.

	Indicators	Panga	Nayabazar
Demography	Median age	50 years	36 years
	Gender	61% female, 39% male	53% female, 47% male
	Occupation	Business (35%)	Business (59%)
	Education (high school or above)	67%	92%
	Distribution of Caste	95% Newar	29 different castes with fairly even distribution
	Income	< $ 850 = 13%, $850-$2500 = 16% > 2500 = 0%, * response rate = 29%	< $ 850 = 20%, $850-$2500 = 25% > 2500 = 10%, * response rate = 55%
Built Environment	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 of 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 that earthquake affected their personal lives	41% agreed that earthquake affected their personal lives
	Move away from community in regards to earthquake safety	57% would not move	71% would not move
	Risk reduction measures	57% Built environment related, 35% no idea	68% urban form related, 17% others, 15% no idea
	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

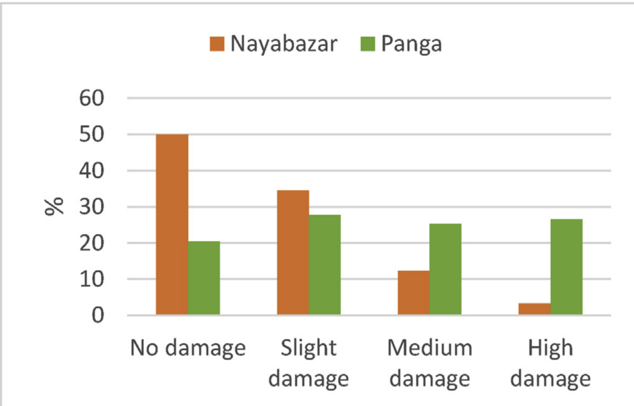

Fig. 2. Perceived damage to buildings in Nayabazar & Panga.

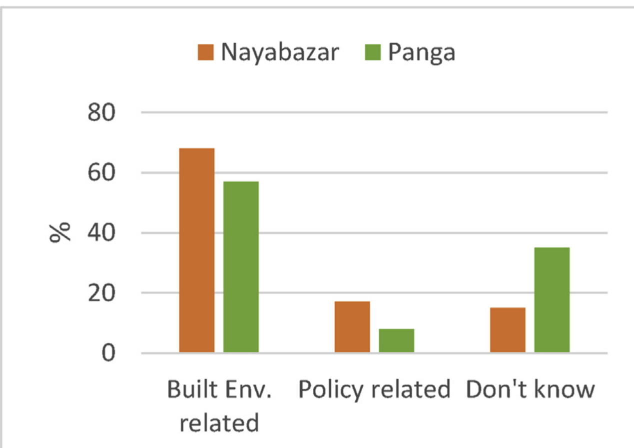

Fig. 3. Measures to reduce risk as stated by respondents in Panga and Nayabazar.

for individual open spaces was not available. Nonetheless conversations with the locals and site visits reveal that these areas are either vacant private plots, agricultural lands or open storage spaces. Here, the internal roads are 6–12 m wide and the peripheral roads are up to 18 m wide which often adds to the coverage of the adjoining open spaces and/or acts as open spaces in themselves.

3.3. Risk perception index (RPI) and escape behaviours

The median RPI value for both communities is 3. The similar range of RPI values and their distribution in both communities (Table 4, Fig. 5) suggests that both communities have a similar overall perception of risk. Pearson correlation of RPI with demographic indicators shows that only age is positively correlated in Panga. In Nayabazar, gender shows positive correlation for female population meaning women's perception of risk is higher. The education level shows negative correlation (Table 4).

The resident's escape behaviour was investigated via three parameters related to open spaces: Euclidean distance travelled, size of the opens spaces (as escape destinations) and density at escape destinations. In Panga, the median escape distance travelled was 70 m compared to 48 m in Nayabazar. However, a pattern emerges against the demographic indicators (Fig. 6). Males have travelled twice as far as females in both communities. Similarly, respondents who have up to high school education have travelled the most and the age group of 41–50 have travelled the least. Only notable inconsistency in the observed pattern is seen in age group 18–30 where residents of Nayabazar have travelled significantly farther than in Panga.

