RELATIONSHIP BETWEEN MULTIPLE DEPRIVATION AND DISASTER RISK PERCEPTION IN RANGPUR CITY, BANGLADESH

MD ZAKIUR RAHMAN

Enschede, The Netherlands, June 2020

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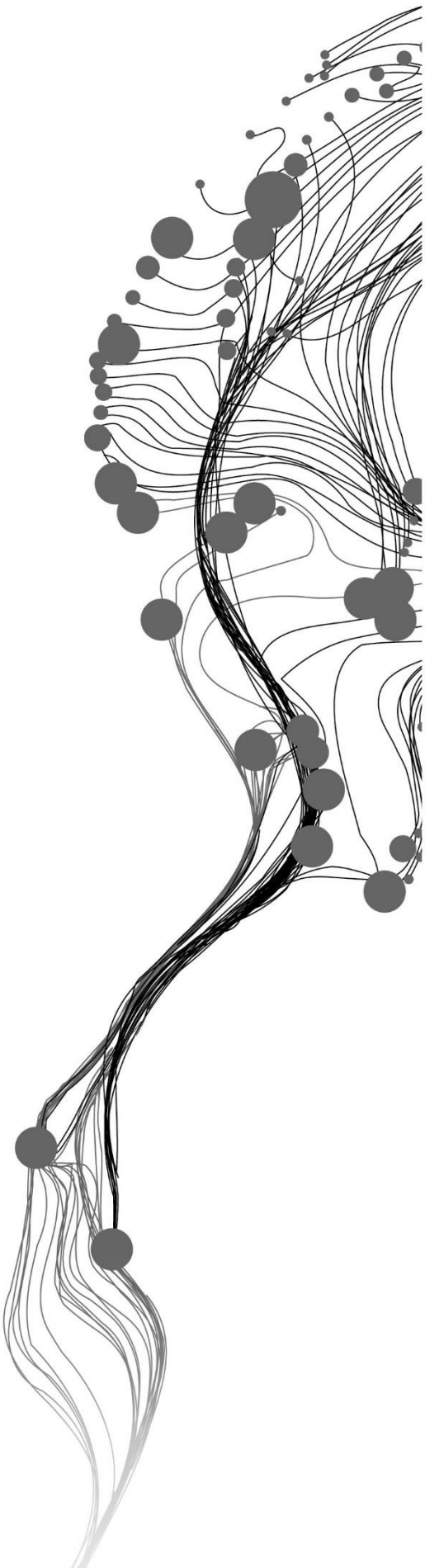

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MD ZAKIUR RAHMAN
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Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
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ABSTRACT

The emerging Rangpur City is located in a deprived zone of Bangladesh. Besides, this area is very much prone to earthquake hazard. Moreover, in recent days, fire hazard became very common in Bangladesh and taking around a thousand life per year. With the growing population, Rangpur City is very much vulnerable to the fire hazard as well. So, here in this research, I investigate the relationship between multiple deprivation and disaster risk perception in Ranpur City Corporation (RpCC). The research methods include the index of multiple deprivation, earthquake and fire risk perception, GIS-based mapping, and statistical analysis. The data for this study were collected from both primary and secondary sources. Primary data were collected through household questionnaire survey and semi-structured interview. The surveyed data were analysed using SPSS. Descriptive analysis, correlation analysis, factor analysis, t-test and cross-table analysis were the key statistical methods of the study. The results identify the hotspots of deprivations, and hazards' risk in the city. The findings of the study include some recommendations for planning guidelines and policy interventions; such as- allocation of development budget to the electoral wards based on the score of multiple deprivation, widening the roads, monitoring the adherence of building codes, ensuring emergency exit and setup fire alarms for every household etc. The novel approach of this study uncovers a method where, at the same time, the deprivations in the cities can be monitored along with disaster risk reduction.

Keywords: Multiple Deprivation, Earthquake hazard, Fire Hazard, Risk Perception, Disaster Risk Reduction, GIS

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1. INTRODUCTION

The first chapter of the thesis includes the background and justification followed by the research problem and research gap, research objectives, research questions, anticipated results, and thesis structure.

1.1. Background and justification

Rangpur city is one of the newly established (in 2012) city corporations of Bangladesh, and this city is acting as the administrative headquarter of the Rangpur Division of the country. This division is located in the northern part of the country, and previously was widely known for 'Monga.' The Bengali term 'Monga' referred to the seasonal phenomenon of poverty/deprivation of food, which ultimately leads to hunger due to lack of work and income opportunity of the agricultural workers (Khandker, 2012; Mazumder & Wencong, 2012). Indeed, poverty or deprivation of poor households has multiple sources of deprivation, which delayed their efforts to attain socio-economic wellbeing (Baud, Sridharan, & Pfeffer, 2008).

As a result, the people of the surroundings always tend to migrate to the urban part of Rangpur for better livelihoods. Besides, after the declaration of the city corporation, the population growth rate increased rapidly (in 2012 the total population was 584448, and in 2017 it is 796556 residents) due to the migration of different service holders and business persons (LGED, 2014; RpCC, 2019). However, from the documents of Bangladesh Bureau of Statistics (BBS, 2013) and Ranpur City Master Plan (LGED, 2014) it is revealed that all the electoral wards (EWs) of Rangpur City Corporation (RpCC) do not have equal opportunities in terms of access to education, employment, electricity connection, sanitary toilets; besides, do not have an equal distribution of household types, gender ratio, ethnicity, age groups, green areas etc. over the city; that may cause multiple deprivation or socio-economic inequality at a large scale within the RpCC. Usually, multiple deprivation calculates the deficiencies of material and the lack of attention given to those materials by a regulatory system (Yuan & Wu, 2014).

Moreover, due to high population growth, the multi-hazard environment (e.g. earthquake and fire hazard) has been intensified (Sullivan-Wiley & Gianotti, 2017) in RpCC; and the multi-hazards environment denotes more than one relevant hazards in a given area (Kappes, Keiler, Elverfeldt, & Glade, 2012). Indeed, the understanding of risk perception of people, and its determining factors is essential to improve risk communications as well as to design effective mitigation policies (Ho, Shaw, Lin, & Chiu, 2008). Moreover, the interconnectedness of population growth and multi-hazard was recognized by the international community; and these are adopted in Sustainable Development Goals (SDG goal 11b) and the Sendai Framework for Disaster Risk Reduction in 2015 (UNHQ, 2015).

Bangladesh is an Asian country, holding the fifth rank among the world's disaster-prone countries (Rahman, Ansary, & Islam, 2015). Notably, "Among all-natural disasters that occurred in Asia during the last decade, earthquakes accounted for approximately 46% of deaths and 43.4% of the total amount of disaster estimated damage" (Kung & Chen, 2012, p. 1535), and Bangladesh is at high risk of a severe earthquake (Rahman et al., 2015). Usually, as like many other cities of Bangladesh, Rangpur city does not encounter regular flooding, but this city is vulnerable to earthquakes.

RpCC is located within earthquake zone-1 and zone-2 (Ali, 1998; Paul & Bhuiyan, 2010), and was shown in epicentral of some of the past major earthquakes (Ali, 1998). In the recent few years, Bangladesh faced a couple of tremors and a notable amount of fire hazards (Paul & Bhuiyan, 2010; Rahman et al., 2015), though those were not life-threatening. Nevertheless, the increasing population might face devastating consequences in the case of 6-7 magnitude (Ali, 1998). Besides, due to high building density, narrow and insufficient roads, flammable building materials, open and exposed electrical wire, chemical factories in residential areas and lack of preparedness by the local people as well as deficiency of skilled workforce, Bangladesh frequently faces fire hazards (Rahman et al., 2015).

Among the fire hazards, *Nimtali* fire accident in January 2010, *Tazreen Fashion* fire accident in November 2012, and Chawkbazar fire in February 2019 drew the world's attention due to the enormous number of deaths (Burke & Hammadi, 2012; Jones, 2010; Safi, 2019). According to the government statistics, 1970 people were killed in Bangladesh from 2004 to 2018 due to this event, and total economic loss was around 66 million US dollars for the said duration; within this period, the number of fire incidents in the Rangpur division was reported as a total of 16,568 (BFSCD, 2019). As already mentioned, the population of RpCC is increasing rapidly, that might cause deadly experience if any fire accident occurs in the residential areas of the city.

To deal with different hazardous events and mitigate the losses, the City Corporation Act 2009 has the provision to form City Disaster Management Committee and other standing committees for ensuring pre and post-disaster mitigation programs (LGED, 2014). However, there is no visible preparedness by the authority seen here in RpCC. Field experience reveals that the concerned authority does not usually organise fire drills and other awareness programs with the residents of the high-density residential areas.

So, considering the above facts, this study focused on the relationship between multiple deprivation and disaster risk perception (especially for the case of earthquake and fire hazards) in Rangpur city.

1.2. Research problem and research gap

In line with the justification, I investigated in this research how disaster risk perception changes with the unequal societal condition or multiple deprivation. Many research works have been done on social vulnerability, disaster risk and disaster management in the context of Bangladesh (Ahsan & Warner, 2014; Alam & Bhadra, 2019; Barua, Akhter, & Ansary, 2016; Brouwer, Akter, Brander, & Haque, 2007; Gray & Mueller, 2012; Karim, 1995; Rabby, Hossain, & Hasan, 2019; Uddin et al., 2019). Besides, few studies found that worked on earthquake and fire risk perception in Bangladesh (M. M. Islam & Adri, 2008; MoDMER, 2015; Paul & Bhuiyan, 2010; Rahman et al., 2015). However, no study has been found on multiple deprivation in RpCC, neither on disaster risk perception in RpCC. Moreover, no study uncovered the relationship between multiple deprivation and disaster risk perception.

1.3. Research objective(s)

1.3.1. Overall objective

The overall objective of this research was to investigate the relationship between multiple deprivation and disaster risk perception in the context of one of the emerging cities of Bangladesh.

1.3.2. Specific objectives

A total of four specific objectives were framed to meet the research aim in the context of RpCC. They are-

I. To conceptualize and extract a valid set of indicators under different capitals to map and analyse the multiple deprivation within the study area.
II. To assess the risk perception of earthquake hazard and fire hazards of the residents of RpCC.
III. To investigate the relationship between multiple deprivation and risk perception.
IV. To propose planning guidelines and policy interventions to reduce the deprivation, as well as to increase the risk perception and preparedness for disaster risk reduction (to meet SDG goal 11.B).

1.4. Research questions

I. (a) What are the suitable indicators (from different capitals/domains) to analyse and map multiple deprivation?
(b) To what extent multiple deprivation is spatially concentrated in Rangpur City?
(c) Are the indicators/capitals correlate with each other?
(d) How the citizens of RpCC anticipate multiple deprivation, and what they prioritize to reduce deprivation?
II. (a) How the citizens of RpCC perceive the risk of the earthquake and fire hazards?
(b) How do different demographic and socio-economic factors influence the risk perception of each hazard?
III. How is the risk perception varying with the score of multiple deprivation?
IV. (a) What is the preparedness to face the potentially life-threatening hazards by the citizens as well by the respective authorities?
(b) What type of policies should be included to eliminate multiple deprivation and to increase risk perception, preparedness, and mitigation measures?
(c) How can the findings of this study contribute to meet the SDGs goal 11.B?

1.5. Anticipated results

Table 1: Anticipated research outcomes / expected results

Sub Objectives	Expected Results
1. To conceptualize and extract a valid set of indicators under different capitals to map and analyse the multiple deprivation within the study area.	❑ After the conceptualization and extractions of indicators of different capitals/domains, it will be possible to map the multiple deprivation. ❑ Deprivations may correlate with different capitals/indicators.
2. To assess the risk perception of earthquake hazard and fire hazards of the residents of RpCC.	❑ Socio-economically advanced citizens will have higher risk perception. ❑ Risk perception may vary with socio-demographic characteristics of the citizens.
3. To investigate the relationship between multiple deprivation and risk perception.	❑ There is a significant correlation between multiple deprivation and risk perception.
4. To propose planning guidelines and policy interventions to reduce the deprivation, as well as to increase the risk perception and preparedness for disaster risk reduction (to meet SDG goal 11.B).	❑ The outcomes of this study can inform the planners and policymakers a few planning guidelines and policy interventions to reduce the deprivations and disaster risk in RpCC.

1.6. Thesis Structure

This thesis is structured in seven chapters. Flowed by this chapter, the second chapter looks for a conceptual framework and literature review. The third chapter discusses the research design and research methods including the description of the study area and data analysis methods. Consequently, chapter four discusses and visualises different aspects of multiple deprivation in Rangpur city. After that, chapter five illustrates the details on earthquake risk perception and fire risk perception in Rangpur city. Then, chapter six did a critical discussion on the results of the study. Finally, chapter seven concludes this thesis with key findings, limitations, and recommendations for future research.

2. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

This chapter includes the conceptual framework and literature review sections. The conceptual framework explains the conceptual boundaries of the research. Besides, Literature review section includes- multiple deprivation and index of multiple deprivation, disaster risk perception, Sendai Framework for Disaster Risk Reduction (2015-30), and SDG goal 11B.

2.1. Conceptual framework

The system of concepts, assumptions, expectations, beliefs, and theories that justify and notify research can be termed as the conceptual framework of a study; besides, the most valuable understanding of the conceptual framework is that it investigates the primary conception or model of the planned research, and tries to answer that why a tentative theory or model is being studied (Maxwell, 2012). 'Figure 1' illustrates the conceptual framework of this research work.

For this study, the multiple deprivation is conceptualized as different capitals, namely- social capital, human capital, financial capital, physical, and natural capital (Baud et al., 2008; S. Mishra, Kuffer, Martinez, & Pfeffer, 2019). Besides, the study of risk perception was limited to the earthquake and fire hazard in line with the objectives of this study. Furthermore, investigating the relationship between multiple deprivation and disaster risk perception was one of the key concerns here in this research. Finally, this relationship would help to understand the citizens' perception and the level of preparedness with different socioeconomic status, which could ultimately contribute to reducing the disaster risk of Rangpur city.

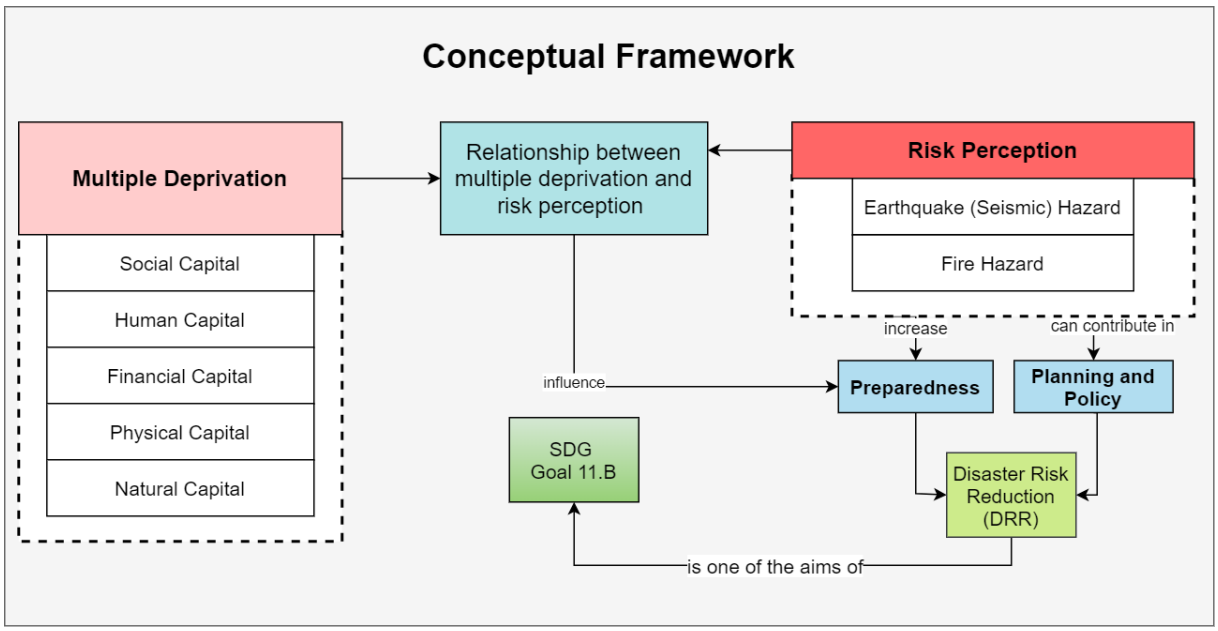

Figure 1: Conceptual Framework

2.2. Literature review

2.2.1. Literature summary

Several numbers of intensive literature searches were done to understand different aspects of this research, including the research methods and the concepts. I conducted the literature searches using Web of Science, Scopus, and Google Scholar databases. There were several search items. They are- i) poverty AND Bangladesh AND Rangpur, ii) multiple deprivation AND imd AND urban poverty AND spatial inequalities, iii) earthquake AND seismic AND hazard AND disaster AND risk perception, iv) fire AND hazard AND disaster AND risk perception, v) earthquake AND fire AND preparedness, vi) disaster AND Bangladesh, vii) urban AND disaster risk reduction etc. Overall search results provided more than one hundred journal articles, books, and book chapters. Among them, more than fifty journal articles, books, and book chapters were reviewed. Besides, a few open web searches were also conducted to get information on recent hazards in Bangladesh. Based on the web search, a few reports/working papers and news from the national daily newspaper also reviewed in this research due to the lack of sufficient research articles in the context of Bangladesh. 'Table 2' summarized the key concepts and their corresponding author's list.

Table 2: Contribution sector-wise authors list

Key Concepts	Authors
Fundamentals of research	Brayman, 2012; Kumar, 2011; Maxwell, 2012
Monga, urban poverty	Baud et al., 2008; Mazumder & Wencong, 2012
Multiple deprivation, IMD, spatial inequalities	Baud et al., 2008; DCLG, 2015; Deas, Robson, Wong, & Bradford, 2003; Martínez et al., 2016; Noble et al., 2006; Nthiwa, 2011; Yuan & Wu, 2014; Yuan et al., 2018
Risk perceptions (seismic and fire)	Dijkstra & Poelman, 2014; Ho et al., 2008; Kung & Chen, 2012; Lindell & Hwang, 2008; Paul & Bhuiyan, 2010; Sullivan-Wiley & Gianotti, 2017; Wachinger et al., 2013
Earthquake and fire hazards in the context of Bangladesh	Ali, 1988; Paul & Bhuiyan, 2010; Rahman et al., 2015
Disaster risk and disaster management in the context of Bangladesh	Ahmed, Nahiduzzaman, & Hasan, 2018; Ahsan & Warner, 2014; Alam & Bhadra, 2019; Barua et al., 2016; Brouwer et al., 2007; Gray & Mueller, 2012; Karim, 1995; Rabby et al., 2019

2.2.2. Multiple deprivation and Index of Multiple Deprivation (IMD)

The deficiency of food and clothing, living conditions, education, etc. is referred to as multiple deprivation (Yuan et al., 2018). According to Oyebanji (1984, p. 71), "Geographical studies of multiple deprivation or social well-being can be sub-divided into three broad types, operating at the interregional, the intra-regional and the intra-urban scale." Multiple deprivation study emphasizes on dimensions or domains and indicators of deprivation (Yuan & Wu, 2014). In general, the dimensions are- social, economic, and environmental, and the indicators are selected from these dimensions to form an Index of Multiple Deprivation. However, other authors emphasized on different capitals (social, financial, human, physical, and environmental) to conceptualize IMD (Baud et al., 2008; S. Mishra et al., 2019).

Beside the capitals or domains, identifying suitable index is very important to measure the deprivation. Oyebanji (1984, p. 73) explained:

> "….it is necessary to be able to identify appropriate indices or criteria of measurement. This problem needs to be carefully tackled, given the lack of a general theory to provide a correct set of social conditions to be considered when dealing with quality of life. It is impossible to use economic accounting methods, for example, in which all variables can be reduced to monetary terms and market forces (Smith 1979: 27). Since there is no general social theory, therefore, it is necessary to rely on widely accepted criteria, modified according to the local environment and culture of the study area."

So, suitable indicators play a crucial role to map the multiple deprivation precisely. Noble, Wright, Smith, & Dibben (2006, p. 174) said:

> "`Multiple deprivation' is thus not some separate form of deprivation. It is simply a combination of more specific forms of deprivation, which themselves can be more or less directly measurable. It is an empirical question whether combinations of these different forms of deprivation are more than the sum of their parts, that is, whether they are not simply additive but interact, and may have greater impact, if found in certain combinations."

Martínez (2009, p. 388) argued that:

> "Economic transformation is taking place around the world, and globalisation, privatisation and deregulation are usually seen as responsible for an increase in spatial segregation, social polarisation and spatial inequalities…. growing concern on inequalities has triggered local governments to target deprived areas. Area-based policies are one of the tools that have been applied since the 1990s to target geographical areas where problems coexist, and to improve the quality-of-life of the people living in those areas."

For a better understanding of this problem, Spatial analysis and visualization of poverty and multiple deprivations (MD) in the city areas are getting more attention (Baud et al., 2008; Martínez et al., 2016; Yuan & Wu, 2014; Yuan et al., 2018). Though "Indicators from census data are good to measure indirect need, but they cannot measure self-expressed demand coming from the population" (Martínez, 2009, p. 393). However, civic organizations and policymakers can be supported by this type of analysis to overcome spatial inequalities (Martínez et al., 2016).

2.2.3. Disaster risk perception

2.2.3.1. Risk Perception

The concept of risk perception is associated with perceived personal risk, hazard experience, hazard information, hazard adjustment, hazard proximity, etc. (Lindell & Hwang, 2008). Moreover, "Within the social sciences, the term risk perception has a long tradition. The term denotes the process of collecting, selecting, and interpreting signals about uncertain impacts of events, activities, or technologies" (Wachinger et al., 2013, p. 1049). In general, risk perception depends on how people perceived the risk personally. In other words, the type of risk, the context of the risk, individual's personality, and the social context influence the risk perception (Wachinger et al., 2013).

That is why risk perception has been considered as a valuable predictor of risk mitigation by many researchers (Ho et al., 2008). Besides, a higher level of protective action is derived from a higher degree of risk perception. Fernandez, Tun, Okazaki, Zaw, & Kyaw (2018, p. 140) proposed that:

> "Without a good understanding of how people perceive disaster risks, well-intentioned disaster risk management policies and interventions may be ineffective. Knowledge of risk perception may provide important insights about people's willingness to take precautionary actions and may guide government risk reduction policies."

Though there is a paradox that increased risk perception is not always connected to the protective measures (Wachinger et al., 2013), still, people should have a minimum understanding of risk which are associated with different hazard to have preparedness and protective actions against potential hazards. Moreover, the assessment of risk perception in a multi-hazard environment is essential to identify the reality of vulnerable individuals on a particular hazard. Because distinct hazard characteristics influence risk perception (Sullivan-Wiley & Gianotti, 2017), consequently, for effective disaster-related planning and policy interventions in Rangpur City Corporation, knowing the risk perception of the stakeholders assumed to be essential.

2.2.3.2. Earthquake risk perception

The prediction of a potential earthquake is still unpredictable by the people or community; though it is possible to reduce the damage by physical and mental preparation, and that could be an appropriate way to reduce the risk (Kung & Chen, 2012). In general, two theories are recognized to explain the risk perception of any hazards; they are psychometric theory and cultural theory (Shrestha, Sliuzas, & Kuffer, 2018).

Armaş & Avram (2008) studied the patterns and trends in the earthquake risk perception for the case of Bucharest Municipality, Romania. Their thought behind this research was that citizens of big cities live their life with suppressed and stable worries about a potential earthquake. They adopted a field-based study. The study results showed that earthquake risk perception is considerably associated with "aspects concerning the subjects' orientation toward institutional factors/human relations/ negativism, and toward financial/material/moral support in case of disaster etc.". Armaş and his colleagues also suggested that human dimensions of disasters should be taken into consideration to make hazard analysis and mitigation more effective.

Paul & Bhuiyan (2010) investigated earthquake hazard risk and perception in Dhaka City, Bangladesh, through a questionnaire survey approach. They found that most of the population of that city was not prepared for a significant earthquake. They also found that residential unit value and education level of respondents were the significant determinants of preparedness. However, Paul and his colleague did not look at the spatial distribution of earthquake risk perception in Dhaka City.

2.2.3.3. Fire risk perception

To assess the risk perception of fire hazards at the household level is very significant for management and policy implications. Because "'having a better understanding of risk perception and knowledge, as well as evaluating the effectiveness of, and knowledge gaps in, fire reduction will be useful for developing strategic fire risk reduction policies" (Chan et al., 2018, p. 306).

Fernandez and his colleagues (2018, p.147) investigated the influence of different factors on risk perception of various hazards, including fire hazard in Myanmar. They identified that "Age, gender, level of monthly household income, type of house ownership, and disaster experience influence fire risk perception items."

Presence of protective equipment in the households like- smoke detector, fire extinguisher and fire blankets could be the indicators of household-level preparedness for fire hazard (Stumpf, Knuth, Kietzmann, & Schmidt, 2017). However, the experience of past disaster may influence the fire risk perception (Chen et al., 2019). Besides, fire-fighting equipment at an institutional level is very significant as fire mitigation measure (Z. Islam & Hossain, 2018).

2.2.4. Sendai Framework for Disaster Risk Reduction (2015-30) and SDG goal 11B

The Sendai Framework for Disaster Risk Reduction (SFDRR) was aimed to ensure the policies requirements for disaster risk reduction (DRR) based on the cities' existing understanding of the complexity of disaster risk (Aitsi-Selmi, Egawa, Sasaki, Wannous, & Murray, 2015). SFDRR is an integral part of SDG 11. Where SDG 11 has a total of 10 targets, and SDG 11.B entirely connected with SFDRR. According to UNHQ (2015), the target of SDG goal 11.B is:
bs

> "By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels."

Align with this target; there are two indicators. They are:

> "11.B.1 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030.
> 11.B.2 Number of countries with national and local disaster risk reduction strategies."

So, findings and experience from disaster risk perception study could propose a few policy measures for RpCC, which could ultimately be aligned with SDG 11.B and SFDRR (2015-30).

3. RESEARCH DESIGN AND RESEARCH METHODS

3.1. Study area

Rangpur city is the core of Rangpur Division. However, this division has the least income (BBS, 2019) and most deprivation since the independence of Bangladesh, however, Rangpur city has a historical background. In the 18th century, it emerged as the headquarter of the Mughal administration in 'Sircar Cooch Behar' (Vas, 1911); the Cooch Behar is currently part of India. Most of the international organizations like Economic Cooperation and Development (OECD), United Nations (UN) and European Union (EU) follow the national definition of city/urban area given by a country (Dijkstra & Poelman, 2014). According to the definition from Bangladesh government (LGED, 2014), Rangpur earned the status as a city a long time ago. Previously this city had a status of a municipality (the local term is 'paurashava'). In 2012, Rangpur city became a city corporation which is an upgraded form of the municipality. Now, this city is known as Rangpur City Corporation (RpCC) and has a total of 33 electoral wards (EWs) over the 205 square kilometre area.

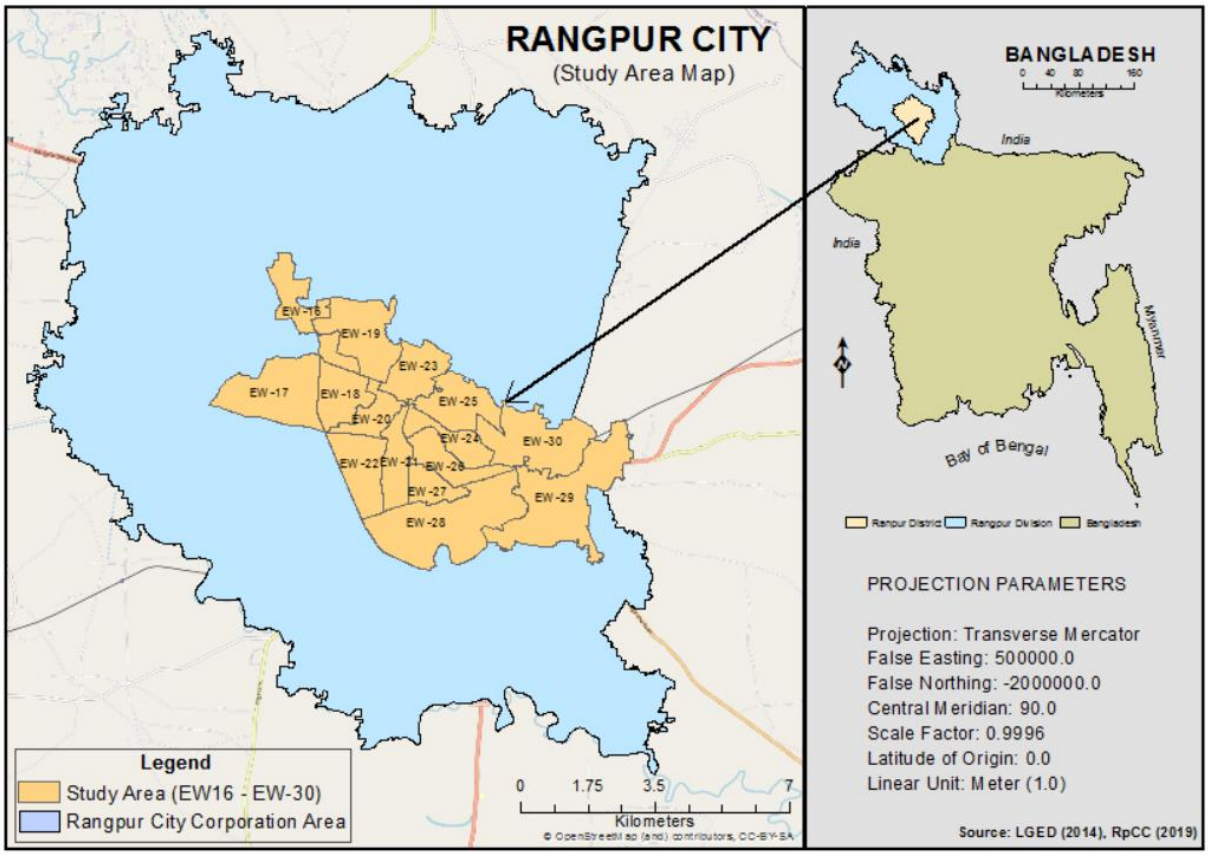

Figure 2: Study area map (Source: LGED, 2014; RpCC, 2019)

Among them, 15 EWs (EW 16 to EW 30) correspond to the area of the former municipality, and this is the core part of the city (Figure 2). For this study, 15 EWs were selected from the RpCC; and the demographic and socio-economic data are available at this level from the census of 2011 (BBS, 2013). Here, 'Table 3' gives a brief description of RpCC and the study area. This table also shows that the study area has a higher population density (9334 per square kilometre) compared to the overall RpCC. Because this part of the city represents the old city area, and most of the economic and business-oriented activities are concentrated

here. That was also a decent reason to select this part of RpCC as the study area. Otherwise, it could give a wrong interpretation regarding the multiple deprivation. Though the study area is not representing all the parts of RpCC; for easy understanding, in the rest of part of this thesis, the study area will be mentioned as RpCC.

Table 3: Brief description of RpCC and the study area

Description	RpCC	Study Area
Number of electoral wards	33	15
Area (in square kilometres)	205.70	38.70
Population	5,85,622 (in 2013)	2,75,592 (in 2011)
Average population density/km²	2847	9334
Number of households	-	64,127
Number of recreational sites	6	6

Source: (BBS, 2013; LGED, 2014)

3.2. Research design

This study adopted a mixed-method (quantitative and qualitative) approach. In this study, the first objective is focused on selecting suitable indicators for developing the Index of Multiple Deprivation (IMD). Furthermore, this study did two types of analysis. The first analysis is calculating the IMD, which is a quantitative approach, and the calculation was done using secondary data based on different indicators under five capitals. Then all 15 EWs were examined to calculate the multiple deprivation score. After that, the risk perception of citizens on earthquake and fire hazards were examined. This phase of the research collected subjective information through a questionnaire survey at the household level. Besides, a total of nine interviews (qualitative approach) were also done with the concerned government, city officials etc. (Table 4). Finally, the relationship between the deprivation score and risk perception was evaluated based on correlation analysis, and recommendations were proposed accordingly for better preparedness, policies and planning. Here, 'Figure 3' is illustrating the overall research design.

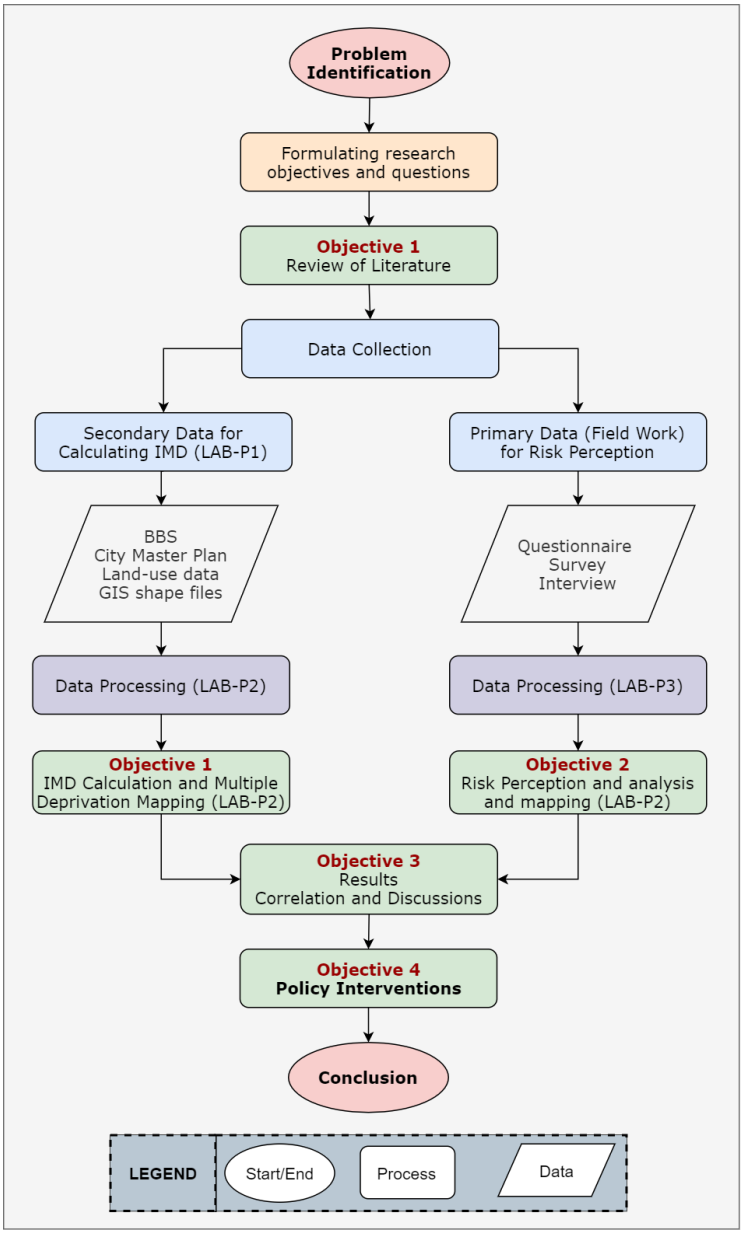

Figure 3: Research Design

3.3. Research methods

3.3.1. Data type, sources, and sampling methods

'Table 4' is showing the list of the required data and their sources for this study. In general, three types of data were needed for this study. Firstly, quantitative data, which includes- demographic data (population, density, age etc.) and socio-economic data (such as- literacy rate, employment rate, dependency rate, household type, ethnicity, sanitation etc.) as the indicators of multiple deprivation. These data were collected from the population and housing census data of 2011. However, these data were published in 2013 by the Bangladesh Bureau of Statistics (BBS). Secondly, for earthquake and fire risk perception, data were collected directly from the field through a questionnaire survey. Thirdly, semi-structured interviews were done to get more insights on deprivations and preparedness on hazards' risk. Finally, different shapefiles and land-use data were collected from RpCC website and Center for Environmental and Geographic Information Services (CEGIS).

Table 4: Required data and their sources

Data Types		Data Sources
Quantitative	Demographic data Socio-economic Indicators	Bangladesh Bureau of Statistics (BBS)
Qualitative and Quantitative	Earthquake risk perception Fire risk perception	Questionnaire survey and semi-structured interview
Geo-spatial	Administrative boundaries (shapefiles)	RpCC, Local Government Engineering Department (LGED)
	Land-use (green areas)	Center for Geographic Information Services (CEGIS)/Google Earth

3.3.2. Sampling methods

According to Brayman (2012, p. 186) "the need to sample is one that is almost invariably encountered in quantitative research". Previously the sampling method of this study was divided into two parts, one is area-based, and another one was population-based. Then it was planned to select four electoral wards for the questionnaire survey based on systematic sampling (Kumar, 2011). However, finally, 15 EWs were taken into consideration for the questionnaire survey. After that, it was essential to determine the sample size of the population of RpCC. Here, the total number of populations were considered from the national statistics of 2011. The total sample size was determined at a 95% significance level, where the confidence interval was 5. As a result, 384 samples were needed (Figure 4). Then proportionate stratified sampling method (Kumar, 2011) was applied to determine to sample size for each electoral ward, but it was not always possible to maintain the exact number. Furthermore, 'non-random-quota' method (Kumar, 2011) was applied to ensure the male-female participation. However, it was not possible to ensure to apply the non-random method for maintain the equal ratio of single-story and multi-story household. 'Figure 5' illustrates the overall planned and executed sampling methods.

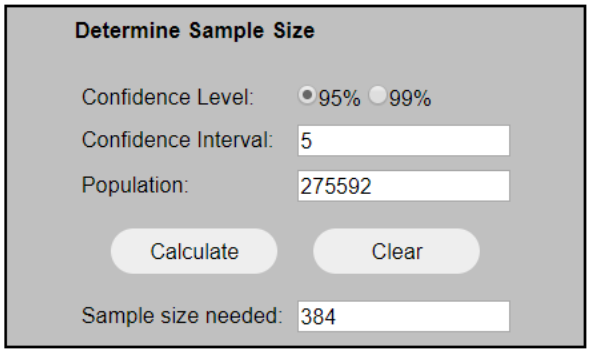

Figure 4: Determining the sample size using online tool (Source: https://www.surveysystem.com)

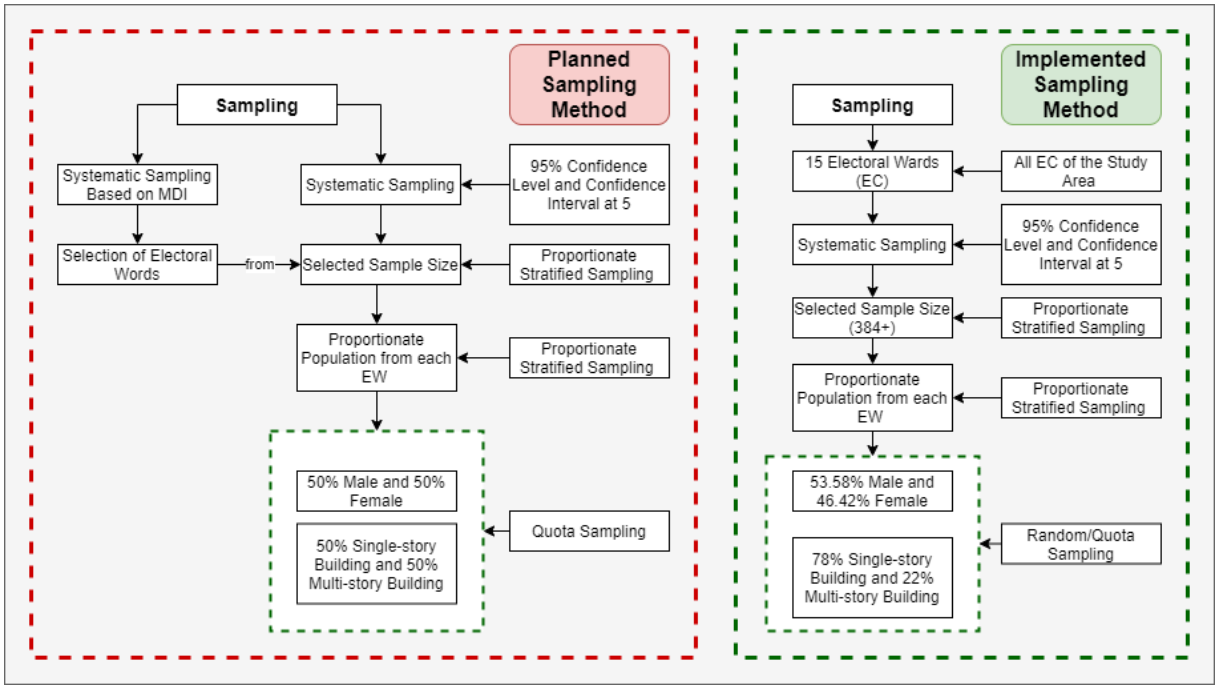

Figure 5: Planned and implemented sampling methods

3.3.3. Questionnaire design and questionnaire survey

The questionnaire was designed using KoBoToolbox (https://www.kobotoolbox.org/). There was a total of 45 questions/information. First, eight information were survey-related information, such as- surveyor ID, location, photograph, ward number, house address and consent for the survey etc. Then there was thirteen general information; they were related to demographic and household characteristics (example- name, age, gender, level of education, household construction type, household ownership type, etc.). The third part of the questionnaire was related to fire risk perception. Here, there was a total of twelve questions. Then the fourth part of the questionnaire had a total of eight questions related to earthquake risk perception. The final part of the questionnaire was related to the citizens' anticipation of multiple deprivation, and there was a total of four questions. Among the questions, two were open-ended, and the other two were close-ended questions.

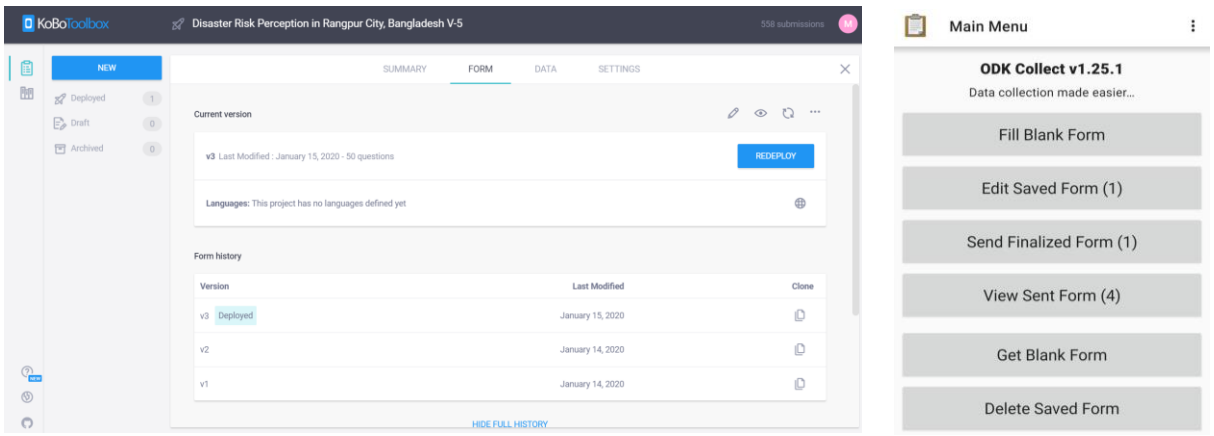

Figure 6: Graphic user interface (GUI) of KoBoToolbox and GUI of ODK Collect

All the questions and possible answers were structured using KoBoToolbox (Figure 6). Then it was deployed in order to retrieved in ODK Collect, which is an open-source Android application for data collection

(Figure 6). First two versions of the questionnaire were tested on the field, and after getting feedback from the data collector, few corrections were made. Finally, the third version was deployed to collect the data.

The questionnaire survey was the principal method for data collection. Data collection process took five days to complete the survey, where 4-7 person was engaged, and a total of twenty-seven person-days were needed to collect the data. The collector reached 600 residents of RpCC, and 558 residents were agreed to participate in the survey. The surveys were done in 15 electoral wards (ward 16-20). The distribution of the data collection points was observed live most of the time on KoBoToolbox (Figure 7), and based on sample distribution map, the data-collectors were guided to change their location if necessary. However, it was not possible to avoid some overlaps because of high residential density in those areas.

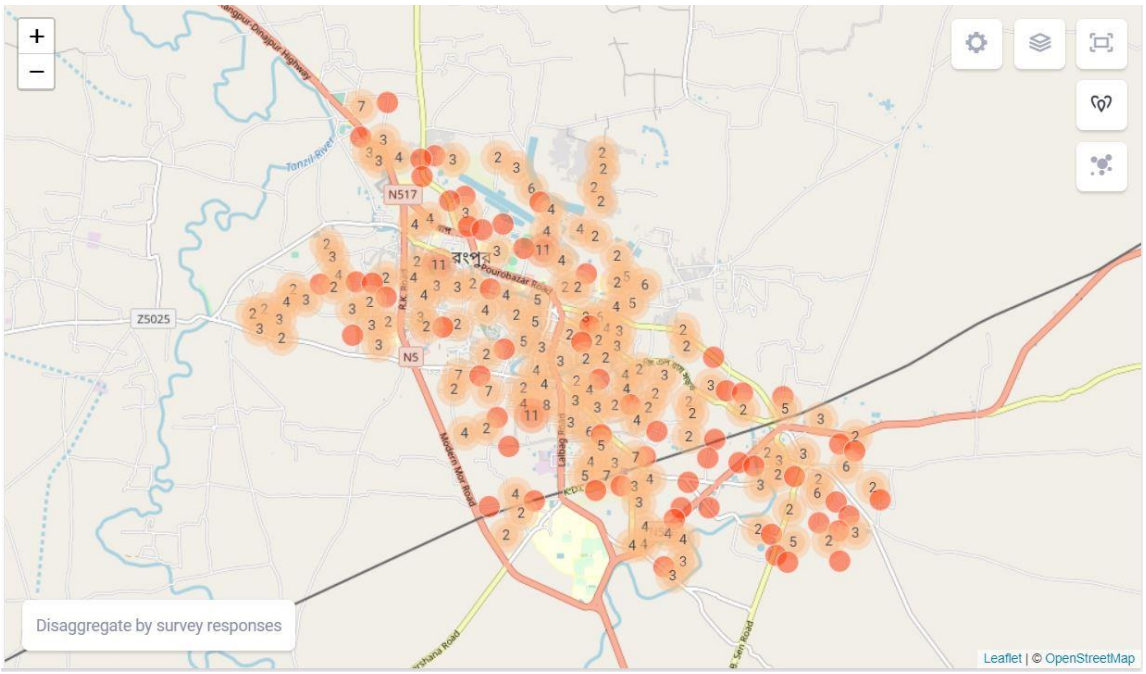

Figure 7: Location of survey points over the study area

During the survey, one of the goals was to maintain an equal male-female ratio. After analysing the collected data, it is observed that 53.38% was male respondents, and 46.42% was female respondents. Another primary goal during the survey was to maintain an equal ratio of single-story and multi-story building. However, that was not possible because the main entrance of multi-story buildings was closed in most of the cases. Finally, 78% of respondents were from single-story buildings, and 22% were from multi-story buildings.

3.3.4. Questionnaire data cleaning

It was essential to check the acquired data from the field survey for reliability. After checking the data carefully, data cleaning was done rationally. During the field survey, it was possible to collect 558 observations. At first, the survey duration was checked. Afterwards, only survey duration equal to or higher 8 minutes were kept for further analysis. This filtering eliminated 174 observations. Moreover, two observations were from EW-32, and this EW was beyond the study area. Besides, the age of the respondents was missing in 5 observations. Average age (43 years) from the rest of the sample were assigned manually to solve this problem. Finally, the complete database contains 382 observations which are almost same as the calculated sample size (384).

3.3.5. Semi-structured interview

Perhaps, semi-structured interviews could bring more insights of the multiple deprivation and disaster risk perception in RpCC, because this is an excellent method of asking targeted questions to understand the views of the interviewees (Bryman, 2012) within a particular conceptual framework. A total of nine interviews were done during the fieldwork (Table 5). Particularly, interviewees were asked different issues on multiple deprivation, earthquake hazard and fire hazard. There were four different sets of questions based on the expertise/profession of the interviewees. Later, the interviews were analysed to justify or compare the research findings. Besides, interviews helped to formulate recommendations in this research.

Table 5: List of interviewees and interview duration

Key persons for the semi-structured interview	Interview Duration		
	Hour	Min	Sec
One of the professors of the Department of Disaster Management, Begum Rokeya University, Rangpur (BRUR)	0	12	14
One of the professors of the Department of Geography and Environmental Science, BRUR	0	20	21
One of the officials of Disaster Management E-learning Center, BRUR	0	18	37
One of the officials of Fire Service and Civil Defence, Rangpur	0	22	18
One of the officials Rangpur City Corporation (RpCC)	0	29	15
One of the professors of the Faculty of Life and Earth Sciences, BRUR	0	32	29
One of the social activists, Ranpur	0	17	30
One of the ward commissioners, RpCC	0	4	26
One of the ward commissioners, RpCC	0	5	50
Total Duration of interview	2	43	0

3.4. Data analysis

3.4.1. Calculation and mapping of multiple deprivation

The calculation of multiple deprivation was derived from 'Equation 1'. Before that, each indicator's value was normalized, followed by the cost-benefit analysis (Equation 2 & 3) to make an overall index. Moreover, equal weights were assigned to each selected indicator. Weights can be determined by practical or/and research experience (Yuan & Wu, 2014). For this study, equal weights were given to each indicator because Baud et al. (2008) also applied same technique for the case of Delhi, India, and I also used a similar type of data and indicators.

$$IMD = \frac{I1+I2+\dots\dots+In}{n} \quad \text{...(Equation 1)}$$

Here,

IMD = Index of Multiple Deprivation

$I_1, I_2, \dots I_n$ = normalized indicators and

N = number of indicators

$$B = \frac{V - V_l}{V_h - V_l} \quad \text{.....(Equation 2)}$$

Here,

B = Benefit
V = Value
V_l = Lowest normalized value of an indicator
V_h = Highest normalized value of an indicator

$$C = 1 - \left(\frac{V - V_l}{V_h - V_l}\right) \quad \text{.....(Equation 3)}$$

Here,

C = Cost
V = Value
V_l = Lowest normalized value of an indicator
V_h = Highest normalized value of an indicator

After combining all attributes, the overall multiple deprivation map was prepared based on the deprivation score of 15 EWs. However, this map is not sufficient to illustrate the deprivations in different capitals. So, separate maps were generated for each capital. Besides, indicator-wise deprivation maps were generated and presented as sub-set maps with different capitals' map. Moreover, spider diagrams were also drawn to understand capital-wise deprivation at electoral ward level. Furthermore, descriptive analysis, correlation analysis, factor analysis, rank-table analysis, Kaiser-Meyer-Olkin (KMO) test etc. were done for detailed statistical analysis of multiple deprivation.