The size of open spaces as escape destination varies considerably between the two communities. In Panga, most people chose open spaces larger than 1500 m^2 whereas smaller open spaces were favoured in Nayabazar (Fig. 7). It should be noted that many of the smaller open spaces in Nayabazar are road networks which accounts for 40% of the escape destination. In addition, larger designated areas were not favoured and people who did choose them travelled more than 200 m (Fig. 9). In both communities, most respondents avoided staying inside their houses and/or escaping to tiny open spaces (50–100 m^2). In Panga, many respondents chose larger open areas although there were smaller courtyards in closer proximity. This behaviour may be attributed to the high building density around the courtyards (Fig. 8). In Nayabazar too, people avoided high building density locations as their escape destinations (Fig. 9) but there is no clear pattern in the escape routes they chose. However, in Panga, escape routes seems to have been guided by the street layout, especially in its southern part where many people followed a similar path to reach a large playground (Fig. 8).

Additionally, Pearson's correlation of RPI and the three parameters discussed above reveals that there are correlation among these variables that differ from one community to the other. RPI is negatively correlated with size of the open spaces in Panga but not in Nayabazar but it still holds when the data is combined, although to a lesser degree (Table 5). There is a mild positive correlation between RPI and escape distance in Panga which is absent in both Nayabazar and the combined data.

3.4. Expert interviews

Most experts reiterated the need for communal open spaces and opined that, where present, these open spaces allowed for improved adaptability to the disaster and facilitated post-event coping. These open spaces are well known and easily accessible to the local communities as was witnessed throughout Kathmandu.

“83 open spaces which were designated as safe place, no one went there. Only in Tudikhel (a large open space, centrally located in Kathmandu) 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.” -DRR expert, ENPHO.

Another expert (also a resident of Panga) opined that, accessibility to large open spaces within 2 min of core area of Panga was vital during the earthquake. In Nayabazar the grid like street layout was useful for easy and multiple access to a given area but experts warned that a repetitive design could incite confusion during a disaster especially for those who are new to the community. It also means valuable space is lost to create roads rather than for the design of appropriate open spaces. People avoided smaller open spaces where the nearby houses were taller and had suffered visible damage. Highly dense areas were also avoided even if there was no damage to the surrounding houses. It is thus evident that a variety of factors combined to influence people's perception of risk during and after the disaster.

These factors evolve over time as emergency needs are succeeded by shelter needs. Shelter needs can be short term (‘during earthquake’ phase) or long term. For short term shelter, higher built density means higher vulnerability to fire hazards especially in Kathmandu where haphazard planning is rampant and ubiquitous. However, experts stressed that higher built density, in itself, does not indicate higher risk. They argued that a well-planned high density area can be advantageous as disaster risk management needs and activities could be concentrated at a single location. This means perception of risks could actually be indirectly lowered through swift and effective response.

Availability of infrastructures and services such as electricity, bathrooms and clean drinking water also become crucial near open spaces. Well managed public bathrooms, where available, prevented open defecation (reducing possibility of epidemics) as many people