3.4.2. Analysing citizens' anticipation of multiple deprivation

Two questions were asked to understand the citizens' perception of multiple deprivation. Besides, they were asked to mention an essential sector (indicator) that needs more attention to reduce the deprivations in RpCC. Based on the answer to the first two questions, a cross-table analysis was done; the result of the last question was shown in a bar diagram.

3.4.3. Calculation of earthquake risk perception

A risk perception index (RPI; Equation 4) was developed based on some questions/statements to measure the earthquake risk perception of the citizens. Different questions/statements were formulated/adapted (Kung & Chen, 2012; Paul & Bhuiyan, 2010; Shrestha et al., 2018) for this purpose. They are-

Q 1. Did you witness or experienced any earthquake?
Q 2. Do you agree that a severe earthquake may hit your living place?
Q 3. Do you agree that the earthquake will affect you and your family?
Q 4. Do you agree that the earthquake may result in your property damage?
Q 5. Do you agree that the earthquake may result in death and injury?
Q 6. How fearful are you about a possible earthquake?
Q 7. Do you have any first aid kit or any emergency kit to face earthquake occurrence?
Q 8. Do you have any emergency exit for such type of situation?

Earthquake $RPI = \frac{P1+P2+.....+Pn}{n}$ ……..(Equation 4)

Here,

$P_1, P_2, ... P_n$ = scores derived from the question/statement

n = number of questions/statements

The answer to the four questions were coded to a five-point Likert scale between 0 to 1 (for example- strongly disagree = 0, disagree = 0.25, neutral = 0.50, agree = 0.75 and very low = 1); answer to the one question were coded to a four-point Likert scale between 0 to 1 (for example- not fearful = 0, little fearful = 0.33, moderate fearful = 0.66, and Highly fearful = 1). Besides, three questions were in binary scale and coded between 0 to 1. Where 1 will be the highest perception, and 0 will be the least perception. Based on the risk perception score, a map was generated, showing the earthquake risk perception at the electoral ward level. Besides, descriptive analysis, cross-table analysis, t-test and correlation analysis was done to understand the linkage among the socio-demographic factors and earthquake risk perception. Furthermore, the cross-table analysis was done to understand the preparedness on earthquake hazard at both electoral and household level.

3.4.4. Calculation of fire risk perception

For the fire hazard, an RPI (Equation 5) was also formulated/adapted (Chan et al., 2018) based on twelve questions to understand the risk perception on fire hazard at the citizen level. The questions are-

Q 1. Did you witness or experienced any fire accident?
Q 2. What is the level of risk of fire at your house do you think?
Q 3. Do you think the fire can occur from cooker/stove at your home?
Q 4. Do you go somewhere else or do other jobs while cooking?
Q 5. How frequently you check the condition/status of your stove/cooker?
Q 6. Do you think an electric short circuit can cause fire at your home?
Q 7. How frequently you check the electricity line of your house?
Q 8. Do you know where the electric main switch of your house is?
Q 9. Do you use multi-plug at your home?
Q 10. Do you have a fire extinguisher (e.g. fireball, fire blanket etc.) at your home?
Q 11. Do you have a smoke detector and or fire alarm at your home?
Q 12. Have you ever participated in any fire drill?

Fire $RPI = \frac{P1+P2+.....+Pn}{n}$ ……..(Equation 5)

Here,

RPI = Risk perception index

$P_1, P_2, ... P_n$ = scores derived from the question/statement

n = number of questions/statements

Among twelve questions, answers to the three questions were coded to a five-point Likert scale (between 0 to 1; example- no Risk = 0, low risk = 0.25, medium risk = 0.50, high risk = 0.75, and very high risk = 1). Besides, answers to the two questions were coded to a three-point multiple-choice scale (coded between 0 to 1; example- yes = 1, maybe = 0.50, and no = 0), and six questions were in binary scale (coded between 0 to 1). Where in general, the value 1 is the highest perception, and 0 is the least perception (please see appendix-2). Mapping and statistical analysis were followed the similar methods as of ERP analysis.

3.5. Ethical considerations

In this research, I always tried to follow five principles, as suggested by the Netherlands Code of Conduct for Research Integrity; the principles are- honesty, scrupulousness, transparency, independence, and responsibility (Netherlands Code of Conduct for Research Integrity, 2018). Besides, the best of the knowledge, I tried to avoid all types of research misconducts. Research misconduct includes plagiarism, data fabrication, data falsification etc.; and indeed, this type of irresponsible research practices are same as questionable research practices (Ana, Koehlmoos, Smith, & Yan, 2013).

The systematic way of producing or falsifying the results or conclusions in research could be termed as bias (Sackett, 1979). Sackett (1979) documented thirty-five biases that occur in sampling and measurement. In this research, I also could have encountered several biases. Keep those in mind; indeed, I tried to make this study completely bias-free. In this study, I mainly focused on the following biases:

Confirmation bias: This could be one of the potential biases of the study. One of the assumptions of this research was 'multiple deprivation' and 'disaster risk perception' are correlated with each other. Nevertheless, I was determined that if the result does not correspond with the assumption, I will accept the result without doing any kind of p-hacking. However, other types of statistical tests could be deployed to get more insights into the said relationship.

Political/social/cultural bias: These biases are very common in the context of developing countries, and Bangladesh is also not an exception. However, luckily for this research, there was no conflict of interest in the political, social, or cultural aspects; because I was doing this research independently as a part of my academic degree. So, I am free to write any kind of significant results.

Selection bias: For this case, it was easy to adopt the selection bias. Because I measured multiple deprivation in a newly declared city; the study area previously had fifteen electoral wards (EWs). After the declaration of the city corporation, the city expanded its jurisdiction from fifteen to thirty-three electoral wards. If I choose thirty-three electoral wards, it was straightforward to establish a wide variety of deprivation at the electoral ward level. However, considering this issue, along with other justification, I selected fifteen EWs to keep the study bias-free.

Surveyor perception bias: surveyor perception bias was one of the significant concerns during the field study. Because the second part of my research is dealing with risk perception, and the risk perception data were directly collected from the field. There was a good chance that the respondents could be motivated by the questioning style or thoughts of the surveyor; considering the facts, the surveyors were continuously requested to motivate the respondents to answer independently.

Besides the above issues, I was cautious about the informed consent of the respondents and their (personal) data protection. As this study deployed a questionnaire survey and semi-structured interview, informed consent was a focal point before conducting the survey or interview. According to Bryman (2012), one of the fundamental principles of social science research ethics is informed consent, and it suggests that maximum information should be given to the participants about the research so that they can decide whether they will participate in the research or not. So, for this case, the purpose and objectives of this research were informed to the respondents and the interviewees. Besides, personal information (e.g., age, income, household status) were kept confidential, and the collected data were used only for the research purpose. Furthermore, a proper acknowledgement was given to the respective authorities for the secondary data or information.

4. MULTIPLE DEPRIVATION IN RANGPUR CITY

This chapter is focused on selecting suitable indicators for deprivation mapping, validation of index of multiple deprivation, the spatial pattern of multiple deprivation, capital-wise deprivation; and correlation among IMD, capital, and indicators.

4.1. Selecting suitable indicators for deprivation mapping

A set of different indicators from/under various capitals and domains were selected based on existing conceptual models or frameworks (Table 6), that could also correspond with the available data within the framework. Here, the concept of four capitals (social, human, financial and physical) was adapted from the study of Baud et al. (2008) and natural capital was adapted from Mishra, Kuffer, Martinez, & Pfeffer (2019). Among the indicators, some are 'benefit', and some are 'cost' based on their contributing characteristics to multiple deprivation. If an indicator increases the IMD score, then it is 'benefit', and if it decreases the score, then it is 'cost'. The list of capitals and domains was formulated based on various studies (Baud et al., 2008; DCLG, 2015; Deas et al., 2003; S. Mishra et al., 2019; Noble et al., 2006; Nthiwa, 2011; Yuan & Wu, 2014; Yuan et al., 2018). Among twenty indicators, seven indicators are close/similar to the indicators used by Baud et al. (2008), one is close to the indicator used by Mishra et al. (2019), another one is close to the indicator suggested by DCLG (2015). Other ten indicators were selected because those also seem relevant for this study.

Table 6: List of indicators of multiple deprivation

Capital	Domain	Indicator	Relevant Literature	Cost-Benefit Formula
Social Capital	Social Discrimination	% of Female Widowed/Divorced/Separated	-	Benefit
		% of Ethnic Population	Baud et al., 2008	Benefit
		% Non-Muslim	Baud et al., 2008	Benefit
Human Capital	Education Deprivation	Literacy Rate	Baud et al., 2008	Cost
		% of population (6-10 yrs) not attending school	-	Benefit
	Health and Disability	% of Disable people	DCLG, 2015	Benefit
	Employment and Workforce	% Employment (7 Years+ old not attending school but employed)	Baud et al., 2008	Cost
		% of population within 25-59 age group capable of working	-	Cost
	Dependent Age group	% of Pop less than 10 years old	Baud et al., 2008	Benefit
		% of Pop 65+		
Financial Capital	Monetary situation	% Floating Population[1]	-	Benefit
		% of Owned house	-	Cost

[1] "Floating population constitutes the mobile and vagrant category of rootless people who have no permanent dwelling units whatever worse these are" (BBS, 2014).

Table 6: List of indicators of multiple deprivation

Capital	Domain	Indicator	Relevant Literature	Cost-Benefit Formula
Physical Capital	Service Deprivation	% of Electricity Connection	Baud et al., 2008	Cost
		% Institutional Households	-	Cost
	Household Condition	% of Pucca Structure	-	Cost
		% of Jhupri Structure	-	Benefit
		% of Sanitary Toilet	Baud et al., 2008	Cost
		% of No Toilet		Benefit
	Living Environment Deprivation	% of Household size greater than 6	Martínez, 2009	Benefit
Natural Capital	Environmental Deprivation	% Green area	S. Mishra et al., 2019	Cost

4.2. Validation of IMD

Two methods were applied to validate conceptual IMD. Firstly, data-driven IMD was calculated. This data-driven IMD used a total of nine variables which were directly collected from the field. However, it was not possible to use those variables directly; data normalization/standardization (Baud et al., 2008; Yuan & Wu, 2014) approach (cost-benefit analysis) was adopted to fit the variables for IMD calculation. These variables are- the percentage of the population more than 59 years old, percentage of households have more than six inhabitants, percentage of female population, percentage of the highly educated population (bachelor and above degree holders), percentage of unemployed people, percentage of the very low-income group (below 10000 BDT), percentage of pucca structure, percentage of multi-story building and percentage of rented households. Secondly, factor analysis was performed to reduce the indicators of the conceptual model. After several iterations, the KMO (Kaiser-Meyer-Olkin) (S. V. Mishra, 2018; Yuan & Wu, 2014) value was 0.581 and ended with ten indicators out of twenty. These ten indicators showed good communality with minimum loading value 0.73 while the highest loading value was 0.948. After that, IMD was calculated, followed by the normalization/standardization method. However, this study did not consider the principal components to map the multiple deprivation because it would not be comparable with the other two methods (conceptual IMD and data-driven IMD).

Finally, Pearson's correlation analysis was done to check the correlation between the three types of IMD score to validate the conceptual model of this study. 'Table 7' shows that IMD (theoretical and conceptual) firmly correlation with IMD (based on field data) and IMD (KMO); the correlation value is 0.631 and 0.692, respectively. Moreover, field data-based IMD highly correlates with IMD (theoretical and conceptual) than the IMD (KMO). However, I decided to strict with conceptual IMD model because some of the indicators seem very important for the context of the study area.

Table 7: Pearson's correlation among three different IMDs

	IMD (Theoretical and Conceptual)	IMD (Based on Field Data)	IMD (KMO)
IMD (Theoretical and Conceptual)	1		
IMD (Based on Field Data)	.631*	1	
IMD (KMO)	.692**	.604*	1

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

4.3. Overall multiple deprivation in RpCC

After calculating the IMD (using equation 1, 2, and 3), the extent of multiple deprivation over the Rangpur city is revealed. The multiple deprivation map was classified into five classes using 'Natural Breaks (Jenks)' methods. 'Figure 8' shows the GIS-based classified map. According to this map, EW-29 and EW-30 have the highest level of deprivation. EW-29 and EW-30 are in the north-western part of the city and are still kind of peri-urban areas. Lack of economic activities and services are observed here.

On the other hand, EW-16 and 18 have the least deprivation. These two EWs are located in the eastern part of the city. The least deprived areas are in general, where most of the services and jobs are available. This part of the city is well known for hospitals, schools, colleges, shopping malls, administrative units, and the other urban facilities.

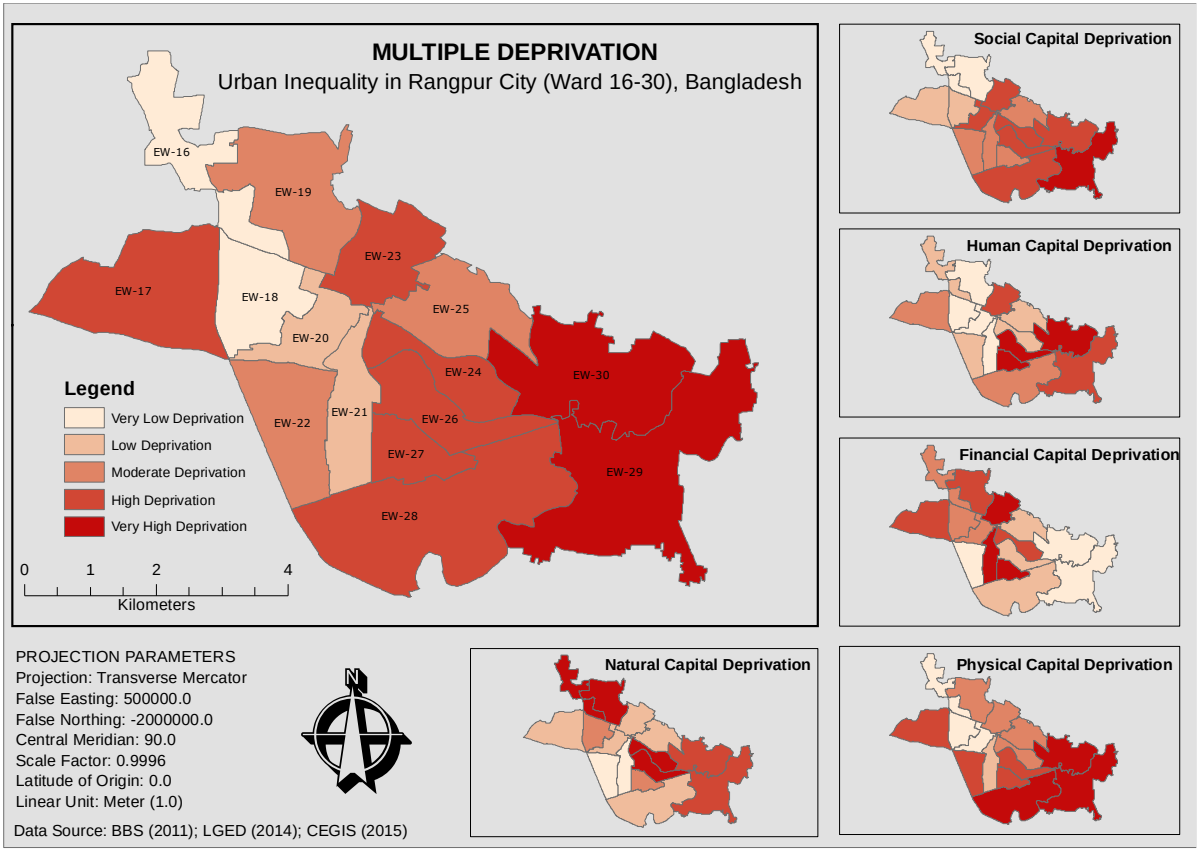

Figure 8: Map of the spatial distribution of multiple deprivation in the Rangpur City (electoral ward 16-30)

a rank-table was generated based on the deprivation values to get more insights into the deprivations. 'Table 8' shows the ranks of the EWs based on the multiple deprivation score. Here, rank '1' denotes most deprived EW and Rank '15' denotes the least deprived EW. Based on the deprivation scores, EW-30 is most deprived, and EW-18 is least deprived. This table also reveals that EW-30 is highly deprived in five indicators. In contrast, this EW is least deprived in three indicators. Similarly, EW-18 is least deprived in five indicators and highly deprived based on the presence of green areas.

However, from the overall deprivation map or rank-table, it is not possible to tell what type of deprivation contributing to the overall multiple deprivation and how. Here sub-set maps in 'Figure 8' give an overall idea on the deprivation of different capitals in RpCC.

Table 8: Ranking of EWs based on IMD score, and relationship among IMD and indicators (Source: BBS, 2013)

			Social Capital Deprivation		**Human Capital Deprivation**								**Financial Capital Depr.**	**Physical Capital Deprivation**							**Natural Capital Deprivation**
EW Number	Multiple Deprivation (IMD) Rank	Multiple Deprivation (IMD) Score	% of Widow and Divorced Female (1)	% of Ethnic Population (2)	% of Non-Muslim Population (3)	Literacy Rate (4)	% of 6-10 Not Attending School (5)	% of Disable People (6)	% of 7 + Not Attending School & Employed (7)	% of Population Less than 10 Years (8)	% of Population Higher than 65 Years (9)	% of Population 25-59 Years Old (10)	% of Floating Population (11)	% of Owned House (12)	% of Electricity Connection (13)	% of Institutional Household (14)	% of Pacca Structure (15)	% of Jhupri Structure (16)	% of Sanitary Toilet (17)	% of No Toilet (18)	% of Household Size Greater Than 6 (19)	% of Green Area (20)
EW-30	1	.60	8.80	1.12	1.96	55.30	19.37	1.10	45.20	21.20	4.00	41.00	0.00	78.00	71.10	0.13	2.30	3.50	36.40	11.70	11.30	6.42
EW-29	2	.58	10.80	1.04	18.13	61.60	16.75	1.00	43.00	19.10	4.70	43.30	0.01	77.90	70.00	0.26	5.20	4.00	14.00	5.70	6.30	7.31
EW-27	3	.53	9.80	0.00	3.11	61.50	25.15	1.30	43.61	16.40	4.20	42.00	0.39	47.70	87.20	0.06	15.80	1.40	22.30	4.00	11.30	8.24
EW-26	4	.53	12.30	0.00	3.03	59.20	25.79	1.40	47.61	19.80	3.80	43.40	0.03	59.30	78.60	0.07	20.50	0.90	29.10	4.70	10.50	1.30
EW-28	5	.52	7.90	0.64	9.09	70.00	23.69	0.90	45.70	15.50	3.20	35.00	0.00	68.00	77.00	0.03	8.00	5.50	20.70	6.50	9.40	15.43
EW-24	6	.48	10.30	0.00	23.48	73.90	16.02	1.70	46.67	16.70	4.10	47.30	0.57	60.50	88.50	0.20	30.20	5.90	40.80	1.20	10.20	2.23
EW-23	7	.48	10.90	0.02	6.79	63.90	17.35	2.80	47.01	17.90	3.10	41.40	0.68	58.40	90.90	0.26	18.90	0.60	45.10	2.80	13.30	16.63
EW-17	8	.44	7.70	0.02	5.76	71.70	20.84	0.80	40.95	20.50	2.80	42.50	0.43	58.50	85.40	0.04	21.00	2.50	36.70	6.00	9.10	19.73
EW-19	9	.36	6.80	0.03	4.88	78.10	18.70	1.10	48.87	16.80	2.80	42.60	0.26	51.80	88.80	0.00	36.70	2.00	45.90	4.00	11.20	0.14
EW-22	10	.35	9.00	0.00	4.26	73.90	18.58	0.80	46.04	18.00	3.10	42.00	0.00	73.20	83.80	0.04	15.50	1.90	34.30	5.10	11.30	47.68
EW-25	11	.34	8.70	0.00	9.04	75.70	11.15	1.40	44.55	15.20	3.60	39.30	0.11	65.90	85.60	0.44	23.00	1.20	50.10	3.20	11.80	17.53
EW-21	12	.32	9.50	0.00	7.17	80.60	19.60	1.00	46.37	14.60	3.40	44.00	0.95	56.50	94.50	0.24	41.10	0.30	54.70	1.40	12.90	34.26
EW-20	13	.31	10.00	0.06	16.25	81.70	17.57	1.10	45.01	16.90	3.80	46.30	0.04	52.50	95.90	0.28	32.70	0.40	58.40	0.10	8.70	18.02
EW-16	14	.29	6.50	0.04	3.97	76.50	19.74	0.90	30.65	16.30	2.80	46.20	0.00	46.50	92.30	0.82	31.20	2.30	66.00	1.00	9.50	0.72
EW-18	15	.28	8.40	0.00	2.30	85.00	22.03	0.80	42.31	15.40	3.60	44.60	0.15	52.00	93.50	0.12	46.10	0.70	68.80	0.50	10.10	8.29

Rank '1' indicates most deprived EW, and Rank '15' indicates the least deprived EW.

Very High Deprivation Medium Deprivation Very Low Deprivation

'Table 9' gives more insights into the deprivation of different capitals. Here, we can see that natural capital deprivation has the highest range and standard deviation. That means, there is a significant variation in terms of the presence of green areas across the different electoral wards. All but human capital has a lower standard deviation. Moreover, social capital and natural capital are quite skewed. So, the mean deprivation value is not enough to understand the diversity of deprivation, whereas details analysis of capitals will enable us to understand the situation more clearly. So, section 4.4 – 4.8 will discuss capital-wise deprivation.

Table 9: Descriptive statistics of capital-wise deprivation

Capitals	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness
Social Capital	0.75	0.04	0.79	0.3000	0.20075	0.967
Human Capital	0.36	0.22	0.58	0.3807	0.12297	0.336
Financial Capital	0.84	0.00	0.84	0.4067	0.25996	-0.234
Physical Capital	0.61	0.20	0.81	0.4913	0.19108	-0.066
Natural Capital	1.00	0.00	1.00	0.7173	0.27948	-1.407
Multiple Deprivation	0.32	0.28	0.60	0.4273	0.11100	0.114

4.4. Social capital deprivation

Social capital deprivation was measured based on the spatial distribution of three indicators (the percentage of the widow and divorced female, percentage of the ethnic population, and percentage of non-Muslim population) in the study area. 'Figure 9' demonstrates that social deprivation is very highly concentrated in the eastern part of the city. EW-29 is showing the highest level of social capital deprivation. The Dewantuli, Bara Rangpur, Conungotola (Dimla), Chak Bazar (Tajhat), Cashaibari, Mahiganj etc. fall under this EW. On the other hand, EW-16 and EW-17 showing the least level of social capital deprivation. Police Fari, Kellabond, Katkipara, Pasharipara etc. are under the jurisdiction of those two electoral wards.

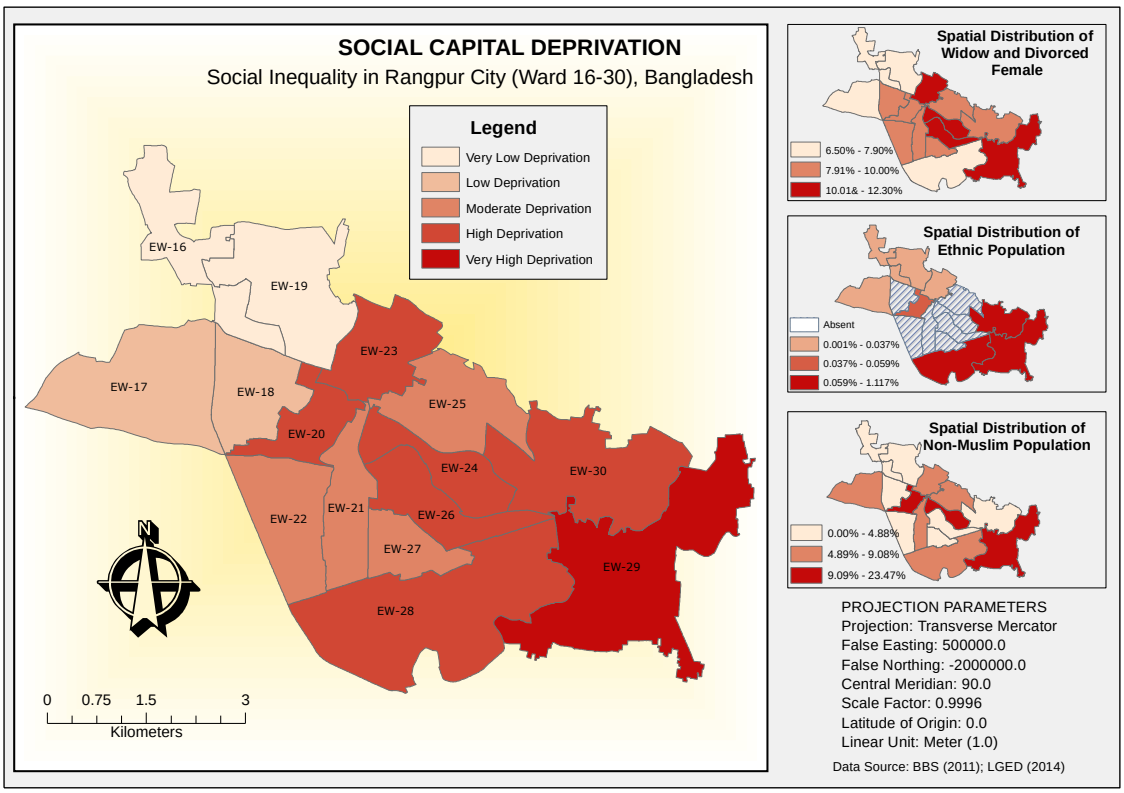

Figure 9: Map of the social capital deprivation in RpCC

'Table 10' shows that number of the widow and divorced female are highest in EW-23, and the lowest number is found in the EW-16. Besides, the highest number of ethnic populations are concentrated in EW-30, and the highest number of the non-muslim population is found in EW-24. On the other hand, the lowest portion of the non-muslim population is in EW-30, and there are no or very few ethnic populations live in several EWs.