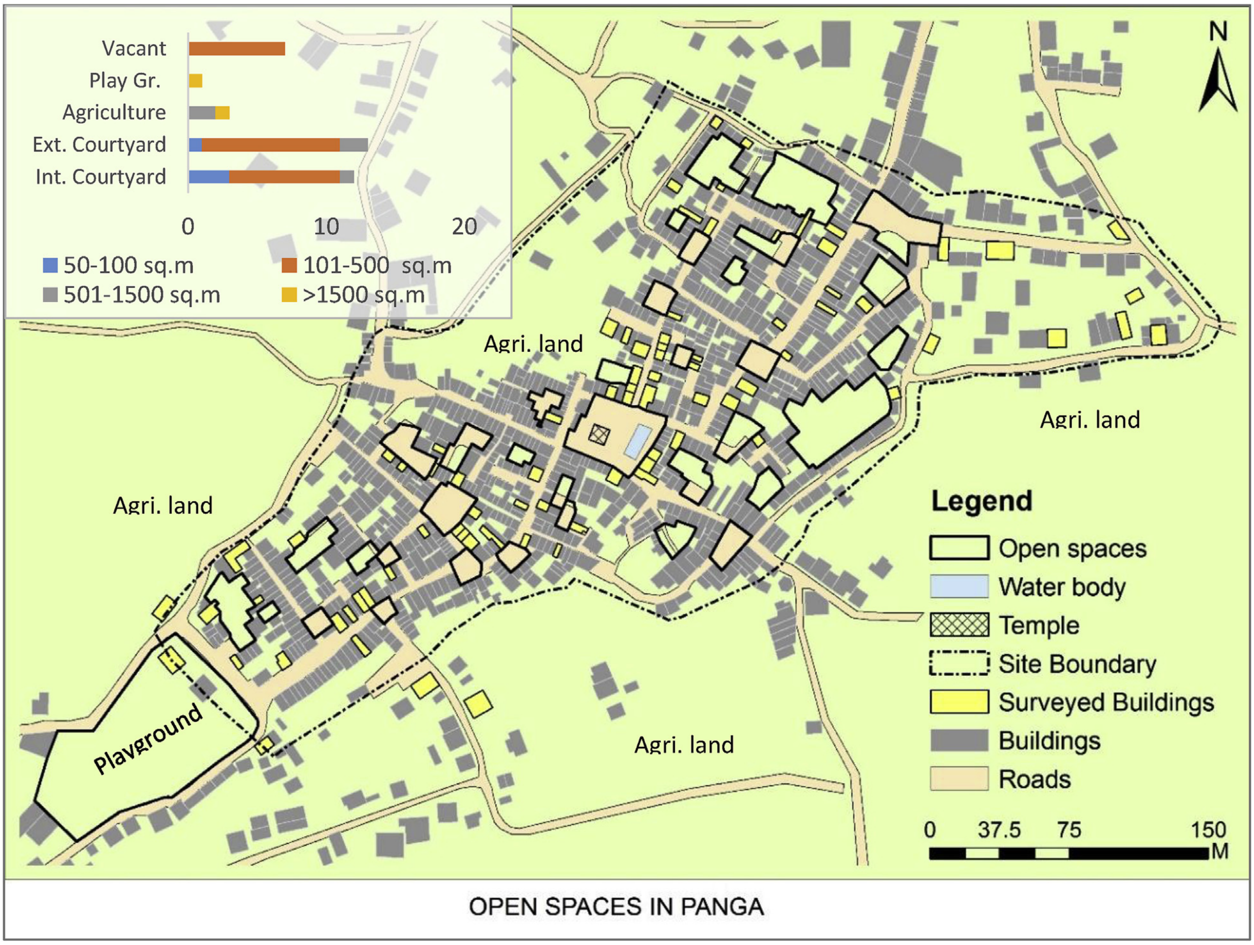

Fig. 4. Open spaces and their distribution in Panga.

Table 4
Descriptive statistics of RPI its and correlation with demographic indicators.

	N	Min.	Max.	Mean	Median	Std. Deviation	Pearson's Correlation			
							Age	Gender	Education	Ownership
RPI (Panga)	83	.75	6.25	3.16	3.0	1.24	.229[a]	-.022	.016	-.130
RPI (Nayabazar)	90	.50	6.50	3.13	3.0	1.16	-.101	.226[a]	-.238[a]	.045

[a] Correlation is significant at the 0.05 level (2-tailed).

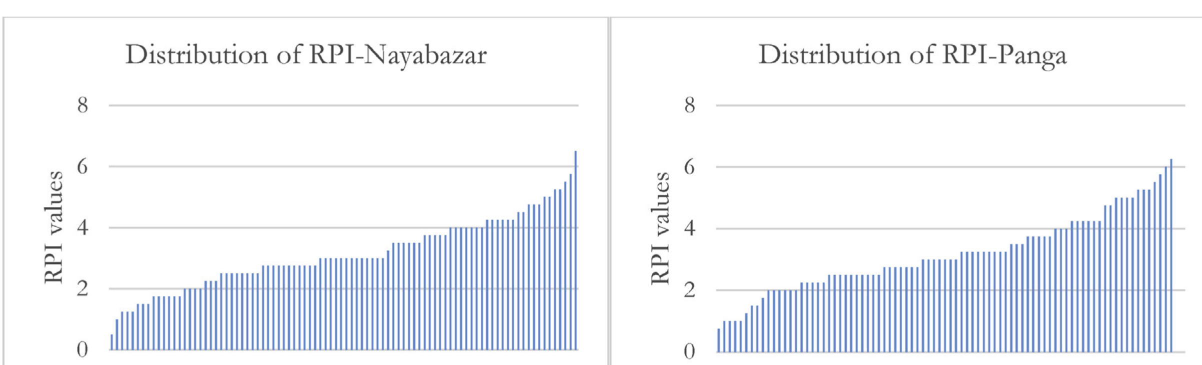

Fig. 5. Distribution of RPI values in Nayabazar and Panga.

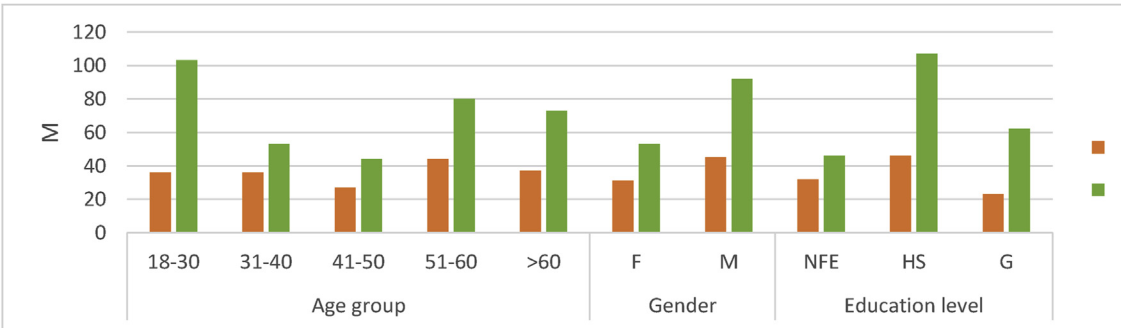

Fig. 6. Median distance travelled to escape destination across three demographic indicators.

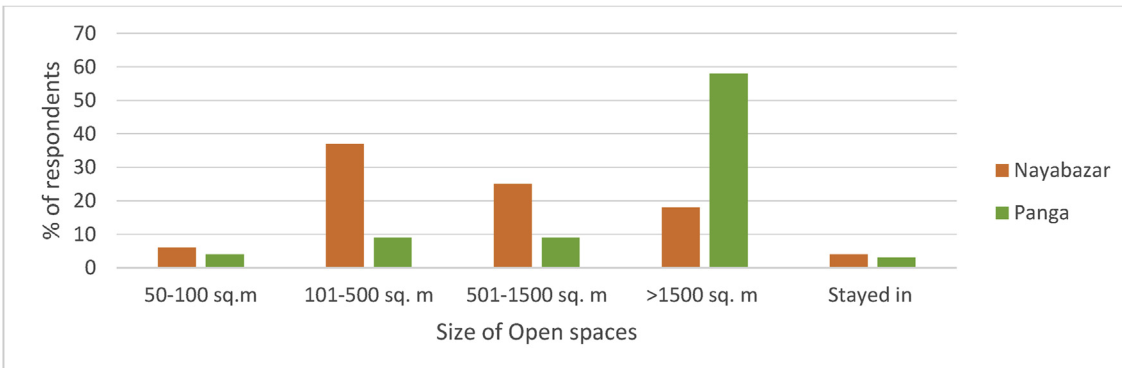

Fig. 7. Respondent's choice of open spaces as escape destinations based on their size.