Table 10: Deprivation scores of social capital's indicators

Indicators/ Capital (% of)	Electoral ward-wise normalized value														
	EW-16	EW-17	EW-18	EW-19	EW-20	EW-21	EW-22	EW-23	EW-24	EW-25	EW-26	EW-27	EW-28	EW-29	EW-30
Widow and Divorced Female	0*	0.21	0.33	0.05	0.6	0.52	0.43	0.76**	0.66	0.38	1	0.57	0.24	0.74	0.4
Ethnic Population	0.03	0.02	0	0.03	0.05	0*	0*	0.02	0*	0*	0*	0*	0.54	0.87	0.93**
Non-Muslim Population	0.09	0.18	0.02*	0.14	0.66	0.24	0.11	0.22	1**	0.33	0.05	0.05	0.33	0.75	0

* Lowest value; ** Highest value

Finally, 'Figure 10' illustrates that the EW-29, EW-24 and EW-20 are sharing the substantial portion of social capital deprivation. All other electoral wards have very low deprivation in social capital compared to those of three EWS.

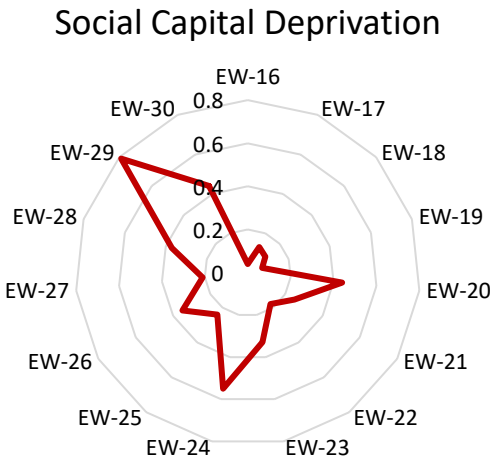

Figure 10: Social capital deprivation at electoral ward level

4.5. Human capital deprivation

The human capital deprivation was estimated from seven indicators. The indicators are- literacy rate, percentage of 6-10 years old population not attending school, percentage of disabled people, percentage of 7+ old population not attending school but employed, population less than 10 years old, population greater than 65 years old, population 25-59 years old. In 'Figure 12' human capital deprivation is classified into five classes (from very low deprivation to very high deprivation). Here, EW-26, EW-27 and EW-30 are classified as very high deprivation, and in contrast, EW-18, EW-19, EW-20 and EW-21 have very low deprivation in terms of human capital. The other seven maps in the sub-sets of 'Figure 12' are showing the spatial distribution of the indicators of the human capital. From the sub-set map, we can see that the spatial distribution of literacy rate has a strong influence on EW-18, EW-19, EW-20 and EW-21 to keep themselves as 'very low deprived'.

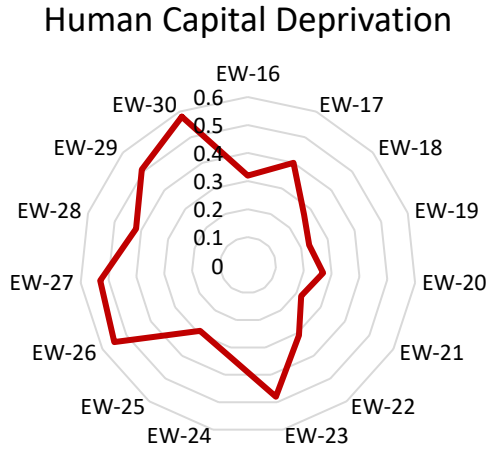

Figure 11: Human capital deprivation at electoral ward level

'Table 11' gives the details on how the indicators contributed to the overall human capital deprivation and how they are spatially distributed. For example, the literacy rate and the percentage of the group of population less than ten years old are highest in EW-30. On the other hand, disabled people, and populations over the age of 65 are absent in several electoral wards. 'Figure 11' is showing the EW-wise share of human capital deprivation.

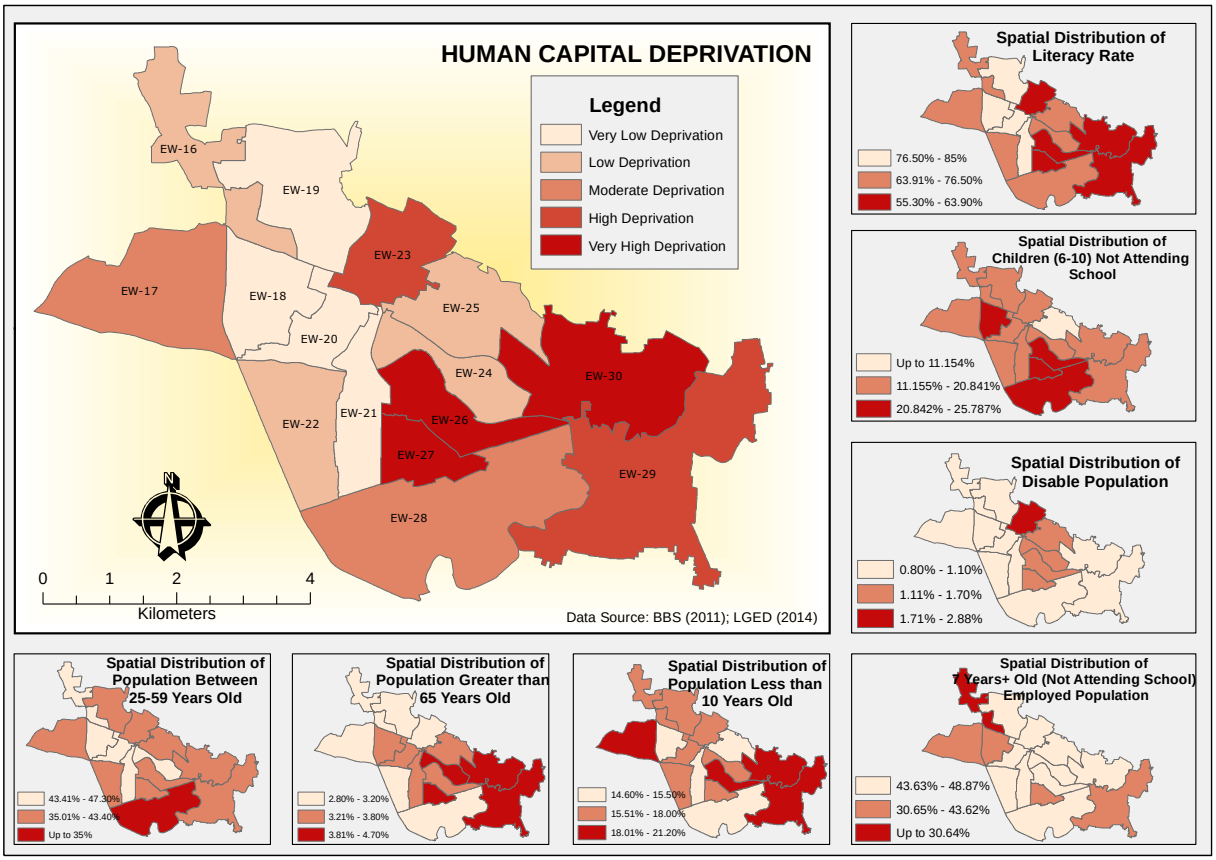

Figure 12: Map of the social capital deprivation

Table 11: Deprivation scores of human capital's indicators

Indicators/ Capital (% of)	Electoral ward-wise normalized value														
	EW-16	EW-17	EW-18	EW-19	EW-20	EW-21	EW-22	EW-23	EW-24	EW-25	EW-26	EW-27	EW-28	EW-29	EW-30
Literacy Rate	0.29	0.45	0*	0.23	0.11	0.15	0.37	0.71	0.37	0.31	0.87	0.79	0.51	0.79	1**
6-10 Not Atten. School	0.59	0.66	0.74	0.52	0.44	0.58	0.51	0.42	0.33	0*	1**	0.96	0.86	0.38	0.56
Disable People	0.05	0*	0*	0.15	0.15	0.1	0*	1**	0.45	0.3	0.3	0.25	0.05	0.1	0.15
7 + NAS Employed	1**	0.43	0.36	0*	0.21	0.14	0.16	0.1	0.12	0.24	0.07	0.29	0.17	0.32	0.2
Population Less than 10 ears	0.26	0.89	0.12	0.33	0.35	0*	0.52	0.5	0.32	0.09	0.79	0.27	0.14	0.68	1**
Population Greater than 65	0*	0*	0.42	0*	0.53	0.32	0.16	0.16	0.68	0.42	0.53	0.74	0.21	1**	0.63
Population 25-59 Years	0.09	0.39	0.22	0.38	0.08	0.27	0.43	0.48	0*	0.65	0.32	0.43	1**	0.33	0.51

* Lowest value; ** Highest value

4.6. Financial capital deprivation

The percentage of floating population and the percentage of people owned a household were considered to calculate the deprivation of financial capital. 'Figure 13' illustrates that EW-21, EW-23 and EW-27 have very high deprivation in financial capital. On the other hand, EW-22, EW-29, and EW-30 have very low deprivation.

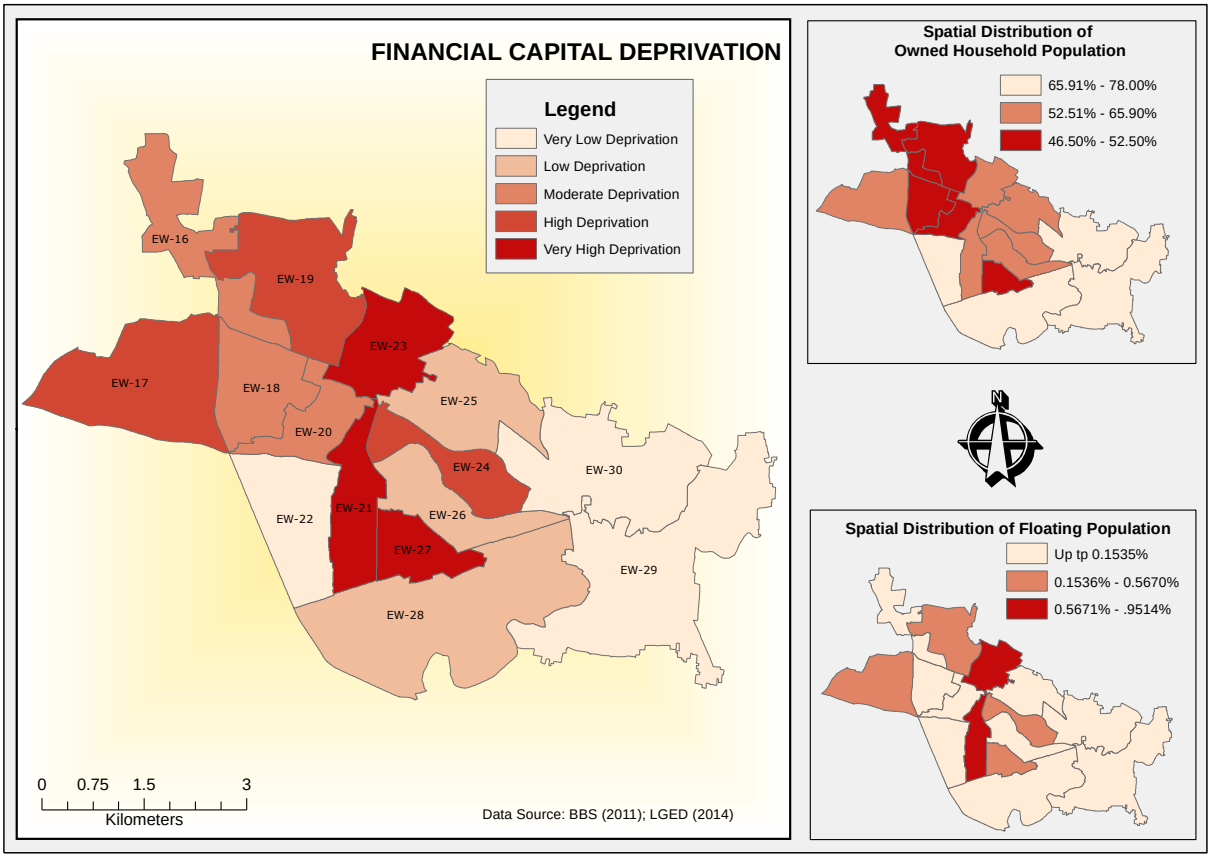

Figure 13: Map of the financial capital deprivation

'Figure 14' reveals that EW-21, EW-23 and EW-27 are largely affected by financial capital deprivation.

Now, if we look at 'Table 12', we can get more details in the financial capital deprivation. Here, EW-16 has the highest share of deprivation in terms of ownership of house. Most of the people who live here have a owned house. This EW jointly shares the lowest deprivation value in terms of the percentage of the floating population with three other EWs (EW-22, EW-28 and EW-30).

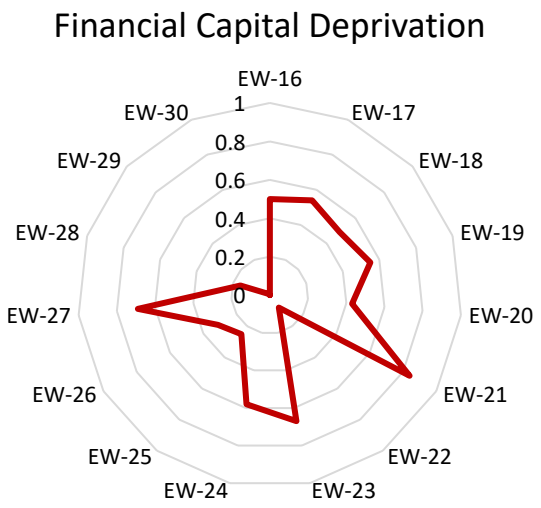

Figure 14: Financial capital deprivation at electoral ward level

Table 12: Deprivation scores of financial capital's indicators

Indicators/ Capital (% of)	Electoral ward-wise normalized value														
	EW-16	EW-17	EW-18	EW-19	EW-20	EW-21	EW-22	EW-23	EW-24	EW-25	EW-26	EW-27	EW-28	EW-29	EW-30
Floating Population	0*	0.46	0.16	0.28	0.04	1**	0*	0.71	0.6	0.11	0.03	0.41	0*	0.01	0*
Owned House	1**	0.62	0.83	0.83	0.81	0.68	0.15	0.62	0.56	0.38	0.59	0.96	0.32	0*	0*

* Lowest value; ** Highest value

4.7. Physical capital deprivation

Physical capital is the fourth capital of the multiple deprivation index. It has a total of seven indicators. They are- the percentage of electricity connection, percentage institutional households[2], percentage of pucca structure, percentage of jhupri structure, percentage of the sanitary toilet, percentage of no toilet and percentage household size greater than six people. 'Figure 15' shows that EW-18, EW-19, EW-20 and EW-21 have very-low physical capital deprivation. On the other hand, EW-26, EW-27, and EW-30 have very high physical capital deprivation. Besides, the sub-set maps from the 'Figure 15' demonstrate the contribution of each indicator to the overall physical capital deprivation.

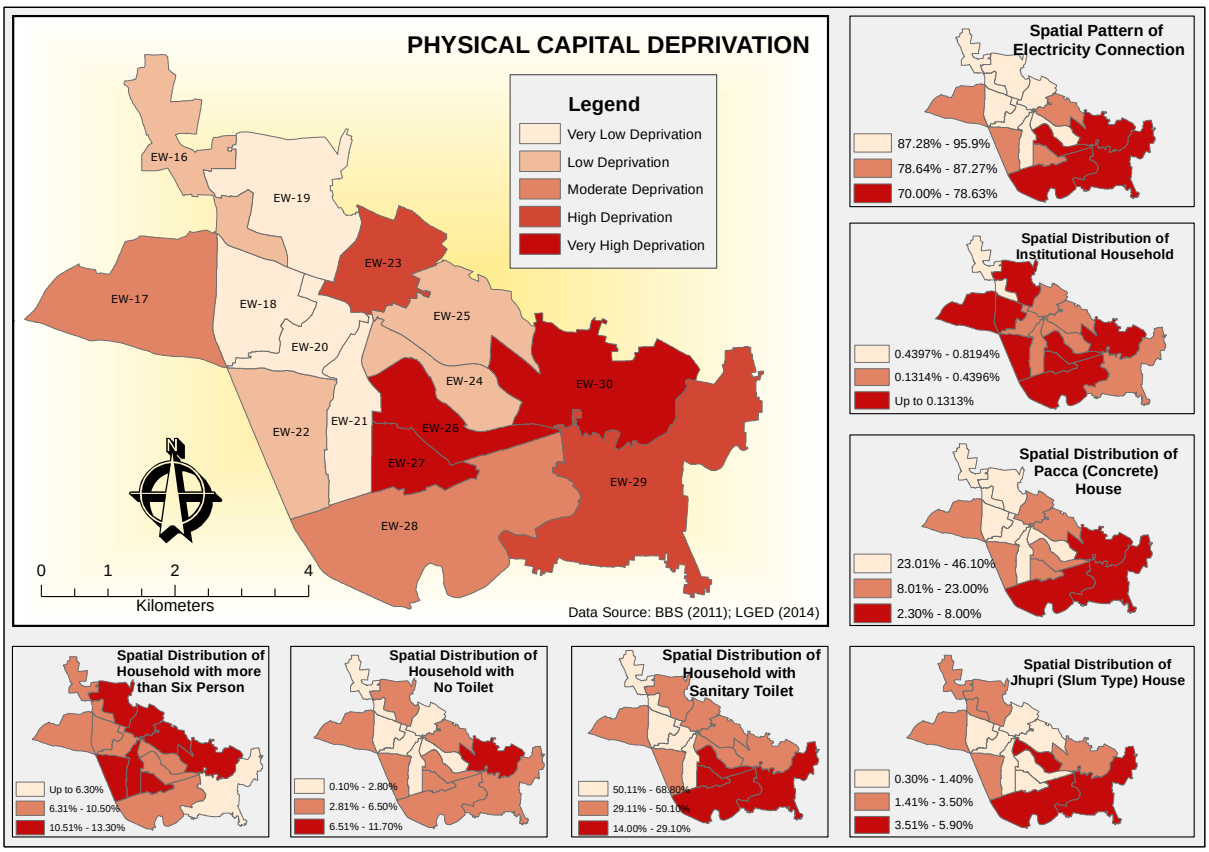

Figure 15: Map of the physical capital deprivation

[2] "Hospitals, clinics, jails, barracks, orphanages, hostels/halls of educational institutions etc. were treated as Institutional Households" (BBS, 2013, p. 7).

Here, 'Figure 16' illustrates that EW-12, EW- 28 and EW-30 are the most sufferers of physical capital deprivation. Besides, if we look at 'Table 13', EW-30 is severely deprived in pucca structure and toilet facilities. EW-24 has the highest percentage of jhupri structure, and EW-3 has the highest number of living environment deprivation. Additionally, EW-19 has a shortage of institutional households, and EW-29 has a shortage of sanitary toilets. Besides, EW-29 is getting the least electricity facilities. On the other hand, EW-20 is getting the highest electricity facilities.

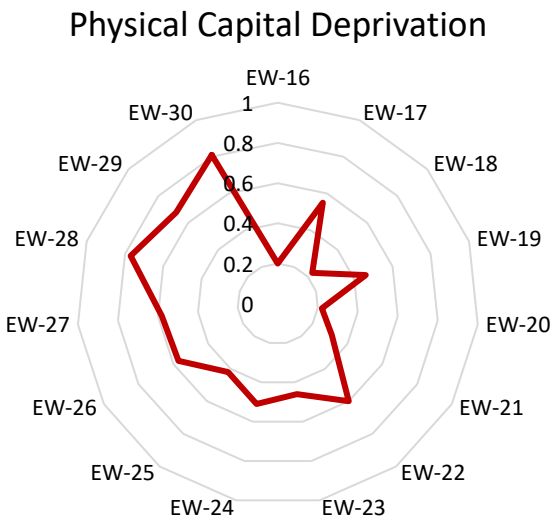

Figure 16: Physical capital deprivation at electoral ward level

(a) Pucca Structure

(b) Jhupri Structure

(c) Institutional Household

Figure 17: Example of physical capitals (a. pucca structure, b. jhupri structure, and c. institutional household)

Source: Fieldwork (January 2020)

Table 13: Deprivation scores of financial capital's indicators

Indicators/ Capital (% of)	Electoral ward-wise normalized value														
	EW-16	EW-17	EW-18	EW-19	EW-20	EW-21	EW-22	EW-23	EW-24	EW-25	EW-26	EW-27	EW-28	EW-29	EW-30
Electricity Connection	0.14	0.41	0.09	0.27	0*	0.05	0.47	0.19	0.29	0.4	0.67	0.34	0.73	1**	0.96
Institutional Household	0*	0.95	0.85	1**	0.66	0.71	0.95	0.68	0.76	0.46	0.91	0.92	0.96	0.68	0.84
Pacca Structure	0.34	0.57	0*	0.21	0.31	0.11	0.7	0.62	0.36	0.53	0.58	0.69	0.87	0.93	1**
Jhupri Structure	0.36	0.39	0.07	0.3	0.02	0*	0.29	0.05	1**	0.16	0.11	0.2	0.93	0.66	0.57
Sanitary Toilet	0.05	0.59	0*	0.42	0.19	0.26	0.63	0.43	0.51	0.34	0.72	0.85	0.88	1**	0.59
No Toilet	0.08	0.51	0.03	0.34	0*	0.11	0.43	0.23	0.09	0.27	0.4	0.34	0.55	0.48	1**
Household Size > 6	0.46	0.4	0.54	0.7	0.34	0.94	0.71	1**	0.56	0.79	0.6	0.71	0.44	0*	0.71

* Lowest value; ** Highest value

4.8. Natural capital deprivation

The Green area is the only indicator of the natural capital deprivation. Here, the green area includes- vegetation, agricultural land, rivers and other water bodies. 'Figure 18' illustrates the natural capital deprivation in the study area. Here we can see EW-21 and EW-22 have the lowest deprivation. On the other hand, EW-16, EW-19, EW-24 and EW-26 have the highest deprivation. 'Figure 17' reveals that besides the above four EWs, EW-27, EW-29 and EW-18 also have a significant contribution to the natural capital deprivation while only EW-22 has a large number of green areas in the Rangpur City.

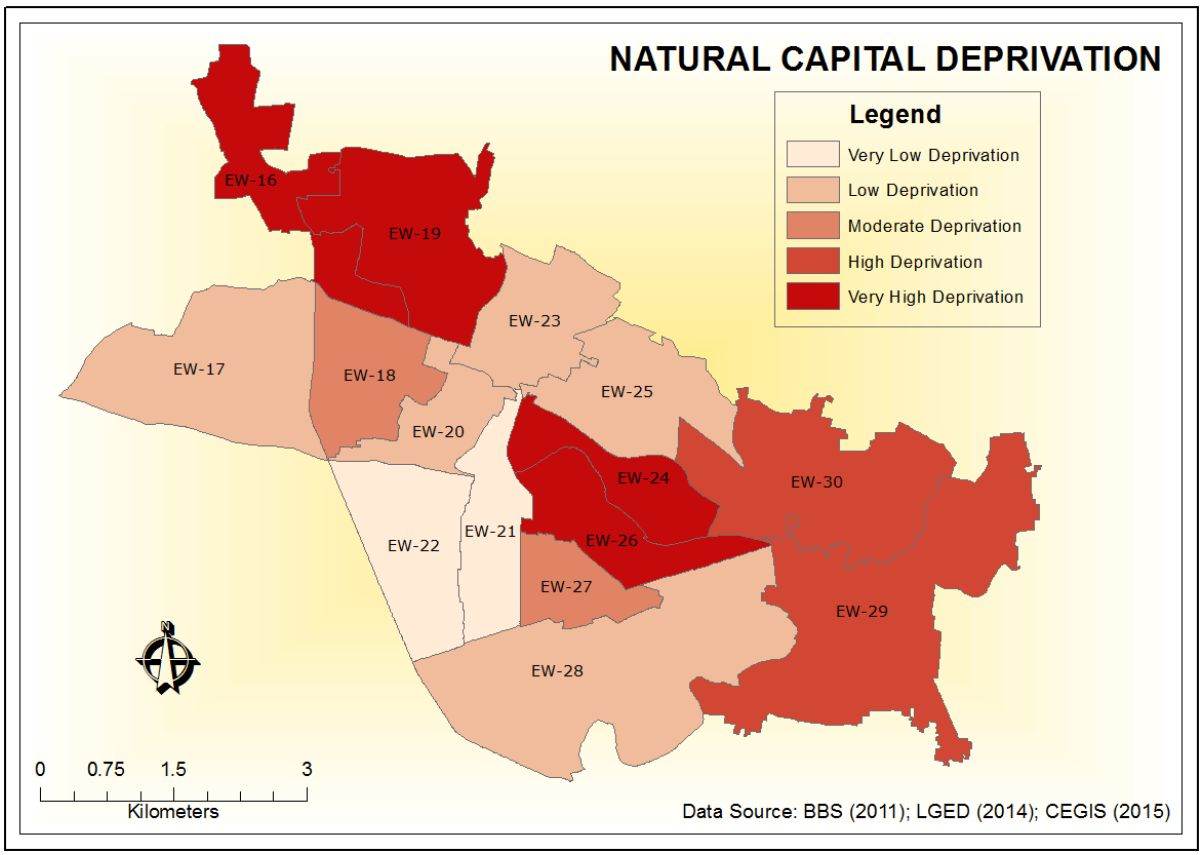

Figure 18: Map of the natural capital deprivation

4.9. Correlation analysis (IMD, capitals, and Indicators)

'Table 14' reveals that the overall multiple deprivation has significant relations with most of its capitals. IMD is highly correlated with human and physical capital. Besides, social capital and IMD have a good positive correlation. However, financial capital does not show a significant relationship with the IMD; and natural capital does not fit in the Pearson correlation model as it has outliers. The Spearman correlation also failed to show a significant relationship between natural capital and IMD.

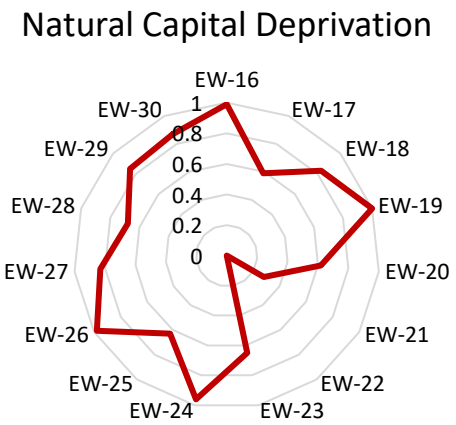

Figure 19: Natural capital deprivation at electoral ward level

Table 14: Pearson Correlation of capital types and multiple deprivation (IMD)

Capitals/IMD	Social	Human	Financial	Physical	IMD
Social	1				
Human	0.446	1			
Financial	-0.429	-0.374	1		
Physical	0.449	**.705****	**-.598***	1	
IMD	**.630***	**.899****	-0.383	**.864****	1

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

'Table 15' shows the correlations among different indicators and IMD. In total ten indicators are significantly correlated with the IMD (% of ethnic population, literacy rate, % of population less than 10 years old, % of population higher than 65 years, % of owned house, % of electricity connection, % of pucca structure, % of jhupri structure, % of sanitary toilet, and % of no toilet), while IMD is not correlated with other ten indicators (% of widow and divorced female, % of non-Muslim population, % 6-10 years old not attending school, % of disabled people, % of population less than 10 years old, % of population 25-59 years old, % of floating population, % institutional household, % of household size greater than 6, and % of green area).

'Table 15' also shows the correlation among the indicators. Here, '% of electricity connection', '% of pucca structure', and '% of no toilet' have the highest number of correlations with other indicators. These indicators are correlated with a total of eight other indicators. After that '% of ethnic population' is correlated with six indicators; 'literacy rate' is correlated with five indicators; '% Of population less than 10 years' and '% of sanitary toilet' are correlated with four indicators; '% of widow and divorced female', '% of population 25-59 years old', '% of floating population', '% of owned house', and '% of jhupri structure' are correlated with two indicators; '% of disabled people', '% of 7 + not attending school & employed', '% of population higher than 65 years', '% institutional household', and '% of household size greater than 6' are correlated with one indicator. Finally, '% of non-Muslim population', '% of 6-10 not attending school', and '% of green area' is not correlated with any of the indicators.

Table 15: Pearson correlation among the indicators and (IMD)

	Multiple Deprivation (IMD)	% of Widow and Divorced Female (1)	% of Ethnic Population (2)	% of Non-Muslim Population (3)	Literacy Rate (4)	% of 6-10 Not Attending School (5)	% of Disable People (6)	% of 7 + Not Attending School & Employed (7)	% of Population Less than 10 Years (8)	% of Population Higher than 65 Years (9)	% of Population 25-59 Years Old (10)	% of Floating Population (11)	% of Owned House (12)	% of Electricity Connection (13)	% of Institutional Household (14)	% of Pacca Structure (15)	% of Jhupri Structure (16)	% of Sanitary Toilet (17)	% of No Toilet (18)	% of Household Size Greater Than 6 (19)	% of Green Area (20)
IMD	1																					
1	0.465	1																				
2	**.653****	0.042	1																			
3	0.122	0.323	0.136	1																		
4	**.918****	0.467	**.561***	-0.135	1																	
5	0.263	0.063	-0.023	-0.507	0.273	1																
6	0.269	**.517***	-0.187	0.177	0.321	-0.254	1															
7	-0.301	-0.479	-0.023	-0.162	-0.159	0.040	-0.342	1														
8	**.607***	0.262	0.443	-0.119	**.688****	0.142	0.039	-0.062	1													
9	**.529***	**.648****	0.459	0.458	0.425	-0.046	0.068	-0.209	0.149	1												
10	0.364	-0.160	0.363	-0.307	0.337	0.121	0.004	-0.281	-0.012	-0.162	1											
11	-0.087	0.170	-0.407	0.117	-0.165	-0.073	0.441	-0.259	-0.265	-0.126	-0.203	1										
12	**-.535***	-0.230	**-.735****	-0.198	-0.480	0.296	0.073	0.307	-0.466	-0.350	-0.445	0.329	1									
13	**.804****	0.205	**.820****	0.018	**.766****	0.107	-0.144	-0.158	**.614***	0.426	0.494	-0.486	**-.814****	1								
14	0.385	0.199	0.090	-0.123	0.211	0.421	-0.086	**-.736****	0.276	0.090	0.339	0.099	-0.234	0.284	1							
15	**.813****	0.230	**.709****	0.013	**.835****	0.065	0.084	-0.092	**.588***	0.331	**.576***	-0.395	**-.730****	**.858****	0.189	1						
16	**.522***	-0.137	**.538***	0.490	0.269	-0.048	-0.126	0.017	0.163	0.212	0.206	-0.197	-0.463	**.554***	0.114	0.470	1					
17	**.844****	0.370	0.512	0.152	**.741****	0.274	0.024	-0.350	0.439	0.418	0.496	-0.159	**-.562***	**.785****	0.512	**.808****	0.503	1				
18	**.715****	-0.038	**.724****	-0.297	**.733****	0.175	-0.150	-0.195	**.689****	0.125	**.587***	-0.336	**-.702****	**.854****	0.412	**.812****	0.392	**.643****	1			
19	-0.179	0.033	-0.435	-0.453	-0.027	-0.061	0.489	-0.359	-0.250	-0.345	0.175	**.544***	0.189	-0.368	0.078	-0.223	-0.440	-0.279	-0.058	1		
20	0.317	-0.016	0.191	0.086	0.266	0.171	0.154	0.196	0.142	0.256	-0.207	-0.210	0.276	0.165	-0.174	-0.024	0.279	0.011	0.021	-0.298	1	

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

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

4.10. Citizens' anticipation on multiple deprivation, and their priority sectors to reduce multiple deprivation

4.10.1. Citizens' anticipation on multiple deprivation

'Table 16' shows that 73% of the respondents think, multiple deprivation exists in RpCC, and 11% of the respondents think the opposite. Besides, 16% of the respondents were not sure about the multiple deprivation. This table also shows that 45% of the respondents are satisfied with the urban facilities of RpCC, while 55% of the respondents are not satisfied.

Table 16: Citizen's anticipation on multiple deprivation

		Do you think that multiple deprivation exists in your area?			
		Yes	Not sure	No	Total
Are you satisfied with the urban facilities in your area?	Yes	25	12	9	45
	No	48	5	3	55
Total		73	16	11	100

All values are in percentage

4.10.2. Priority sectors by citizens to reduce multiple deprivation

'Figure 20' shows that the improved road network and drainage system are essential to half of the respondents. Besides, good governance and monitoring, education facilities, equal service and budget allocation at electoral ward level, awareness build-up among citizens etc. should be a top priority according to the respondents. However, less than one per cent of respondents think that increased collaboration among citizen and government could reduce deprivation in RpCC.

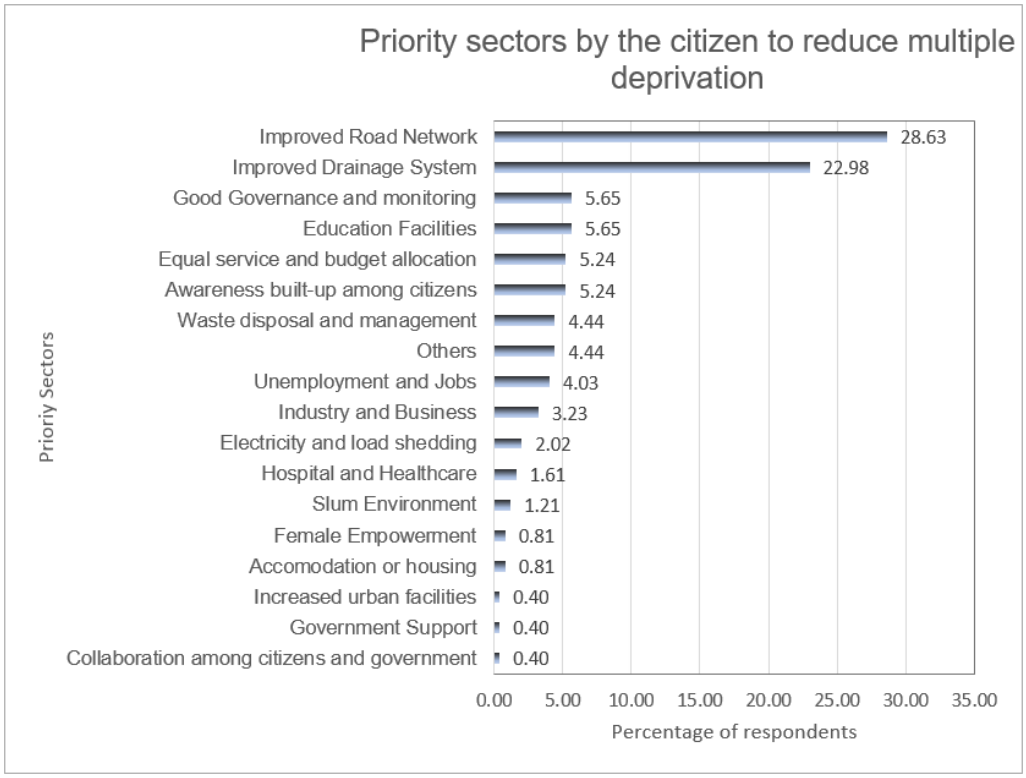

Figure 20: Priority sectors by citizens to reduce multiple deprivation in RpCC

5. DISASTER RISK PERCEPTION IN RANGPUR CITY

In this chapter at first, I discussed the socio-demographic and household characteristics of the respondents. Next sections of this chapter include earthquake and fire risk perception and related preparedness.

5.1. Socio-demographic and household characteristics of the respondents

According to the survey results (Table 17), the age group composition was 10.7% (18-24 years old), 37.4% (25-39 years old), 44.2% (40-59 years old), and 7.6% (more than 59 years of age) respectively. However, according to BBS (2013), 5.8% of the total population in RpCC is higher than 59 years of age. In the total sample, male respondents were 53.1%, and female respondents were 46.9%. So, the male-female ratio in

Table 17: Socio-demographic and household characteristics from the household survey

Indicators	Categories	Percentage
Age Group	18-24	10.7
	25-39	37.4
	40-59	44.2
	59+	7.6
Gender	Male	53.1
	Female	46.9
Household Membership composition	Up to 6 persons	74.3
	More than 6 persons	25.7
Education Level	No formal education	8.1
	Primary (up to class 5)	12.3
	Secondary (up to class 8)	19.9
	SSC/HSC	35.6
	Bachelor or Above	24.1
Occupation	Unemployed	21.7
	Student	8.6
	Housewife	20.2
	Self-employed/Business	29.1
	Farmer	2.1
	Day wage earner	1.8
	Private Service	8.1
	Government Service	8.4
Household Monthly Income (in BDT)	Up to 10000	16
	10001-20000	25.1
	20001-30000	24.3
	30001-40000	19.3
	40001-50000	8.6
	Above 50000	7.6
Household Structure Type	Jhupri	2.9
	Kucha	15.4
	Semi-Pucca	50
	Pucca	31.7
Household Story Type	Single-Story	78.5
	Multi-Story	21.5
Household Ownership Type	Tenant	23.3
	Owner	76.7

(Source: Fieldwork 2020)

respondents were quite well distributed. According to BBS (2013), there are 51.13% male and 48.86% female, respectively of the total population in the 15 EWs of RpCC; which is very close to our field data.

According to the survey data, the overall education level is quite satisfactory. Only 8.1% of respondents have no formal education whereas 12.3%, 19.9%, 14.4%, 21.2%, and 24.1% have primary, secondary, SSC, HSC, and Bachelor or above level education, respectively. However, the unemployment rate is 21.7%, which is quite a lot. Besides, 20.2% of respondents introduced themselves as a housewife, which also could be considered as unemployment in the context of Bangladesh, while the percentage of self-employed/businessman, private service holders, and government service holders are 29.1, 8.1, and 8.4, respectively.

The survey data also shows that around 60% of the household have a monthly income of more than 20000 BDT[3]. According to 'Final Report on Household Income and Expenditure Survey 2016', the average household expenditure is 19,697 BDT in urban areas (BBS, 2019). So, indeed, around 40% of surveyed households are living under the poverty line. Besides, 16% of the households have income only up to 10000, and they might be considered as extremely poor households.

The household ownership type reveals that 76.7% of respondents live in an owned house; the rest of the respondents are in a rental house. Moreover, 74.3% of households have a decent living condition with up to six persons household membership composition. On the other hand, 25.7% of households have more than six persons in the house.

From the survey data, it is overserved that half of the houses are semi-pucca (made by concrete and tin-shed). Around 30% of houses have concrete construction, and only 3% are 'Jhupri' house (made by bamboo and grass). Most of the 'Jhupri' houses are seen in the slum areas of Rangpur city. Besides, 15% of houses are 'Kuccha,' which are made by mud and shaded by tin.

5.2. Earthquake risk perception

5.2.1. Respondent's anticipation/opinion on different aspects of earthquake hazard

Respondent's anticipations/opinions on different aspects of earthquake hazard are shown in 'Table 18'. Anticipation related first question was related to the experience of previous earthquake events. 99% of respondents have experienced at least one earthquake. Among the respondents, only 3% strongly disagreed that a severe earthquake may hit their living place. On the other hand, 48% of the respondents were agreed or strongly agreed about the possibility of the occurrence. Similarly, more than 50% of respondents agreed or strongly agreed that a possible earthquake could affect them and their family members. However, 7% of respondents disagreed or strongly disagreed in this regard.

On the anticipation of property damage by an earthquake, 66% were agreed/strongly agreed. Still, 4% were disagreed or strongly disagreed about the possibility of property damage by an earthquake. Similarly, 68% of people think that an earthquake may result in death and injury. At the same time, 49% of the population were little fearful about an earthquake; 15% were not fearful at all. On the contrary, 36% of the respondents were moderate to highly fearful.

[3] BDT = Bangladeshi Taka; 1 USD = 85.15 BDT (exchange rate as of 26 May 2020)

Table 18: Respondent's anticipation/opinion on different aspects of earthquake hazard

Questions	Opinion/anticipation	Respondents	
		Number (*n*)	Percentage (%)
Did you witness or experienced any earthquake?	Yes	380	99
	No	2	1
Do you agree that a severe earthquake may hit your living place?	Strongly disagree	10	3
	Disagree	42	11
	Neutral	147	38
	Agree	128	34
	Strongly Agree	55	14
Do you agree that an earthquake could affect you and your family?	Strongly disagree	3	1
	Disagree	23	6
	Neutral	123	32
	Agree	126	33
	Strongly Agree	107	28
Do you agree that an earthquake may result in your property damage?	Strongly disagree	2	1
	Disagree	12	3
	Neutral	115	30
	Agree	126	33
	Strongly Agree	127	33
Do you agree an earthquake may result in death and injury?	Strongly disagree	1	0
	Disagree	20	5
	Neutral	101	26
	Agree	120	31
	Strongly Agree	140	37
How fearful are you about a possible earthquake?	Not fearful	58	15
	Little fearful	188	49
	Moderate fearful	75	20
	Highly fearful	61	16

Source: Fieldwork (January 2020)

5.2.2. Analysis of earthquake risk perception by socio-demographic factors

This section analysed how risk perception of earthquake hazard changes with different socio-demographic factors. 'Figure 21' illustrates the changing nature of earthquake risk perception with the variation of socio-demographic factors. Earthquake risk perception was calculated using 'Equation 4'.

Earthquake risk perception by gender

The risk perception of earthquake hazard varies with gender. Female respondents have higher risk perception than the male respondents (Figure 21A). The median risk perception value of the women is 0.70, while the median value is 0.66 for the men. The interquartile range is also higher for women. Results from the t-test also show that women have higher ERP than the men ($p = 0.007$).

Earthquake risk perception by age group

The ERP value also changes within the different age groups. Respondents between 18-24 years old had the highest ERP value (mean value is 0.67, and the median value is 0.70) while the elderly (59 years+) has the least ERP (0.65). However, the lowest ERP median value (0.67) was calculated in the second age group (Figure 21B).

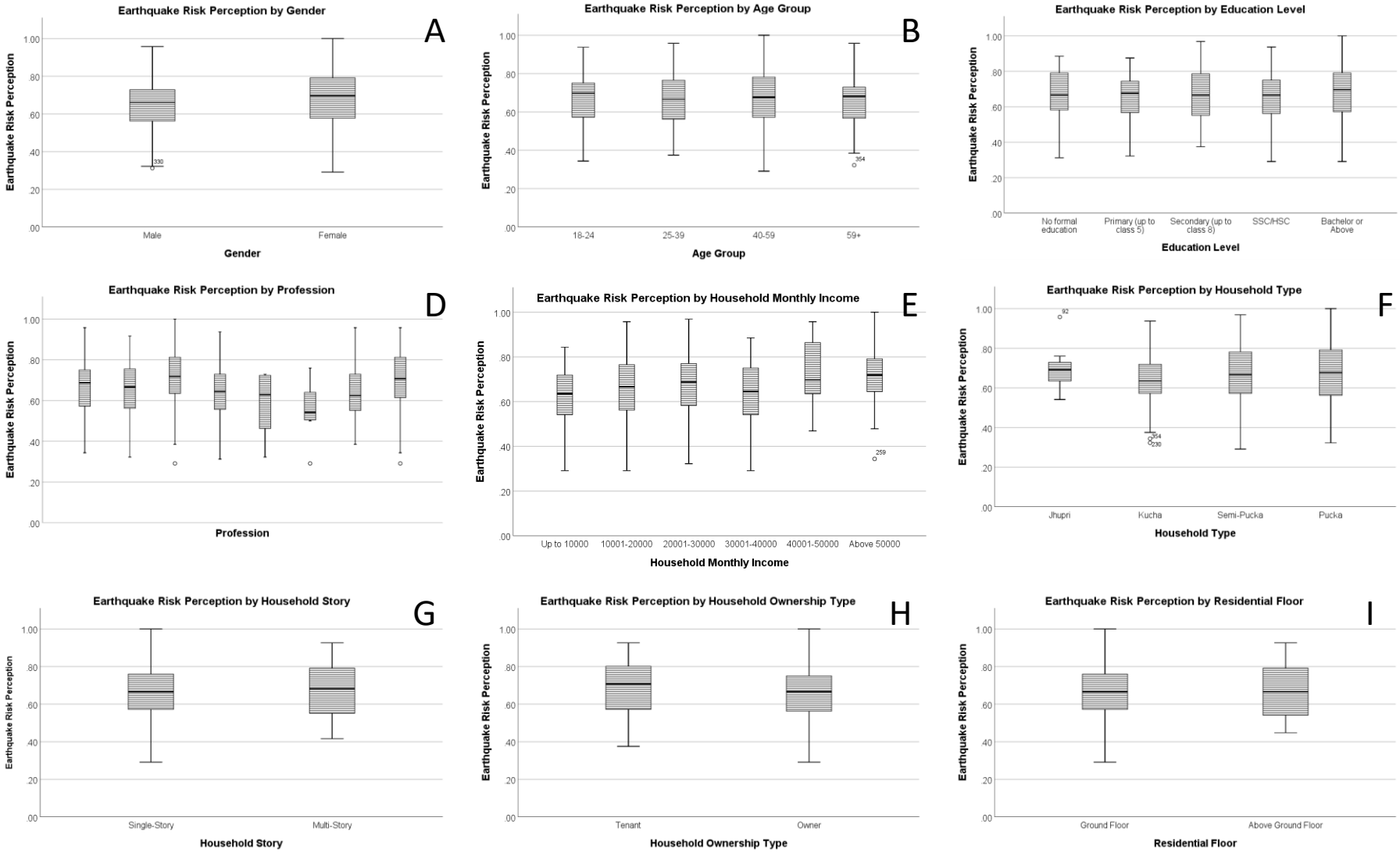

Figure 21: Earthquake risk perception, and socio-demographic factors

Earthquake risk perception by education level

The education level did not show significant changes in the ERP. However, respondents with a bachelor or higher degree showed higher risk perception based on the median ERP value (0.70) (Figure 21C).

Earthquake risk perception by profession

Diversified ERPs were observed among the professional group. The housewives and government service holders had the highest ERP (median values are 0.72 and 0.71, respectively). On the other hand, daily wage earners had the least ERP (median value is 0.56). However, farmers had the lowest ERP based on the mean value (0.59), while the mean ERP value for the daily wage earners was 0.60 (Figure 21D).

Earthquake risk perception by monthly household income

'Figure 21E' shows that the lower-income group had a lower ERP score, and the higher-income group had a higher ERP score. However, the fourth income group (30001-40000 in BDT) did not follow the risk perception trend as of other income groups. This group has a lower ERP than the first two income groups.

Earthquake risk perception by household type

In general, ERP by household type reveals that better the household construction type, higher the ERP. Though, the 'Jhupri' houses had the highest ERP value based on both mean and median value. The reason behind this result could be the outlier and the low number of samples (n=11) of 'Jhupri.' After eliminating the outlier, 'Jhupri' shared the highest ERP with 'Pucca' house based on (mean 0.68) (Figure 21F).

Earthquake risk perception by a household story

'Figure 21G' shows that multi-story household has higher earthquake risk perception than the single-story households. The mean and median ERP value of single-story households are 0.66 and 0.67, respectively. On the other hand, both the mean and median ERP value of multi-story households is 0.68. However, t-test did not find any significant relation with the ERP (p = 0.294).

Earthquake risk perception by household ownership type

It was observed that the tenants have higher ERP than the house owners. The median ERP value of tenants is 0.71, where the median ERP value of house owners is 0.67 (Figure 21H). Besides, t-test also showed that the tenants have higher risk perception of earthquake hazard than the house owners (p = 0.027).

Earthquake risk perception by residential floor

The residential floor had no significant impact on the ERP (based on the median value). T-test also failed to show significant relations (p = 0.699). However, the mean ERP value of ground floor residents are lower than the respondents are living above the ground floor (Figure 21I).

5.2.3. Correlative analysis of Earthquake risk perception and socio-demographic factors

Among the eight socio-demographic factors, four were binary variables. 'Table 19' shows the (Pearson) correlation matrix of those variables. This table shows that ERP has a positive correlation (r = 0.139) with gender. That means, higher the ratio of the female member, higher the risk perception on earthquake hazard. Besides, household ownership type has a negative correlation (r = -0.113) with ERP. That means the tenants

have higher ERP than the house owners. However, two other variables, household story and household residential floor, do not have a statistically significant correlation with earthquake risk perception.

Table 19: Pearson correlation matrix of earthquake risk perception, and socio-demographic factors

	Gender	Household Story	Household Ownership Type	Residential Floor	Earthquake Risk Perception
Gender	1				
Household Story	0.007	1			
Household Ownership Type	-0.004	-.345**	1		
Residential Floor	0.013	.663**	-.329**	1	
Earthquake Risk Perception	.139**	0.054	-.113*	0.020	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

5.2.4. Spatial pattern of earthquake risk perception

'Figure 22' illustrates the spatial pattern of earthquake risk perception in RpCC (using 'Equation 4'). The RPI was calculated based on eight questions (see method section). The classification method was (Natural Breaks (Jenks)'. According to the GIS-based classification scheme, EW-20 and EW-23 have very high ERP (0.73 and above). On the other hand, EW-18 has very low ERP (0.56-0.62). Besides, EW-22, EW-24, EW-26, and EW-29 have a low-risk perception of earthquake hazard. Where EW-16, EW-27, and EW-30 have high ERP (0.68-0.73). Based on the ERP score, five electoral wards (EW-17, EW-19, EW-21, EW-25, and EW-28) have a moderate ERP score (0.62-0.68).