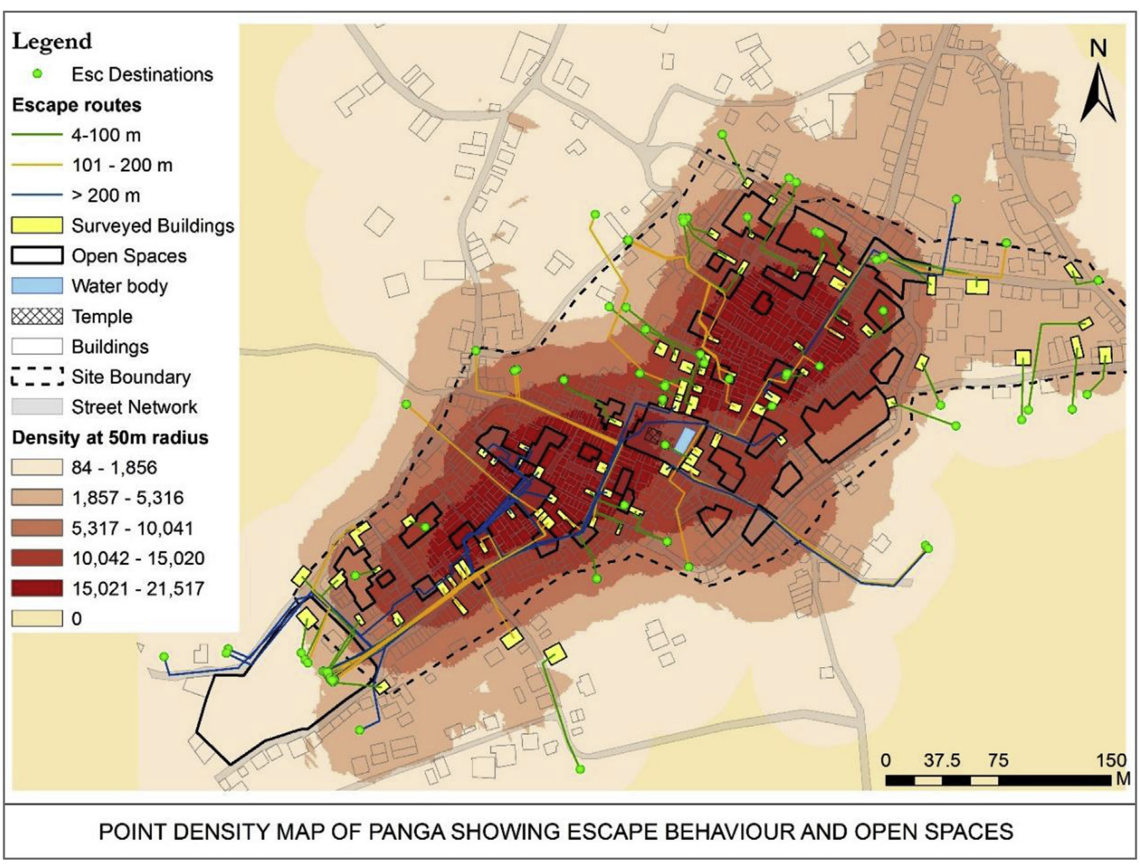

Fig. 8. Escape behaviour and open spaces presented over point density map of Panga.