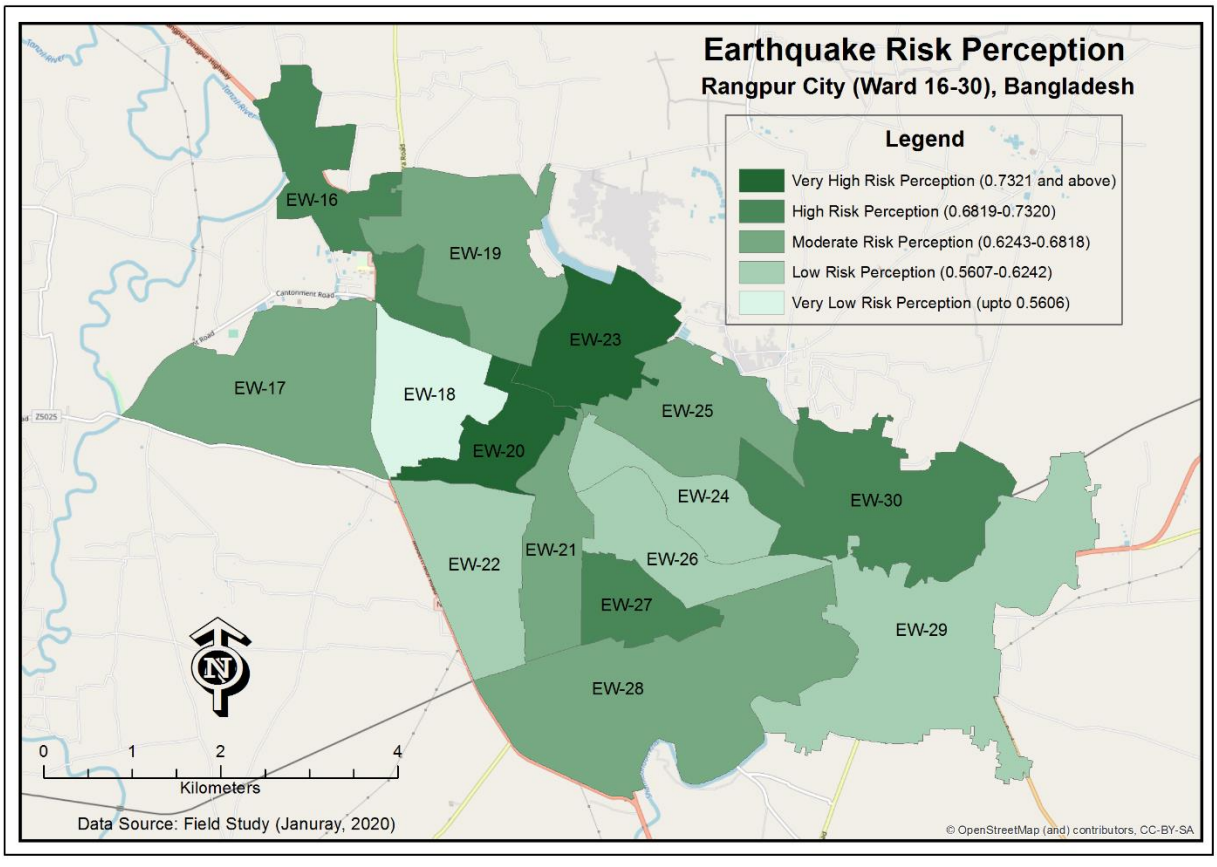

Figure 22: Spatial pattern of earthquake risk perception in RpCC (EW16-30)

5.2.5. Preparedness on earthquake hazard in RpCC at the household level

'Table 20' shows overall preparedness on earthquake hazard in RpCC. 47% of respondents have an emergency first-aid kit at home. Besides, 59% of households have an emergency exit. No household has an emergency kit in the most vulnerable area, EW-18. Moreover, households of EW-18 have the least percentage emergency exit. On the other hand, 89% of households of EW-20 have an emergency first-aid kit, and 84% of households of EW-16 have an emergency exit. It is worth to mention again that 99% of the respondents have experienced an earthquake.

Table 20: Preparedness on earthquake hazard at the household level

	Have Emergency Kit (%)		Have Emergency Exit (%)	
Ward Number	**Yes**	**No**	**Yes**	**No**
EW-16	16	84	84	16
EW-17	38	62	59	41
EW-18	0	100	53	47
EW-19	39	61	66	34
EW-20	89	11	47	53
EW-21	71	29	59	41
EW-22	42	58	63	37
EW-23	54	46	62	38
EW-24	60	40	60	40
EW-25	72	28	55	45
EW-26	42	58	63	37
EW-27	64	36	61	39
EW-28	53	47	73	27
EW-29	40	60	38	62
EW-30	27	73	64	36
Total	**47**	**53**	**59**	**41**

***n* = 382** Source: Fieldwork (January 2020)

5.3. Fire risk perception

5.3.1. Respondent's anticipation/opinion on different aspects of fire hazard

Respondent's anticipations/opinions on different aspects of fire hazard is shown in 'Table 21'. Among 382 respondents, 81% of respondents were witnessed/experienced the fire hazard. 70% of respondents anticipated that fire risk is less likely to affect their households. On the other hand, only 6% of respondents think that there are high and very high risk of fire which could affect their household.

More than half of the population (53%) assume that fire can occur from the household's cooker or stove, while 15% responded as 'no', and 31% replied as 'maybe'. Among the respondents, 16% never leave the kitchen until the cooking is finished and the cooker is switched off. However, a large number of respondents (43%) replied that they frequently or often leave the kitchen during the cooking activity to attend another task.

A quite large number of respondents (60%) are aware of that a short-circuit or electric disturbance may result in a fire at home. According to 30% of the respondents, an electric short-circuit could cause fire at home, while 9% denied the possibility. However, 93% of respondents knew the location of the electric main switch, which could be switched off during such an event. Besides, 68% of households use multiplug to connect their electric appliances though it could occur electric short-circuit.

Table 21: Respondent's anticipation/opinion on different aspects of fire hazard

Questions	Opinion/ anticipation	Respondents	
		Number (*n*)	Percentage (%)
Did you witness or experienced any fire accident?	Yes	309	81
	No	73	19
What is the level of risk of fire at your house do you think?	No-Risk	104	27
	Low Risk	164	43
	Medium Risk	93	24
	High Risk	15	4
	Very High Risk	6	2
Do you think the fire can occur from cooker/stove at your home?	Yes	204	53
	Maybe	120	31
	No	58	15
Do you go somewhere else or do other jobs while cooking?	Frequently	104	27
	Often	62	16
	Occasionally	98	26
	Very Rare	58	15
	Never	60	16
Do you think an electric short circuit can cause fire at your home?	Yes	230	60
	Maybe	116	30
	No	36	9
Do you know where the electric main switch of your house is?	Yes	357	93
	No	25	7
Do you use multi-plug at your home?	Yes	260	68
	No	122	32

Source: Fieldwork (January 2020)

5.3.2. Analysis of fire risk perception by socio-demographic factors

I analysed in this section how fire risk perception changes with different socio-demographic factors. 'Figure 23' shows how earthquake risk perception changes with different socio-demographic factors. Fire risk perception was calculated using 'Equation 5.'

Fire risk perception by gender

'Figure 23A' shows that fire risk perception also varies with gender as like earthquake risk perception. However, here the observation is opposite to ERP. The median line shows that female have lower risk perception than the male. Moreover, the mean FRP value of the male population is also higher than the female population (0.42 for male, and 0.39 for female). The results of t-test also showed significance (p = 0.006).

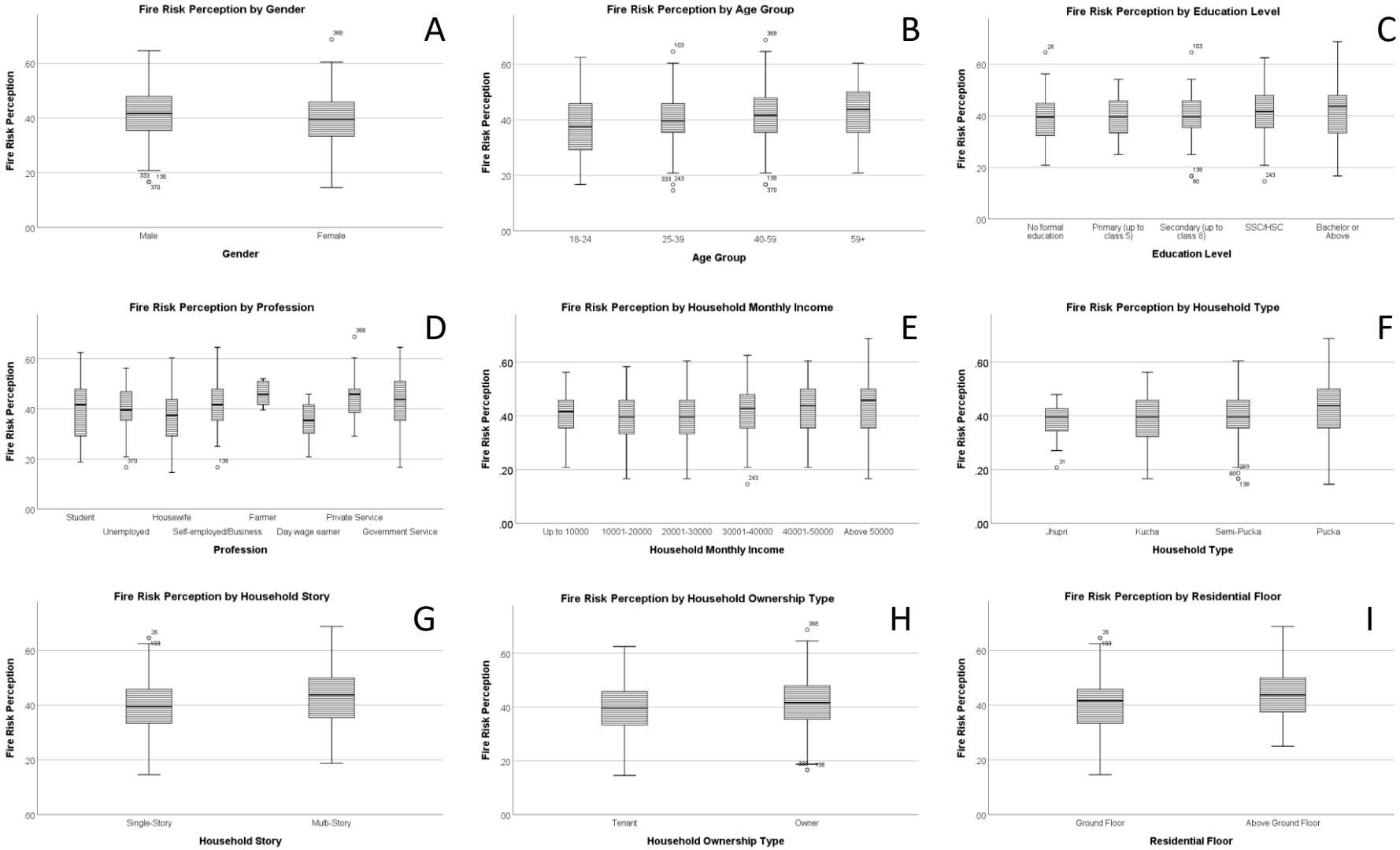

Figure 23: Fire risk perception, and socio-demographic factors

Fire risk perception by age group

The FPR value by age group reveals that the higher the age, the higher the fire risk perception. The respondents between 18-24 years old have the lowest risk perception of fire hazard, where the respondents with 59+ years of age have the highest risk perception. The median value for the younger group is 0.38, and the older group had a 0.44 median value on FRP (Figure 23B).

Fire risk perception by education level

'Figure 23C' shows that the level of education positively influenced the FRP. Respondents with no formal education to secondary level education more likely to have lower risk perception (median FRP 0.40). Respondents with SSC or HSC level has higher FRP than the previous group (0.42 median FRP value). Consequently, People having a bachelor or above education had the highest FRP (median FRP value is 0.44).

Fire risk perception by profession

Like ERP, the relationship between fire risk perception and profession also has a diverse pattern. Farmers, private service holders, and government service holders have the highest FRP (median value 0.46). Day wage earners likely to have least FRP (median value is 0.35). This time, housewives also have a low-risk perception of fire hazard (median FRP value is 0.38), which is the second-lowest score (Figure 23D).

Fire risk perception by monthly household income

'Figure 23E' Higher income group likely to have higher FRP. However, the least income group (income up to 10000 BDT) do not follow the trend. On the other hand, the highest income group (income more than 50000 BDT) has higher FRP (median value is 0.46).

Fire risk perception by household type

'Figure 23F' uncovers that jhupri, kucha and semi-pucca houses likely have the same median FRP value (0.4). However, the mean value is different for these three types of houses. Mean FRP values are 0.37, 0.39, and 0.40 of Jhupri, Kucha, and Semi-Pucca, respectively. The Pucca houses have FRP (mean and median values) 0.43 and 0.44, respectively. It can be said that there is a similarity in the pattern of FRP with the household types considering the mean value.

Fire risk perception by a household story

'Figure 23G' shows that single-story household has lower risk perception on fire hazard than the multi-story households. The mean and median FRP values of multi-story households are 0.4 and 0.44, respectively. On the other hand, the mean and median FRP values of single-story households are 0.40 and 0.44, respectively. The observed *p*-value from t-test is 0.11.

Fire risk perception by household ownership type

The scenario of FRP by household ownership type shows that the house owners likely have higher FRP than the tenants. The significance ($p = 0.04$) was observed by the t-test when an equal variance is assumed. Here, FRP values of owners and tenants are 0.40 and 0.42, respectively (Figure 23H).

Fire risk perception by residential floor

The residential floor showed a trend in FRP (Figure 23I). Residents of the ground floor have lower FRP (mean is 0.40 and median is 0.42), where residents from above the ground floor have higher FRP (mean is 0.43 and median is 0.44). The results of t-test also showed the significance ($p = 0.04$) when an equal variance is assumed.

5.3.3. Correlative analysis of fire risk perception, and socio-demographic factors

'Table 22' shows that fire risk perception has a statistically significant correlation with all four binary variables. FRP and gender have a negative correlation (r = -0.140). According to our assigned value (for male and female), this correlation means that men have higher FRP than women. Correlation between FRP and the household story reveals that FRP increases with the height/floors of a building. Besides, ownership also has a positive correlation (0.102) with FRP. Finally, the residential floor also has a positive correlation (r = 0.105) with FRP; higher the residential floor number, likely to has higher FRP of the residents.

Table 22: Pearson correlation matrix of fire risk perception and socio-demographic factors

	Gender	Household Story	Household Ownership Type	Residential Floor	Fire Risk Perception
Gender	1				
Household Story	0.007	1			
Household Ownership Type	-0.004	-.345**	1		
Residential Floor	0.013	.663**	-.329**	1	
Fire Risk Perception	-.140**	.129*	.102*	.105*	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

5.3.4. Spatial pattern of fire risk perception

The spatial pattern of fire risk perception in RpCC is illustrated by 'Figure 24'. A total of twelve questions were asked to calculate FRP. Then the FRPs were classified into five groups based on 'Natural Breaks (Jenks)' methods. This figure shows that EW-23, EW-24, and EW-28 have very low FRP (0.3540-0.3663). On the other hand, EW-16 and EW-21 have very high FRP (0.4301-0.4424). Besides, EW-18, EW-22, EW-25 and EW-30 have a high-risk perception of fire hazard (0.4216-0.4300). Where EW-17, EW-19, EW-20, and EW-27 have low ERP (0.3664-0.4028). This figure also shows that two electoral wards had an average FRP score (0.4029-0.4215).

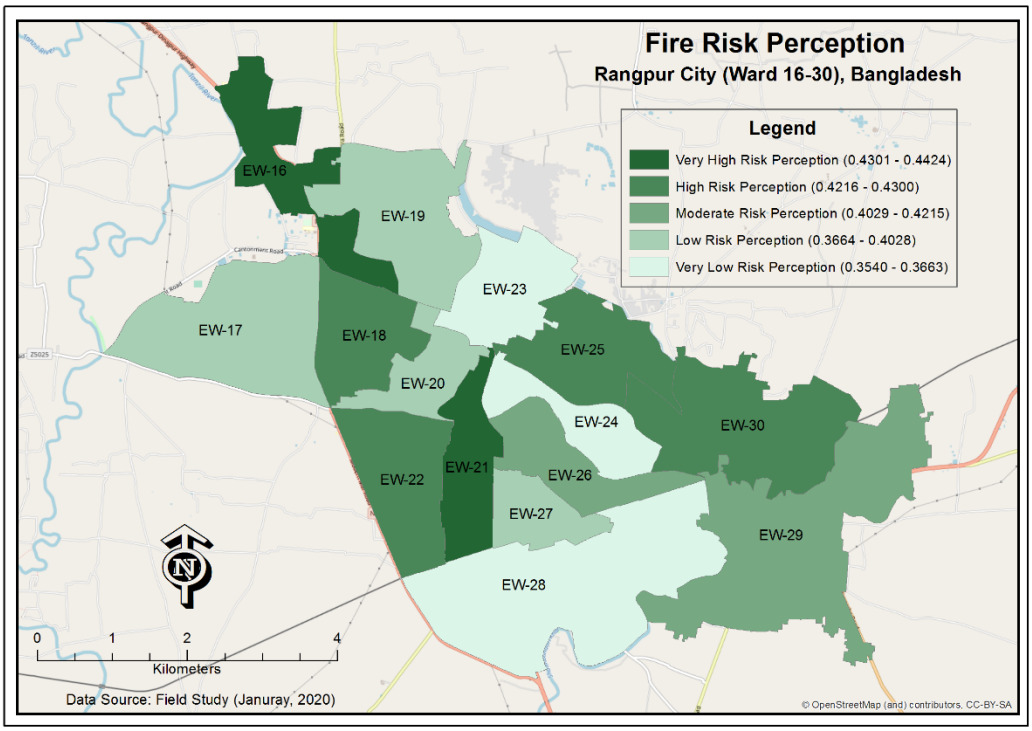

Figure 24: Spatial pattern of fire risk perception in RpCC (EW16-EW30)

5.3.5. Preparedness on fire hazard in RpCC at the household level

'Table 23' shows preparedness on earthquake hazard in RpCC at the household level. A total of five questions were asked to understand the preparedness on that hazard. The first question was related to checking the condition of the stove/cooker. According to the survey results, 67% of respondents never check their cooker; they only check if that is broken or not functional. Moreover, 79% of people have experienced fire hazard; still, they never check their cooker. However, 13% of respondents check once a year, and 13% of respondents check once a month.

On the other hand, 6% of respondents check the cooker once a month, and the other 2% check every day before cooking. Respondents from EW-20 have the highest tendency of not to check their cooker. In this electoral ward, 95% of respondents said that they never check their stove or cooker, while 5% of respondents check once a year. On the contrast, 32% of respondents from EW-22 said that they check the stove or cooker at least once a month as a precaution of fire safety.

Table 23: Preparedness on fire hazard at the household level

Questions	Opinion/ anticipation	Percentage (%)															
		EW-16	EW-17	EW-18	EW-19	EW-20	EW-21	EW-22	EW-23	EW-24	EW-25	EW-26	EW-27	EW-28	EW-29	EW-30	Mean
How frequently you check the condition/status of your stove/cooker?	Never	28	74	47	66	95	53	26	77	70	72	58	86	80	76	55	67
	Once a year	20	8	35	8	5	18	21	12	10	10	11	11	7	13	18	13
	Once a month	28	10	12	16	0	24	32	4	20	7	21	4	10	4	27	12
	Once a Week	20	5	6	8	0	6	21	8	0	3	11	0	3	2	0	6
	Everyday	4	3	0	3	0	0	0	0	0	7	0	0	0	5	0	2
How frequently you check the electricity line of your house?	Never	52	77	53	68	79	71	58	85	80	66	58	68	77	45	55	65
	Once a year	24	18	47	29	21	29	37	12	20	28	42	32	17	49	27	30
	Once a month	20	5	0	3	0	0	5	4	0	7	0	0	3	5	9	4
	Once a Week	4	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1
	Everyday	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Do you have a fire extinguisher at your home?	Yes	12	23	59	3	26	53	53	4	0	24	21	4	17	20	18	20
	No	88	77	41	97	74	47	47	96	100	76	79	96	83	80	82	80
Do you have a smoke detector and or fire alarm at your home?	Yes	0	0	18	0	0	0	11	0	0	0	0	0	0	0	0	1
	No	100	100	82	100	100	100	89	100	100	100	100	100	100	100	100	99
Have your ever participated in any fire drill?	Yes	4	13	24	8	21	6	26	8	0	59	5	25	7	15	18	16
	No	96	87	76	92	79	94	74	92	100	41	95	75	93	85	82	84

Source: Fieldwork (January 2020)

Among the respondents, 65% never check their electricity connections until any electric line/switch broken; however, around 80% of them already experienced fire hazard. This trend is highest in EW-23; 85% of respondents of this electoral ward never check their electricity connections. 30% of respondents check the electricity line at least once a year. Besides, 4% of respondents check it once a month and 1% once a week. No respondents found who check the electricity connections every day.

'Table 23' also reveals that 80% of the total respondents do not have a fire extinguisher at their home; other 20% have. From EW-18, 59% of respondents had a fire extinguisher. Besides, fire alarms were only used

by the respondents of EW-18 and EW-22. 18% of respondents form EW-18, and 11% from EW-22 has a fire alarm at their house. However, considering all the respondents, only 1% had a fire alarm at their house.

The last question related to the preparedness on fire hazard was related to the participation in a fire drill. 16% of respondents said that they have this experience, while 84% do not have. EW-25 is far more ahead in this regard; here, 59% of respondents participated in a fire drill. On the other hand, the worst-case was seen in EW-24. No respondents from this electoral ward have ever participated in any fire drill.

6. DISCUSSION

In this chapter, I critically discussed the results of multiple deprivation, disaster risk perception, and the relationship between multiple deprivation and disaster risk perception. This chapter also critically reflects the preparedness of earthquake hazard and fire hazard. Finally, this chapter outlined some suggestions for planning and policy interventions.

6.1. Multiple deprivation analysis

In this study, I did multiple deprivation analysis based on a conceptual model (Baud et al., 2008; DCLG, 2015). Besides, I validated the conceptual model of Index of Multiple Deprivation (IMD) with two other IMDs (IMD based on field data, and IMD based on Kaiser-Meyer-Olkin). All three IMDs correlate significantly (Table 7, p. 20). As a result, I decided that conceptual IMD can bring more insights into the multiple deprivation of Rangpur City Corporation (RpCC).

Multiple deprivation map (Figure 8, p. 21) reveals that Rangpur City has a wide range of deprivation at electoral ward level. Based on the IMD score, EW-29 and EW-30 (very high deprivation) are deprived as twice of EW-18, EW-16 and EW-20 (very low deprivation). So, these two EWs are the hotspot of multiple deprivation in Rangpur city. Baud et al. (2008) also found a similar type of spatial concentration/hot spot of multiple deprivation for the case of Delhi.

Here in RpCC, the extent of deprivation of the EWs varies with different capitals and indicators. The indicators of multiple deprivation also reveal that the least deprived EWs are located in the urban part of RpCC, and most deprived EWs are located in the peri-urban areas (Table 8, p. 22). Moreover, the results of this study showed that the deprivation of physical capital and natural capital are quite skewed (Table 9, p. 23). This result also uncovers that the overall IMD scores might hide the diverse combination of deprivations (Baud et al., 2008).

Then, the capital-wise deprivation maps (figure 9, p. 23; figure 12, p. 25; figure 13, p. 26; figure 15, p. 27; and figure 18, p. 29) showed that the deprivations of EWs had a large scale of diversity. Social, human, and physical capital deprivation is highest in EW-30; financial capital deprivation is highest in EW-21 and couple of EWs (EW-16, EW-19, EW-24, and EW-26) have a high level of natural capital deprivation.

I also found counter-intuitive results for the financial capital deprivation. Here the most deprived EW-30 is least deprived in this capital, and field experience revealed that there are two reasons behind it. Firstly, the centrum (Mahiganj) of EW is well known as the former business center of Rangpur district. Most people in 'Mahiganj' centrum are engaged with wholesale business. Secondly, this EW located in the peri-urban area (Figure 25, p. 47; and Table 8, p. 22), where land price is low compared to the core city areas. As a result, many people are likely owning a large parcel of lands and involved in agricultural activities. So, the affordability the majority citizens of this EW is solvent enough to own a house.

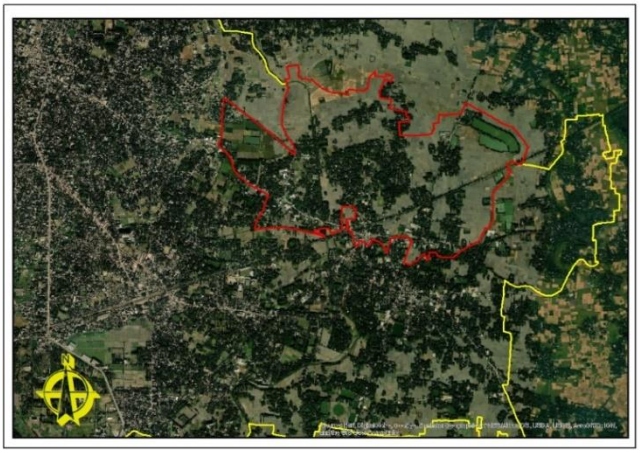

Figure 25: Satellite image showing the location of EW-30, which is a peri-urban area. Yellow line is for overall study area
Source: ArcMap (base map imagery)

At the same time, the floating population is absent here because this EW is far from the core part of the city. Floating population is redundant in EW-21, EW-23, and EW-24; because these areas can provide them informal jobs or food to survive. According to one of the social activists: *"Still people are living and sleeping on the pavements. They are collecting food from the waste-bins. So, considering this situation, deprivation exists in RpCC".* Results from this study also show that there is a high concentration of the floating population in EW-21 and EW-23 (Table 12, p. 27; Figure 13, p. 26). EW-21 and EW-23 have 0.95% and 0.68% floating population, respectively compared to the overall population of those EWs. So, in RpCC, the floating population shows a spatial concentration. However, Rabby et al. (2019) found that floating or destitute population do not follow any spatial pattern.

Martínez (2009) found that overcrowded households suffer all aspects of inequality. In contrast, I found that only the floating population has a significant correlation with overcrowded households (r = 0.544; p<.01). Here in this study, households with 'no toilet' are more likely to suffer from other many other aspects of inequality; for instance- education deprivation, electricity deprivation, etc. So, indicator-based deprivation may widely vary with the local contexts (Table 15, p. 31).

Besides interviewing the residents, I also talked with few elected ward councillors and planners to understand the thoughts of local officials and policymakers on the multiple deprivation of RpCC (Table 5, p. 15). One of the female ward councillors said that *"Of course, there are deprivations. The women are most deprived; compared to the men. Men always received more benefits."*. So, considering this statement, 'percentage of women' could be a good indicator of multiple deprivation for the case of RpCC. Noble et al. (2006) also gave an example of gender-based deprivation, and he termed as 'health-deprived women'.

Another female ward-councillors emphasised on roads and slum population. Besides, the ward-councillor expected international funding, and she said:

> *"Here in RpCC, Deprivation exists; roads are very narrow here. Slum population is not getting benefits. Besides, we are not getting funding from JICA for old electoral wards anymore. If we get funding from JICA, we can widen the roads. Widening the roads could improve overall city environment."*

One of the professors from the local university expressed his thoughts on multiple deprivation in RpCC as: *"This region (Rangpur Division) does not get importance during the government budget allocation. Besides, there is a lack of coordination between the elected members such as- member of the national parliament and the city mayor."*

One of the officials from the RpCC raised another issue defending the budget allocation system for the EWs. According to him:

> *"RpCC has thirty-three EWs, but we earn a majority from the fifteen electoral wards. So, these fifteen EWs get priority during budget allocation as they are paying more. Consequently, other EWs (who pay less) get less priority. Besides, due to the low financial contribution, they have less power in the decision-making process."*

In summary of the above statements, it can be said that gender-based deprivation, roads and accessibility, presence of slum population, annual budget allocation etc. could be significant indicators beside the conceptual indicators to calculate IMD in RpCC.

Besides, I also agree with Martínez (2009, p. 393) that "indicators from census data are good to measure indirect need, but they cannot measure self-expressed demand coming from the population". Here in RpCC, road network, drainage system, good governance and monitoring, education, waste management, fair budget allocation etc. are more relevant to the local citizens (Figure 20, p. 22). So, to identify the priority sectors,

citizen participation could be an appropriate step beside the theoretical and technical approaches to IMD. Moreover, the anticipation of citizens on multiple deprivation also need to be taken into consideration by the authority as they have committed during the election campaign for the urban facilities and development.

Based on the results of this study, I also agree with Baud et al. (2008). I would like to suggest that capitals and indicators of IMD give more insight into the overall IMD; which can help to communicate with policymakers easily (Martínez & Dopheide, 2014). For example- natural capital deprivation or green area deprivation map could inform the policymaker which EW/EWs need/s more attention on green areas. Besides, it can also help the policymakers to distribute the responsibilities among different authorities reduce the level of deprivation, because different capitals/indicators are the concern of different authorities or ministries. Moreover, the city corporation can allocate its development budget more transparently among the EWs, avoiding political conflicts or biases.

6.2. Disaster risk perception analysis

In this study, risk perception analysis is mainly focused on earthquake hazard and fire hazard. I looked in three different aspects of the said hazards. Firstly, how risk perception changed with socio-demographic factors. Secondly, how the citizen's perception of hazards spatially distributed. Finally, how the preparedness level of citizen's spatially distributed.

The risk perception analysis in this study suggests that women likely have a higher anticipated risk of earthquake hazard than men. Paul & Bhuiyan (2010) also overserved a similar result for the case of Dhaka City. On the other hand, men likely have a higher anticipated risk of fire hazard than women. However, Chan et al. (2018) did not find any statistically significant association between gender and fire risk perception. "Though woman is more vulnerable than man in case of any hazard" (Rahman et al., 2015). The field observation reveals that as a family head, men are most likely concern about financial loss due to any hazard, while women are concern about the severity of a hazard. Fire hazards could bring more financial loss to men than the earthquake hazard, and that is why men perceived higher risk in fire hazard than the women.

Risk perception by age group also reveals counterintuitive results. Young people (18-24 years old) have a higher anticipated risk of earthquake hazard than the older age group (59+), while the reverse result was observed for fire risk perception (Figure 21, p. 36; Figure 23, p. 41). Experience from the field suggests that the older people have a firmer religious belief, and they think that an earthquake is a God's will, and they have nothing to do in this case. As a result, older people anticipated low risk of earthquake hazard.

Fire risk perception is positively correlated with education level. However, respondents with bachelor and above degree more likely to have higher risk perception of earthquake hazard risk. Risk perception by profession also suggests that government employees have higher anticipation than others, and it could be due to their higher level of education (Figure 21, p. 36; Figure 23, p. 41).

The correlation study found that ERP is correlated with gender and household ownership, while FRP is correlated with gender, household story type and residential floor (Table 19, p. 38; Table 22, p. 44.) Household ownership type is negatively correlated with ERP but positively correlated with FRP. Because the owners are informed about the condition of their house and are less likely fearful of an earthquake, however, they are afraid of fire hazard considering immediate financial loss.

The spatial pattern of risk perception is different for both hazards (Figure 22, p. 38; Figure 24, p. 44). The reason could be the variation of socio-demographic factors. Besides, there might be other factors related to this result, for example- residential density and population density. However, those indicators were beyond the conceptual framework of this study.

6.3. Assessment of the relationship between multiple deprivation and disaster risk perception

The novel attempt of this study was to investigate the relationship between multiple deprivation and disaster risk perception. One of the hypothesises of this study was that there is a strong correlation between multiple deprivation and disaster risk perception. However, the results of this study falsified the hypothesis. Based on the spatial distribution of IMD, ERP, and FRP at electoral ward level (Table 24), the results did not find a statistically significant correlation between multiple deprivation and disaster risk perception. Besides, earthquake risk perception and fire risk perception also do not show any linear correlation.

Table 24: Correlation (Pearson) between multiple deprivation and hazards' risk perceptions

	IMD (Theoretical and Conceptual)	Earthquake Risk Perception	Fire Risk Perception
IMD (Theoretical and Conceptual)	1		
Earthquake Risk Perception	0.002	1	
Fire Risk Perception	-0.313	-0.171	1

So, I performed a correlation analysis between Capitals, ERP and FRP. The correlation matrix also does not show any significant correlation (Table 25). Furthermore, the correlation between indicators of multiple deprivation, ERP and FRP were checked. The result shows that only one indicator, 'percentage of disable population' negatively correlates with FRP ($r = -0.522$; $p = 0.05$). That means the EWs with a higher number of disabled people have lower perceived risk on fire hazard. Though the reason behind this result was uncovered in this study; a further study might explain the reason.

Table 25: Correlation (Pearson) between capitals and hazards' risk perception

	SC	HC	FC	PC	ERP	FRP
Social Capital (SC)	1					
Human Capital (HC)	0.446	1				
Financial Capital (FC)	-0.429	-0.374	1			
Physical Capital (PC)	0.449	.705**	-.598*	1		
Earthquake Risk Perception (ERP)	-0.119	0.161	0.301	-0.172	1	
Fire Risk Perception (FRP)	-0.249	-0.118	-0.235	-0.204	-0.171	1

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

After getting the previous results, again, I performed another correlation analysis among IMD (Based on Field Data), IMD Kaiser-Meyer-Olkin (KMO), ERP, and FRP (Table 26). This correlation table also shows that earthquake risk perception and fire risk perception do not have a significant correlation with both types of IMDs.

Table 26: Correlation (Pearson) analysis among IMD (Based on Field Data), IMD (KMO), ERP and FRP

	IMD (Based on Field Data)	IMD (KMO)	Earthquake Risk Perception	Fire Risk Perception
IMD (Based on Field Data)	1			
IMD (KMO)	.604*	1		
Earthquake Risk Perception	0.371	-0.264	1	
Fire Risk Perception	-0.276	-0.221	-0.171	1

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

Considering the above results, I did a cross-table analysis to see the relationship from a different point of view. Then I found some valuable insights on the said relationship, which could be crucial for planning, and policy interventions. The cross-table result shows that EW-29 and EW-26 ranked second and fourth based on multiple deprivation score (Table 26). Besides, these two EWs ranked third and fifth, respectively based on the lowest ERP. Similarly, EW-28 and EW-27 also second and fifth in rank, respectively based on lowest FRP. So, EW-28 and EW-29 need much attention because these two EWs have very high or high multiple deprivation beside low or very low risk perception in at least in one hazard category. Moreover, EW-24 did not ranked top five based multiple deprivation score, but this electoral ward ranked second and first respectively for lowest ERP and FRP.

Table 27: Cross-table of top five EWs with highest multiple deprivation, top five EWs with lowest ERP and FRP

Rank	Top Five EWs with Highest Multiple Deprivation	Top Five EWs with Lowest ERP	Top Five EWs with Lowest FRP
1	EW-30	EW-18	EW-24***
2	EW-29*	EW-24***	EW-28**
3	EW-27	EW-29*	EW-23
4	EW-26	EW-22	EW-20
5	EW-28**	EW-26*	EW-27*

* IMD-ERP relation; ** IMD-FRP relation; *** ERP-FRP relation

On the other hand, 'Table 28' shows that EW-18, EW-16, EW-20, EW-21, and EW-25 are the least deprived electoral wards of RpCC based on the IMD score. Among these EWs, EW-20 and EW-16 ranked first and third, respectively based on higher ERP. Similarly, EW-21 and EW-25 ranked in the top five based on the higher FRP; EW-16 remained in the top five in all three categories. Besides, EW-30 ranked fifth and third based on higher ERP and higher FRP, respectively. Again, I would like to mention that higher ERP or FRP value indicates higher risk perception.

Table 28: Cross-table of top five EWs with lowest multiple deprivation, top five EWs with highest ERP and FRP

Rank	Top Five EWs with Lowest Multiple Deprivation	Top Five EWs with Highest ERP	Top Five EWs with Highest FRP
1	EW-18	EW-20*	EW-21**
2	EW-16***	EW-23	EW-16***
3	EW-20*	EW-16***	EW-30****
4	EW-21**	EW-27	EW-25**
5	EW-25**	EW-30****	EW-22

* IMD-ERP relation; ** IMD-FRP relation; ***IMD-ERP-FRP relation; **** ERP-FRP relation

Finally, considering the result of 'Table 28', I would like to suggest that EW-16 could be a model for spatial planning and policymaking. Because, this EW has very low multiple deprivation, and very high ERP and FRP. The socio-demographic and other characteristics could be a model for most vulnerable EWs.

6.4. Preparedness on earthquake hazard and fire hazard

We already know, RpCC is in earthquake zone 1 and 2 of Bangladesh. Near about one million people living in this city. Thousands of new buildings are in the construction phase. As one of the oldest former municipality of Bangladesh, the core area of RpCC has hundreds of old buildings as well. Considering those, one of the professors of the local university warned that:

> *"In every hundred years, we face a severe earthquake. The last one was at Assam in 1897. As Rangpur is in earthquake zone 1 and 2, we are in danger. If it occurs, most of the building of the city will collapse. So, building code needs to be maintained properly."*

Nobody can stop the incidence of an earthquake, but sufficient preparedness measures can reduce the vulnerability to this hazard (Paul & Bhuiyan, 2010). Indeed, the overall preparedness on earthquake hazard in RpCC seems insufficient. The results of earthquake risk perception show that 53% of the household do not have any emergency kit (Table 18, p. 35). That means they need external help for any kind of medical or evacuation support. Having the first-aid kit at home is also one of the preparedness measures (Paul & Bhuiyan, 2010). If we look at the spatial distribution of the availability of the emergency kit (Table 20, p. 39), we can see that EW-18 is most vulnerable (100% surveyed households do not have an emergency or first-aid kit) and EW-20 most prepared (89% surveyed households have an emergency or first-aid kit).

The results on preparedness also show that 41% of the surveyed households do not have an emergency exit to escape during or after an event (Table 20, p. 39). In general, the escape behaviour of a resident during or after an earthquake event changes with the nearby road layout as well as with the knowledge about a place (Shrestha et al., 2018). So, residents from these households will try to escape from the only door to the nearby roads, which could create a chaotic situation at that moment. From the field experience, I was informed that many of the house owners lock the main entrance during night. They do not even give the keys to the tenants. So, if an earthquake event occurs at night, the consequence could be more devastating.

Institutional initiatives on the earthquake preparedness are not visible so far here in RpCC. However, one of the officials of RpCC confirmed that they have a contingency plan to deal with a possible severe earthquake. According to the official:

> *We have a contingency plan considering 7-8 scale earthquake. We have used the HAZUS earthquake model to calculate the possible damages. Besides, we have modelled night time and day time scenarios. We have calculated how many people might die and how many people might injure. Moreover, we calculated how many buildings could partially or completely collapse. This contingency plan has everything, including healthcare service, evacuation, relief management, security….. everything."*

On the other hand, according to field evidence, the preparedness on fire hazard is also not satisfactory. Only 80% of households do not have a fire extinguisher, and 84% of respondents did not ever participate in a fire drill. Moreover, only 99% of the household do not have a smoke detector (Table 21, p. 40). Notably, a smoke detector can protect the life of the residents by alerting the residence, and fire extinguisher can reduce the damage of a residential fire hazard (Stumpf et al., 2017).

Here in RpCC, Fire Service and Civil Defence (FSCD), Rangpur plays a significant role in the preparedness and mitigation of fire hazard. Their enthusiasm, hard work and professionalism seem very high from the field experience and observations. The FSCD has identified several causes of fire hazards in RpCC. One of the officials from FSCD said:

> *"We identified total 17/18 reasons behind fire hazard. Among them, the biggest reason is electrical disturbances. In addition, the blast of gas cylinder is another reason. Besides, use of anti-mosquito coils, throwing of cigarette filters, the use of poly bags plays a great role for occurring fire hazard."*

Although the hard work of the FSCD members, several issues make their efforts more challenging. Considering this, I asked the previous spokesman about the difficulties of FSCD during an event, and he replied:

> *"Firstly, the narrowness of the roads. The fire service team cannot reach the location of the events properly. Traffic jam due to auto-rickshaw also creates a barrier to reach the location. There is a lack of water sources; most of the sources are filled up for the residential or commercial purpose. Especially, the 'Shyamashundari Canal' is almost destroyed. These could play a vital role. We need to setup fire hydrants as like the developed countries; it will be beneficial in the long term to fight the fire. Besides, too much curious people create an extra barrier during a fire accident. It is challenging to control curious people."*

He also emphasized that:

> *"More than 250 high-rise buildings (above six floors) are planned to construct and have approval from the city corporation, but we do not have sufficient and suitable equipment supports for those buildings. We need separate vehicles (for example TTI's) to fight at a high-rise building. We are expecting to get those soon from the government."*

(a) High-rise building

(b) Traffic jam

(c) Narrow road

Figure 26: Challenges and barriers for FSCD in RpCC (a. high-rise building, b. traffic jam, and c. narrow road)
Source: Fieldwork (January 2020)

From the above few quotes, it can be summarized as- electrical disturbances, the blast of a gas cylinder, flammable anti-mosquito coils, cigarette filters are the major causes of fire hazard in RpCC. Narrow roads

and traffic jam are the main barriers to reach a fire event (Figure 26). Besides, FSCD faces difficulty to obtain the sources of water during the fire-fighting. Because the sources of water are being filled up and there is an absence of fire hydrants in RpCC. Furthermore, FSCD needs proper equipment to protect more than 250 high-rise buildings in case of any fire event. Besides, FSCD should arrange more fire drills across the city.

6.5. Planning guidelines and policy interventions

I would suggest that the results of the index of multiple deprivation (IMD) of this study could be significant for the planners and policymakers to eliminate the deprivations in RpCC. The concern authorities could obtain both broad and specific views of deprivation the from IMD. The rank table (Table 8; p. 22) of this research could be taken into consideration for area-based as well as indicators-based planning and policies.

According to RpCC master plan, the city corporation supposed to formulate City Disaster Management Committee (CDMC) along with other supporting standing committees (LGED, 2014). These committees should have been formulating provisions for pre-disaster risk mitigation and post-disaster recovery program. Nevertheless, this committee has not been formed yet. After formulating the committee, I strongly suggest that the results of this study could be taken into consideration for planning and policy interventions to reduce the risk of different hazards based on the need of the local context.

Based on the evidence from the study, I would say that RpCC needs planning guidelines and policy interventions to reduce the risk of earthquake and fire hazard. To reduce the risk for earthquake hazard, widening the roads, ensuring the availability of water, and maintaining the building code are at the highest priority. Though RpCC master plan has plans and provisions for wide road and building safety (LGED, 2014); neither plans nor provisions are well functional yet.

Spatial pattern of fire risk perception and preparedness can assist the authority to initiate area-based awareness programs. Highest priority for awareness campaigns should be given to the EWs with very low risk perception and preparedness. Besides, the presence of emergency exit in every household should be obligatory; it will help the residents to evacuate the residential building quickly in the occurrence of both hazards. Moreover, the use of a smoke detector and fire extinguisher should be mandatory for every household of RpCC.

I also suggest that preparedness on both hazards need cooperation and collaboration among citizens and different authorities. The local university could provide intellectual support to the respective authorities. Besides, as a parent organization of the city, the RpCC needs to increase awareness programs significantly.

7. CONCLUSION

In this chapter, I summarized the key findings of this research. After that, the limitations of the research and recommendations for future research are discussed in this chapter. Finally, this thesis ends with concluding remarks.

7.1. Key findings and recommendations

The first objective of the study focused on the conceptualization and analysis of multiple deprivation. The results of the multiple deprivation analysis revealed many aspects of deprivation at electoral ward level. Here in this study, the conceptual model of the Index of Multiple Deprivation (IMD) was able to map multiple deprivation of RpCC. The core areas of the city have the lowest multiple deprivation. In contrast, the peri-urban areas have higher multiple deprivation. Electoral ward number 30 (EW-30) is most deprived (Figure 8, p. 21; Table 8, p. 22). This EW is most deprived in five indicators (% of ethnic population, literacy rate, % of population less than 10 years old, % of pucca structure, and % of no toilet households) as well. On the other hand, EW-18 is the least deprived (Figure 8, p. 21; Table 8, p. 22), and this EW has the least deprivation in five indicators (% of ethnic population, literacy rate, % of disabled people, % of pucca structure, % of sanitary toilet).

The concepts of different capitals enabled this study to bring more insights of multiple deprivation in RpCC. According to the results, social capital deprivation and natural capital deprivation are quite skewed (Table 9, p. 23). EW-29 has the highest social capital deprivation (Figure 10, p. 24), and EW-19 has the highest natural capital deprivation (Figure 19, p. 30). However, that result from IMD was not sufficient to explain how the deprivation of different capitals is spatially distributed over the RpCC. That is why I mapped all the capital-wise deprivation maps separately (figure 9, p. 23; figure 12, p. 25; figure 13, p. 26; figure 15, p. 27; figure 18, p. 29).

The correlation matrix shows that the IMD significantly correlates with social capital, human capital, and physical capital (Table 14, p. 30). IMD has highest positive correlation with human capital ($r = 0.988$, $p < 0.01$). So, policymakers might prioritize the human capital deprivation to eliminate the overall deprivation. In contrast, financial capital deprivation did not show any significant correlation with IMD; that might be due to the counter-intuitive results compared to other capitals. However, the availability of ward-wise income data could have provided a different result.

Correlation between IMD and indicators (Table 15, p. 31) reveals that the IMD is correlated with ten indicators (% of ethnic population, literacy rate, % of population less than 10 years old, % of population higher than 65 years, % of owned house, % of electricity connection, % of pucca structure, % of jhupri structure, % of sanitary toilet, and % of no toilet). So, the policymakers can focus on these indicators to reduce the level of deprivation at RpCC.

Similarly, the correlation within the indicators reveals that three indicators (% of electricity connection, % of pucca structure, and % of no toilet) have the highest number of correlations with other indicators (Table 15, p. 31). These indicators are correlated with a total of eight other indicators (Table 15, p. 31). So, housing condition or electricity connection largely influence other aspects of deprivation. On the other hand, three

indicators (% of non-Muslim population, % of 6-10 not attending school, and '% of green area) do not correlate with any of the indicators. These three indicators are less likely important for deprivation related planning and policies herein RpCC.

Semi-structured interviews revealed that women and slum people are the most vulnerable group due to deprivation. Elected and non-elected, both types of officials from RpCC admitted that narrow roads in the older part of the city are a big issue among the deprivations. To overcome this problem, they expect funding from international organisations. One of the officials from RpCC argued that logically RpCC gives priority to highest tax-paying EWs. Moreover, the lowest tax-paying EWs has less power in decision making. So, I think prioritising EWs based on tax-paying capacity fosters the deprivation in the city; this approach needs to be changed accordingly to minimise the multiple deprivation in RpCC.

Questionnaires during the survey with the citizens reveal that roads and drainage are likely most concerning issues for the citizens. Almost half of the population (51.61%) expect an improved road network and drainage system. Based on the field experience, I would like to suggest that the drainage system should be constructed along with the improvement and widening the roads. Otherwise, in some areas, the drainage system needs to be constructed again due to the widening of roads. Besides the above issues, good governance, education facilities, equal service and budget allocation, awareness built-up among citizens, solving unemployment are also priority concern of the significant part (30.05%) of citizens (Figure 20, p. 32).

The second objective of this study was focused on the analysis and mapping of disaster risk perception at electoral ward level and as well as at the household level. Here, two concerned hazards were earthquake and fire. The results showed that 99% of respondents had experienced an earthquake (Table 18, p. 35). Among the respondents, 48% were agreed either strongly agreed that a severe earthquake may hit their property. Similarly, 61% of respondents agreed and strongly agreed that an earthquake could affect them and their family members. Moreover, 66% agreed and strongly agreed that an earthquake might result in their property damage. So, still, 35% to 40% anticipated low risk of earthquake hazard.

According to the results (Figure 21, p. 36; Figure 23, p. 41), earthquake risk perception (ERP) might vary with gender. Women are likely to have higher ERP. ERP also changes with education. Respondents with bachelor and above degree more likely to have higher FRP; however, the results showed that people with no education also likely to has higher ERP; the reason behind this result is yet not known. Further investigation might reveal any valid reason. Risk perception by profession also suggests that government employees are more likely to have higher anticipation than others, and it could be due to their higher level of education.

The results (Figure 21, p. 36; Figure 23, p. 41) also showed that pucca houses have a high earthquake risk perception. Similarly, the higher residential level has higher ERP. In the case of ERP, tenants likely have higher risk perception than the owner of the houses; the reason is still unknown. Correlation analysis (Table 19, p. 38) found that gender has statistically significant correlation with ERP ($r = 0.139$, $p < 0.01$). Similarly, household ownership type also has a statistically significant correlation with earthquake risk perception ($r = 0.113$, $p < 0.05$). Besides, the spatial pattern of earthquake risk perception revealed that EW-20 and EW-23

had very high ERP; on the other hand, EW-18 had a very low ERP (Figure 22, p. 38). So, policies for reducing the risk of hazards could focus on the above issues.

The results of fire risk perception (FRP) revealed that 81% of the respondents experienced at least one fire hazard (Table 21, p. 40). Though 70% responded anticipated no or low risk of fire at their living place; that might make them very vulnerable during a possible fire hazard. However, 53% believed that fire could occur from the cooker or stove of the household. Besides, 60% agreed that an electric short circuit could cause fire at home. So, fire risk perception has a wide degree of diversity among the respondents.

As like ERP, FRP also varies with gender. However, the result is opposite for FRP; here, the men have a higher risk perception of earthquake hazard. The possible reason could be, as a family head, men perceived more risk on fire hazard because of the immediate financial loss. Besides, the higher-income group likely to have highest FRP; as like ERP, government service holders likely to have highest FEP. Moreover, people with higher education level, higher age, and people living in a multi-story building and higher residential level more likely to have higher risk perception. However, different professional and income group likely have diversely anticipated the FRP. Besides, unlikely to ERP, house owner anticipated higher risk on fire hazard. The correlation matrix (Table 22, p. 43) also showed that FRP had statistically significant correlation with gender, household story, household ownership type and residential floor (r = -0.140, p <0.01; r = 0.129, p <0.01; r = 0.102, p <0.01; r = 0.105, p <0.01 respectively).

The spatial pattern of FRP resulted that EW-23, EW-24 and EW-28 had very low FRP (Figure 24, p. 43). On the other hand, EW-16 and EW-21 had very high FRP. The results show that the preparedness level on fire hazard is likely low in RpCC (Table 23, p. 44). Here, 67% of respondents never check the condition of their cooker. If we look EW-wise, the situation in EW-20 is worst; here, 95% of the respondents never checked their cooker, which is very alarming.