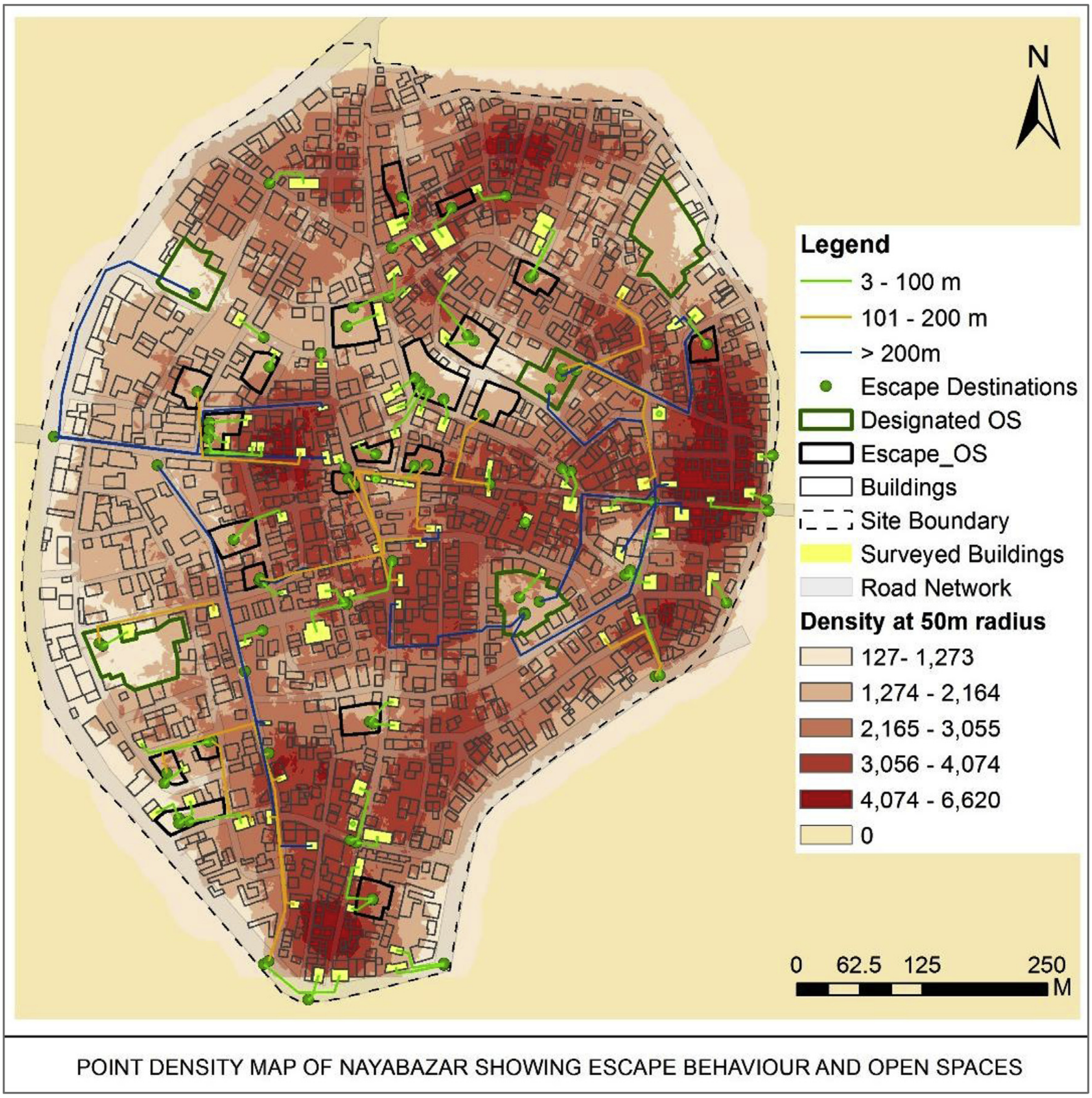

Fig. 9. Escape behaviour and open spaces presented over point density map of Nayabazar.

were hesitant to enter their houses due to recurring aftershocks.

"Availability of electricity gives a lot of psychological peace to people because they don't have to stay in the dark." - Urban Planner, IOE.

For long-term shelter needs, ownership of open spaces becomes relevant. Fewer people are willing to share open space, public and/or private with others (even strangers) a few weeks after the disaster. Many public spaces hosted people for months and some still do even after two year of the disaster. However, this is not possible for private open spaces or road networks after normal traffic flow resumes. Furthermore, cultural institutions, where present, such as *Guthi* [2] played an important role in solving disputes among people and validated household for government aid amongst other activities carried out to mitigate the impacts of the disaster. Such activities were observed throughout Kathmandu and also in Panga. Economic ability was another important factor which becomes prominent with time as it governs an individual's ability to adapt to the impacts of the disaster.

"Only yesterday I went to a house which had cracks in the walls and had external supports. The owner knows that it is not safe to stay in the house but he does not have a choice. He and his wife stay there in the cold. 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, else, it becomes acceptable risk." - DRR Expert, OXFAM.

4. Discussion

4.1. Analysing RPI, escape behaviour and open spaces

The RPI developed in this research presents a novel approach in seismic risk perception studies but they are evident in climate change studies (see Leiserowitz, 2006). The median RPI values for both communities suggests that the perceived risk was moderate. The observed direction of correlations are consistent with other research, for example, women and older people perceive the risk to be higher (see Ainuddin et al., 2014; Armaş & Avram, 2008; Wachinger, Renn, Begg, & Kuhlicke, 2013). Respondents of Panga are older and less educated which suggests that the former are more dependent on others for support from family, community and cultural institutions which in turn has significant impact on their perception of risk. However, Nayabazar is a young and well educated community where individual identity and immediate family has perhaps a greater role in influencing perceived risks.

Correlation of RPI with escape behaviour suggests that open spaces are inter-related with perceived seismic risks. Among the various

Table 5
Pearson correlation of RPI and other urban parameters.