Similarly, 65% replied that they never check their electricity connections until it is broken. Besides, 85% of respondents from EW-23 replied as same. The results of participation in a fire drill showed that 84% of the respondents do not have this experience, where no respondents from EW-24 ever participated in a fire drill. Here, the most notable things are only 1%, and 20% of respondents have a smoke detector and fire extinguisher at home, respectively. Moreover, 59% of households do not have an emergency exit. These numbers are sufficient to conclude that the residents of RpCC are very less likely prepared for a potential fire hazard.

The attendees from the semi-structured interviews informed that road accessibility is the great concern for Fire Service and Civil Defence (FSCD) to fight the fire or to evacuate the building. Most of the time, the narrow roads and traffic jams created by auto-rickshaws do not allow the fire fighting vehicles to reach the place of fire accident timely or adequately. Besides, curious people create a blockage in the road as well during a fire event. One of the most concerning issues related to fire safety in RpCC is the FSCD does not have sufficient equipment to safeguard more than 250 high-rise buildings (six floors or higher). FSCD also face difficulties due to the shortage of water. Because most of the water bodies of RpCC are being destroyed including the historical Shyamasundari canal, and there is absence for fire hydrants as well in the city.

The third objective of this study was focused on the relationship between multiple deprivation and disaster risk perception. The study results falsified the hypothesis, and the IMD does not have a statistically significant relationship with ERP and FRP. However, the cross-table analysis brought some valuable findings which could be supportive for spatial planning and policy interventions (Table 27, p. 50; Table 28, p.50). According to the cross-table results, EW-28 and EW-29 had high multiple deprivation and low disaster risk perception. So, these electoral wards need much attention. On the other hand, EW-16 is best EW considering the IMD, ERP and FRP. So, this EW can be an excellent example for the policymakers to bring out other EWs from deprivation and disaster risk.

The fourth and final objective of the study was focused on the planning guidelines and policy interventions to reduce the deprivation, as well as to increase the risk perception for increasing preparedness to the reduction of risk of those potential hazards. Several planning guidelines and policy interventions were suggested based on the study results, which could ultimately help to meet SDG goal 11B.

7.2. Limitations of the study and recommendation for future works

In this research, I encountered a few limitations that I would like to mention here in this section. Maintaining an equal ratio for single-story and multiple-story buildings was not possible during the questionnaire survey due to the accessibility issue. Residents from the upper floors were not reachable due to the lock at the main entrance. Besides, they do not feel safe to open the gate and to answer the questionnaire. Another limitation of this study is the questions (for risk perception analysis) were formulated based on previous literature to quantify the risk perception of fire hazard and earthquake hazard. However, there were very few pieces of literature (M. M. Islam & Adri, 2008; MoDMER, 2015; Paul & Bhuiyan, 2010; Rahman et al., 2015) available in the context of Bangladesh.

Based on the experience of this study, I suggest formulating the IMD based on a multi-dimensional approach. For example, using the conceptual models, preliminary indicators could be extracted; after that, citizen's priority sectors should take into consideration if the data is available. Besides, residential density, building density, population density, road network density, drainage density could be significant indicators to map IMD. So, future studies could include these indicators along with other indicators. At the same time, Bangladesh Bureau of Statistics (BBS) could collect the deprivation related information during a census. Finally, if it is possible to manage representative samples from each electoral words or neighbourhoods, raster analysis could produce more detailed maps on risk perception, which will ultimately help in risk-related spatial planning.

7.3. Concluding remarks

Multiple deprivation map visualized an overall picture of the deprivation of the city, which is very easy to communicate with the local government and policymakers. Besides, capital-wise and indicator-wise deprivation are also very significant for targeting planning and policy interventions at electoral ward level. Similarly, the spatial distribution of risk perception maps could enable the planners, policymaker, and respective authorities to formulate planning guidelines and policy interventions more effectively. Furthermore, this study uncovered many aspects of risk perception and preparedness at the household level as well as at electoral ward level. Finally, the novel approach of combining 'multiple deprivation' and 'disaster risk perception' uncovered a method for cities' disaster risk reduction, where at the same time the deprivations in the cities also can be monitored along with disaster risk reduction.

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Appendix-1

Table 1.1: List of indicators of Index of Multiple Deprivation (IMD) and their rational in IMD

Capital	Domain	Indicator	Rational	Cost/Benefit
Social Capital	Social Discrimination	% of Female Widowed/Divorced/ Separated	These three variables are the minority group in society. In the context of Bangladesh, they are less privileged and often they are segregated. So, these variables contribute positively to the IMD.	Benefit
		% of Ethnic Population		
		% Non-Muslim		
Human Capital	Education Deprivation	Literacy Rate	Higher the literacy rate, lower the deprivation.	Cost
		% of population (6-10 yrs) not attending school	According to national policy, primary education is mandatory. This age group do not attend school; so, contributes positively to IMD.	Benefit
	Health and Disability	% of Disable people	This indicator represents the dependent population group, and they contribute positively to the IMD.	
	Employment and Workforce	% Employment (7 Years+ old not attending school but employed)	This group of people is more than seven years old, and they do not attend school. However, they are employed and generating income for the family. So, they contribute negatively to the IMD.	Cost
		% of population within 25-59 age group capable of working	This age group can work and generate income for the family. So, they contribute positively to the IMD.	Cost
	Dependent Age group	% of Pop less than 10 years old	Those two variables represent the dependent age group. So, these groups are considered as the benefit to the IMD.	Benefit
		% of Pop 65+		
Financial Capital	Monetary situation	% Floating Population	This indicator means the population has no place to stay. Surely this is deprivation and contributes positively to IMD	Benefit
		% of Owned house	People who owned a house indicates a decent monetary situation. So, it contributes negatively to the IMD.	Cost
Physical Capital	Service Deprivation	% of Electricity Connection	Access to electricity connect is a privilege and contributes negatively to the IMD	Cost
		% Institutional Households	This indicator indicates Hospitals, clinics, jails, barracks, orphanages, hostels/halls of educational institutions. They provide necessary services and low-cost housing. So, this indicator contributes negatively to the IMD.	Cost
	Household Condition	% of Pucca Structure	Pucca structure means the household with concrete construction. So, that indicates the good state of household condition and contribute negatively to the IMD.	Cost
		% of Jhupri Structure	Jhupri structure is a very temporary type of construction. This type of house is very much vulnerable to numerous natural catastrophise. So, they indicate a good state of household condition and contribute positively to the IMD.	Benefit

Table 1.1: List of indicators of Index of Multiple Deprivation (IMD) and their rational in IMD

Capital	Domain	Indicator	Rational	Cost/Benefit
		% of Sanitary Toilet	Sanitary toilet is related to hygiene and a good indicator of the social wellbeing. So, this indicator contributes negatively to the IDM.	Cost
		% of No Toilet	No toilet indicates a poor state of a household. So, this indicator contributes positively to the IDM.	Benefit
	Living Environment Deprivation	% of Household size greater than 6	Overcrowded household indicates the living condition deprivation and contributes positively to the IDM.	Benefit
Natural Capital	Environmental Deprivation	% Green area	This indicator means the percentage of green areas in the electoral wards. Access to the green area often considered as a benefit to the citizens. So, this indicator contributes negatively to the IMD.	Benefit

Appendix-2

Table 2.1: Indicators, interview questions, and assigned values of earthquake risk perception

SN	Indicator	Interview Question	Assigned Perception Value		Type	
1	Witness of previous incident	Did you witness or experienced any fire accident?	Yes No	1 0	Perception	Risk Perception
2	Anticipation of fire risk	What is the level of risk of fire at your house do you think?	No Risk Low Risk Medium Risk High Risk Very High Risk	0 0.25 0.50 0.75 1.00		
3	Anticipation of fire risk from cooker/stove	Do you think the fire can occur from cooker/stove at your home?	Yes Maybe No	1.00 0.50 0		
4	Level of sincerity	Do you go somewhere else or do other jobs while cooking?	Frequently Often Occasionally Vary Rare Never	0 0.25 0.50 0.75 1.00		
5	Anticipation of fire risk from short circuit	Do you think an electric short circuit can cause fire at your home?	Yes Maybe No	1.00 0.50 0		
6	Alertness	Do you use multi-plug at your home?	No Yes	1 0		
7	Safety information	Do you know where the electric main switch of your house is?	Yes No	1 0		
8	Level of alertness	How frequently you check the condition/status of your stove/cooker?	Never Once a year Once a month Once a Week Everyday	0 0.25 0.50 0.75 1.00	Preparedness	
9	Level of alertness	How frequently you check the electricity line of your house?	Never Once a year Once a month Once a Week Everyday	0 0.25 0.50 0.75 1.00		
10	Availability of smoke detector	Do you have a smoke detector and or fire alarm at you home?	Yes No	1 0		
11	Availability of fire extinguisher	Do you have a fire extinguisher (e.g. fireball, fire blanket etc.) at you home?	Yes No	1 0		
12	Practical knowledge and skill	Have your ever participated in any fire drill?	Yes No	1 0		

Table 2.2: Indicators, interview questions, and assigned values of fire risk perception

SN	Indicator	Interview Question	Assigned Perception Value		Type	
1	Witness of previous incident	Did you witness or experienced any earthquake?	No Yes	0 1	Perception	Risk Perception
2	Future possibility	Do you agree that a severe earthquake may hit your living place?	Strongly disagree Disagree Neutral Agree Strongly Agree	0 0.25 0.50 0.75 1		
3	Effect to personal life and family	Do you agree that the earthquake will affect you and your family?	Strongly disagree Disagree Neutral Agree Strongly Agree	0 0.25 0.50 3 4		
4	Perceived risk of property damage	Do you agree that the earthquake may result in your property damage?	Strongly disagree Disagree Neutral Agree Strongly Agree	0 0.25 0.50 0.75 1		
5	Perceived risk of death	Do you agree the earthquake may result in death and injury?	Strongly disagree Disagree Neutral Agree Strongly Agree	0 0.25 0.50 0.75 1		
6	Fearfulness	How fearful are you about a possible earthquake?	Not fearful Little fearful Moderate fearful Highly fearful	0 0.33 0.66 1		
7	Prior arrangement of first aid and emergency kits	Do you have any first aid kit or any emergency kits to face earthquake occurrence?	No Yes	0 1	Preparedness	
8	Presence of emergency exit	Do you have any emergency exit for such type of situation?	No Yes	0 1		

Appendix-3

Multiple Deprivation and Disaster Risk Perception in Rangpur City, Bangladesh

Survey Related Information

Questionnaire Number

_____

Interviewer ID

(Please use your student ID)

Your Student ID (always in same format)

_____

Photography of the Property/House

If not possible to take picture of the the property then take a picture of the interviewee

Click here to upload file. (< 5MB)

GPS Location

If not possible in app, take it manually

_____

latitude (x.y °)

_____

longitude (x.y °)

_____

altitude (m)

_____

accuracy (m)

_____

Ward Number

_____

Para/Mohalla/Mauza Name

_____

House Number
If not available, write 'N/A'

_____

Good morning/afternoon. I am (mention your name). On behalf of Md Zakiur Rahman, MSc student (urban planning and management), University of Twente, The Netherlands I would like to request your time to ask few questions. The purpose of this questionnaire survey is to understand the earthquake and fire hazard risk perception of the citizens of Rangpur City Corporation. We also want to know your perception on the deprivations in Rangpur City. This survey will take 15-20 minutes and the information provided by you will be kept confidentially. The data will only be used for the research purpose and no where your identity will be published without you consent. Do you agree to continue this survey?

- ◯ Yes (if yes, please continue the questionnaire survey)
- ◯ No (if no, please give thanks to the respondent and go for next survey)

1. General/Demographic/Household Information

1.1 Name of the Respondent (উত্তরদাতার নাম)

_____

1.2 Age (বয়স)
*Not less than 18 (18 **বছরের উপরে**)*

_____

1.3 Gender (লিঙ্গ)

- ◯ Male (পুরুষ)
- ◯ Female (মহিলা)
- ◯ Other (অন্যান্য)

1.4 Level of Education (শিক্ষাগত যোগ্যতা)

- ◯ No formal education (নিরক্ষর)
- ◯ Primary (প্রাইমারী)
- ◯ Secondary (সেকেন্ডারী)
- ◯ SSC (এসএসসি)
- ◯ HSC (এইচএসসি)
- ◯ Bachelor or above (সম্মান বা ঊর্ধে)

1.5 Profession (পেশা)

If multiple job, please ask the major job

- ◯ Student (ছাত্র)
- ◯ Unemployed (কর্মহীন)
- ◯ Housewife
- ◯ Self-employed/Business (রিক্সাচালক, অটোচালক, ব্যবসা ইত্যাদি)
- ◯ Farmer (কৃষক)
- ◯ Day Labour (দিন মজুর)
- ◯ Private Service
- ◯ Government Service

1.7 Number of household member (Male) [বাড়ির পুরুষ সদস্য সংখ্যা]

_____

1.8 Number of household member (Female) [বাড়ির মহিলা সদস্য সংখ্যা]

_____

How money people earn money at your home? আপনার পরিবারে উপার্যনক্ষম ব্যক্তি কতজন?

_____

1.6 Monthly (Household) Income (পরিবারের মাসিক আয় কত?)

- ◯ 1-10000
- ◯ 10,001-20,000
- ◯ 20,001-30,000
- ◯ 30,001-40,000
- ◯ 40,001-50,000
- ◯ More than 50,000

1.9 Household type (বসত-বাড়ির ধরন)

- ◯ Pucka (পাকা)
- ◯ Semi Pucka (সেমিপাকা)
- ◯ Kutcha (কাঁচা)
- ◯ Jhupri (ঝুপরি)

1.10 Household story type (উক্ত বাড়ি মোট কত তলা)

(1,2,3,4,5 etc)

_____

1.11 Household ownership type (বাড়ির মালিকানার ধরন)

- ◯ Tenant (ভাড়াটিয়া)
- ◯ Owner (বাড়িওয়ালা)

1.12 Which floor the respondent live in? (উত্তরদাতা কত তলায় বসবাস করেন)

(1,2,3,4,5 etc)

_____

2. Fire hazard related questions

2.1 Did you witness or experienced any fire accident? (আপনি কি কখনও অগ্নিকান্ড দেখেছেন বা সে অবস্থায় পরেছেন?

- ◯ Yes (হ্যাঁ)
- ◯ No (না)

2.2 What is the level of risk of fire at your house do you think? (আপনার মতে আপনার বাড়িতে অগ্নিকান্ড ঘটার ঝুঁকি কেমন বলে আপনি মনে করেন?)

- ◯ No Risk (0) [কোন ঝুঁকি নেই]
- ◯ Low Risk (1) [অল্প ঝুঁকি]
- ◯ Medium Risk (2) [মধ্যম ঝুঁকি]
- ◯ High Risk (3) [উচ্চ ঝুঁকি]
- ◯ Very High Risk (4) [অতি উচ্চ ঝুঁকি]

2.3. Do you think the fire can occur from cooker/stove at your home? (আপনি কি মনে করেন রান্নার চুলা থেকে অগ্নিকান্ড হতে পারে?)

- ◯ Yes (হ্যা)
- ◯ Maybe (হতেও পারে নাও হতে পারে)
- ◯ No (না)

2.4. Do you go somewhere else or do other jobs while cooking? (রান্না করার সময় আপনি অথবা যিনি রান্না করেন অন্য কোন কাজে রান্নাঘরের বাইরে যান?)

- ◯ Frequently (নিয়মিত)
- ◯ Often (প্রায়ই)
- ◯ Occasionally (মাঝে মাঝে)
- ◯ Very rare (খুব কম)
- ◯ Never (কখনই না)

2.5. How frequently you check the condition/status of your stove/cooker? (কতদিন পর পর রান্নার চুলার অবস্থা পরীক্ষা করেন/করান?)

- ◯ Never (কখনই না)
- ◯ Once a year (বছরে একবার)
- ◯ Once a month (মাসে একবার)
- ◯ Once a week (সপ্তাহে একবার)
- ◯ Everyday (প্রতিদিন)

2.6. Do you think an electric short circuit can cause fire at your home? (আপনি কি মনে করেন ইলেক্ট্রিক শর্ট-সার্কিট থেকে বাড়িতে আগুন লাগতে পারে?

- ◯ Yes (হ্যা)
- ◯ Maybe (হতেও পারে নাও হতে পারে)
- ◯ No (না)

2.7. How frequently you check the electricity line of your house? (আপনি কতদিন পর পর বাড়ির বিদ্যুত লাইন পরীক্ষা করেন/করান?)

- ◯ Never (কখনই না)
- ◯ Once a year (বছরে একবার)
- ◯ Once a month (মাসে একবার)
- ◯ Once a week (সপ্তাহে একবার)
- ◯ Everyday (প্রতিদিন)

2.8. Do you know where the electric main switch of your house is? (আপনার কি জানা আছে বাড়ির বিদ্যুতের মেইন-সুইচটি কোথায় আছে?)

- ◯ Yes (হ্যা)
- ◯ No (না)

2.9. Do you use multi-plug at your home? (আপনি কি বাড়িতে মাল্টিপ্লাগ ব্যবহার করেন?)

- ◯ Yes (হ্যা)
- ◯ No (না)

2.10. Do you have a fire extinguisher (e.g. fireball, fire blanket etc.) at you home? (আপনার বাড়িতে অগ্নিনির্বাপনের কোন ব্যবস্থা কি আছে? যেমন- কার্বন সিলিন্ডার, ফায়ার বল ইত্যাদি)

- ◯ Yes (হ্যা)
- ◯ No (না)

2.11. Do you have a smoke detector and or fire alarm at you home? (আপনার বাড়িতে কি কোন ফায়ার অ্যালার্ম বা স্মোক ডিটেক্টর আছে?)

- ◯ Yes (হ্যা)
- ◯ No (না)

2.12 Have your ever participated in any fire drill? (আপনি কি কখনও কোন অগ্নি-নির্বাপন মহরায় অংশগ্রহন করেছেন?)

- ◯ Yes (হ্যা)
- ◯ No (না)

3. Earthquake (seismic) risk perception related questions

3.1. Did you witness or experienced any earthquake? (আপনি কি কখনও ভূমিকম্প দেখেছেন বা উক্ত অবস্থায় পরেছেন?)

- ◯ Yes (হ্যা)
- ◯ No (না)

3.2. Do you agree that a severe earthquake may hit your living place? (আপনি কি মনে করেন যে আপনার বাসস্থান ভূমিকম্প কবলিত হতে পারে?)

- ◯ Strongly disagree (পুরোপুরি অসম্মত)
- ◯ Disagree (অসম্মত)
- ◯ Neutral (হতেও পারে নাও হতে পারে)
- ◯ Agree (সম্মত)
- ◯ Strongly agree (পুরোপুরি সম্মত)

3.3. Do you agree that the earthquake will affect you and your family? (আপনি কি মনে করেন ভূমিকম্পে আপনি এবং আপনার পরিবার ক্ষতিগ্রস্থ হতে পারে?)

- ◯ Strongly disagree (পুরোপুরি অসম্মত)
- ◯ Disagree (অসম্মত)
- ◯ Neutral (হতেও পারে নাও হতে পারে)
- ◯ Agree (সম্মত)
- ◯ Strongly agree (পুরোপুরি সম্মত)

3.4. Do you agree that the earthquake may result in your property damage? (আপনি কি মনে করেন যে ভূমিকম্প জান-মালের ক্ষতি করতে পারে?)

- ◯ Strongly disagree (পুরোপুরি অসম্মত)
- ◯ Disagree (অসম্মত)
- ◯ Neutral (হতেও পারে নাও হতে পারে)
- ◯ Agree (সম্মত)
- ◯ Strongly agree (পুরোপুরি সম্মত)

3.5. Do you agree the earthquake may result in death and injury? (আপনি কি মনে করেন যে ভূমিকম্প মৃত্যু বা জখম ঘটাতে পারে?)

- ◯ Strongly disagree (পুরোপুরি অসম্মত)
- ◯ Disagree (অসম্মত)
- ◯ Neutral (হতেও পারে নাও হতে পারে)
- ◯ Agree (সম্মত)
- ◯ Strongly agree (পুরোপুরি সম্মত)

3.6. How fearful are you about a possible earthquake? (একটা সম্ভাব্য ভূমিকম্পের জন্য আপনি কতটা আতঙ্কিত?)

- ◯ Not fearful (একেবারেই ভীত নই)
- ◯ Little fearful (কিছুটা ভীত)
- ◯ Moderate fearful (ভীত)
- ◯ highly fearful (খুবই ভীত)

3.7. Do you have any first aid kit or any emergency kit to face earthquake occurrence? (আপনার বাড়িতে কি ভূমিকম্প মোকাবেলার জন্য কোন ফার্স্ট-এইড কিট বা কোন জরুরী কিট আছে?)

- ◯ Yes (হ্যা)
- ◯ No (না)

3.8. Do you have any emergency exit for such type of situation? (এই ধরনের দূর্যোগে বাড়ি থেকে বের হবার বিকল্প কোন দরজা/পথ আছে?)

- ◯ Yes (হ্যা)
- ◯ No (না)

Urban Quality of Life and Perception

4.1 For how long are you living in Rangpur city? (আপনি কতদিন যাবৎ রংপুর শহরে বসবাস করছেন?)

_____

4.2 Do you think that multiple deprivation exist in your area? (আপনি কি মনে করেন রংপুর শহরের বিভিন্ন ওয়ার্ডে বহুমুখী বৈশম্য বিদ্যমান?)

- ◯ Yes (হ্যা)
- ◯ No (না)
- ◯ নিশ্চিত না

4.3 Are you satisfied with the urban facilities in your area? (আপনার এলাকায় বিদ্যমান নাগরিক সুবিধায় আপনি কি সন্তুষ্ট?)

- ◯ Yes (হ্যা)
- ◯ No (না)

4.4 What could be the priority service (mention one) to reduce the deprivation/ in your area? (বৈষম্য কমানোর জন্য কোন বিষয়টি সর্বোচ্চ গুরুত্বপূর্ণ বলে আপনি মনে করেন?)
(শুধুমাত্র একটা গুরুত্বপূর্ণ বিষয় উল্লেখ করতে হবে)

_____

Appendix-4

4.1 Interview Questions for officials and elected members of Rangpur City Corporation

Q1: According to some definitions, 'multiple deprivation' is referred to the deprivations in different services and capitals within the city area, such as at electoral ward level. Do you agree with this definition?

Q2: According to our understanding, do you think the multiple deprivation exists in Rangpur City?

Ans: will be recorded.

Q3: What are the possible reasons behind this situation?

Q4: to what extent it can be reduced, and what are the ways?

Q5: Do you have any experience of earthquake or fire hazard or both?

Q6: What do you think about a potential earthquake hazard at this city? What is the preparedness RpCC has to deal with if there is an earthquake hazard? What is the future-plan of RpCC in this regard

Q9: What do you think about a potential fire hazard at this city? What is the preparedness RpCC has to deal with if there is a fire hazard? What is the future-plan of RpCC in this regard

4.2 Questions for Social worker/activist

Q1: According to some definitions, 'multiple deprivation' is referred to the deprivations in different services and capitals within the city area, specifically, at electoral ward level. Do you agree with this definition? According to our understanding, do you think the multiple deprivation exists in Rangpur City?

Q2: What are the possible reasons behind this situation?

Q3: As a social worker/activist what you want from the authority to reduce the deprivation or to ensure equal access to services over the city?

Q4: What do you think about a potential earthquake hazard at this city? That is the preparedness do you think already have here to deal with if there is a disaster? What could be the future planning?

Q5: What do you think about a potential fire hazard at this city? That is the preparedness do you think already have here to face if there is a disaster occurred by fire? What could be the future planning in this regard?

4.3 Questions for Fire service Officers/fighters

Q1: According to some definitions, 'multiple deprivation' is referred to the deprivations in different services and capitals within the city area, specifically, at electoral ward level. Do you agree with this definition? According to our understanding, do you think the multiple deprivation exists in Rangpur City? Is some part of this city deprived of your services?

Q2: What do you think about a potential fire hazard at this city? What is the preparedness do you have to face if there is a disaster that occurred by fire?

Q3: Which period of a year is more vulnerable to the fire hazard?

Q4: What type of difficulties do you face during an operation?

Q5: What is/are the strength that fire service have/has?

Q6: What are missing/lacking?

Q7: How this can be improved?

Q8: Do you have ambulance service integrated with your team? If not, what you do with the evacuated/injured people?

4.4 Questions for University Teachers/Subject Expert

Q1: According to some definitions, 'multiple deprivation' is referred to the deprivations in different services and capitals within the city area, specifically, at electoral ward level. Do you agree with this definition? According to our understanding, do you think the multiple deprivation exists in Rangpur City?

Q2: What are the possible reasons behind this situation? What are the solutions in general?

Q3: As a teacher/researcher, what you expect from the authority to reduce the deprivation or to ensure equal access to services and developments over the city?

Q4: What do you think about a potential earthquake hazard at this city? What is the preparedness do you think needed to face if there is a disaster? What could be the future plan?

Q5: What do you think about a potential fire hazard at this city? What is the preparedness do you think is needed to face if there is a disaster that occurred by fire? What could be the future plan?

Q6: Have you conducted or have the plan to conduct research activities/seminars/workshop on those issues?

Q7: What could be the possible role of your organization to reduce the vulnerability of those hazards?
Ali,