		RPI	Escape distance	Size of Open Space	Density
Panga	RPI		.286[a]	-.511[a]	
	Escape distance	.286[a]		-.397[a]	.270[b]
	Size of open spaces	-.511[a]	-.397[a]		-.441[a]
	Density		.270[b]	-.441[a]	
Nayabazar	RPI				
	Escape distance			.287[a]	
	Size of open spaces		.287[a]		
	Density				
Panga and Nayabazar combined	RPI			-.334[a]	
	Escape distance				
	Size of open spaces	-.334[a]			-.412[a]
	Density			-.412[a]	

Note: The table only includes values that showed correlations.
[a] Correlation is significant at the 0.01 level (2-tailed).
[b] Correlation is significant at the 0.05 level (2-tailed).

attributes of and in relation to open spaces, size is the most significant indicator. In Nayabazar many people who went to the larger designated open spaces travelled more than 200 m, although the median escape distance was just 48 m. It suggest that people who knew of larger open spaced deemed it safer and travelled the longer distance. Men have also travelled farther than women. Although clear reasons are not known, a possible reason might be women's attire, *Saree*[3]. Physical attributes as well as socio cultural norms might also have played a role but is not studied in this research. In The pattern of escape behaviour seems to be influenced by the street layout and knowledge of place. Lynch (1981), argued that the considerably higher number of intersections points encourage long succession of turnings which are disturbing to the human brain and landmarks are important factors that influence urban perceptions of a given area. Perhaps such issues influenced the people's choices to escape to nearby roads in Nayabazar rather than travelling farther to larger open spaces. However, in Panga, the interconnected street and courtyards create a distinctive path and offer distinct landmarks in the form of small shrines or larger temples proportionate to the size of the courtyards. This ensures ease in traversing through Panga even for non-residents. Furthermore, the locals have spent their whole life here and are well aware of surrounding open spaces. Thus a different escape pattern is observed where people preferred to travel longer distances passing by smaller open spaces on their way often guided by the street network.

In both communities high built density areas were avoided. Visually free and uncluttered open spaces were preferred indicating that the ratio of building height should be such that, even if these collapse, people within the open spaces will not be affected. The survey results, clearly show that the perceived risk manifested in the response behaviour is directly related to open spaces and its attributes.

4.2. Open spaces as temporary shelter locations

Many open spaces become temporary shelter locations after a disaster. The unpredictable nature of earthquake means planned evacuation is not possible (Wright & Johnston, 2010), however, designated spaces can be prepared for shelter and escape beforehand. Even if the open spaces are pre-determined, the choice of safe location is dependent on several other factors such as ownership, available infrastructure as well as social and communal factors. Many people chose to stay closer to their homes and 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 case study sites. Similar behaviour during disasters have been observed in other countries as well (see Allan et al., 2013).

Open spaces with functioning services are more attractive as shelter locations. These services can attract people to public shelters even if their house is otherwise intact but lacks functioning services (Anhorn & Khazai, 2015) which was also observed in Kathmandu. It also depends on some cultural peculiarities. In Nepal, even in densely populated urban areas where shelter demands exceeded the supply, people stayed harmoniously together even with strangers. This behaviour was attributed to the *Nepalipan*[4] of the people as claimed by one of the experts. This notion echoes Palm (1998) who argues that cultural constructs differs tremendously across different location and should be considered as determinants of perceived seismic risk.

5. Conclusion

This paper aimed to identify and analyse the relationship between open spaces and seismic perception of risk through an analysis of actual response of people during and after the 2015 Nepal earthquake. The results indicate that open spaces are a key component of disaster response which directly or indirectly affect people's perception of seismic risk. It was found that medium sized communal spaces are preferred within a proximity of 200 m as immediate safe destinations. The choices for such spaces are dependent on the built environment of the site given by its layout, landmarks, building density and building height. For temporary shelters in the during-earthquake phase, the availability of necessary infrastructure and services are relevant whereas for long term shelter needs the ownership of the open spaces, economic capability as well as local institutions become more important.

The findings of this research can guide policy makers and urban planners to support the development of safer communities through consideration of their specific needs and contextual peculiarities. Such considerations related to open spaces should take into account all possible functions these may support which could be risk mitigation, immediate response as well as disaster recovery. It is understood that both qualitative (land use, services available, ownership), quantitative (number, size, surrounding built density) and relational attributes of open spaces are significant for developing risk-sensitive land use plans that facilitates adaptive responses and cater to the needs and perceptions of the people.

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[3] Saree is a traditional outfit worn by women in Indian-sub continent (especially older generation or after marriage) which is draped around the body and generally limits the foot movement.

[4] Nepalipan is a stereotype of Nepalese people which suggests brotherhood and the willingness to help others.

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