RISK EVALUATION AND ITS PRIORITIZATION IN THE LESSER HIMALAYA CITY, NAINITAL

THESIS

SUBMITTED TO

FOREST RESEARCH INSTITUTE (DEEMED TO BE) UNIVERSITY

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FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN ENVIRONMENT MANAGEMENT

SUBMITTED BY

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UNDER THE GUIDANCE OF

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(INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION)

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Dated: 07/07/2022

DECLARATION

This is to certify that the thesis entitled, "**Risk Evaluation and its Prioritization in the Lesser Himalaya city, Nainital**" submitted to Forest Research Institute (Deemed to be) University, Dehradun by **Mr. SACHIN YADAV** for the fulfillment of award of the degree of M.Sc. (Environment Management). It is a record of my original piece of work carried out at Forest Research Institute, Dehradun. No part of this work has been submitted for the award of any degree or equivalent.

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He bears very good moral character and is sincere and hardworking; I wish him success in all endeavors.

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This is to certify that the thesis entitled **"Risk Evaluation and its Prioritization in the Lesser Himalaya city, Nainital"** is a record of bonafide work carried out by **Mr. SACHIN YADAV**, student of M.Sc. (Environment Management) programme of Forest Research Institute (Deemed to be) University, Dehradun, submitted in fulfillment of the requirement for the degree of M.Sc. Environment Management.

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ABSTRACT

The number of disasters around the world has seen a spike, be it biological pandemics, economic disparities, high inflation, high unemployment, high population, flash floods, water scarcity and sanitation. The impact of any hazard depends on vulnerability and resource availability at the area of effect. After rapid urbanization in plains, hilly areas have observed a surge of infrastructure development, population increase but unlike plains hilly areas often face geological constrictions, different ecological state, hydrological issues, different economic & livelihood profile and different weather patterns than plains; making these locations more vulnerable to such type of risks. This work of research tends to focus on risk analysis from the perspective of people involved and a model for prioritizing risks according to the local area and situations. The studied site Nainital city provides all the possible aspects for any other hilly terrain town/city, where the study provides with a baseline data for disaster management in its proactive stage. Tackling a disaster when it's a risk reduces the losses, fiscal amount involved and the time taken to recuperate from the damages. Thus, prioritization of the risk provides ample clarity for opting the risks to tackle according to their risk levels, this type of model might be taken up by other cities in plains. The study also provides the citizens and the authorities an insight required for the awareness and concurrent update for the place and the risks associated with it. In the same way in Nainital landslide, healthcare crisis, earthquake, in-migration, storm water management & flash floods, livelihood crisis have been turned out as major risks accordingly; different cities/towns or locations in lesser and middle Himalayas can carry out risk prioritization for the same purpose of pro-active planning and prevention of disaster which are better than post-disaster rescues and cure.

Keywords: Urbanization, Natural Disasters, Hydrological Issues, Nainital, Proactive approach, Risk Prioritization

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BD – Biodiversity Loss

EQ – Earthquake

FF – Flash Floods

G Dept – Government Department

HC – Healthcare Crisis

IM – In-Migration

IMSW – Inadequately Managed Storm Water

IWS – Inconsistent Water Supply

LBG – Lower Business Group

LC – Livelihood Crisis

LLD – Lake Level Decline

LS – Landslide

LULC – Land Use Land Cover

M – Matrix

P – Pollution

PC – Photo Courtesy

RP – Risk Prioritization

SWD – Solid Waste Disposal

UB – Urbanization

WR – Water Resources

CHAPTER 1

1. Introduction

We reside in a disaster-prone world, where there are risks lurking in the dark ready to vandalize the vulnerable masses with the hazard it possesses due to lack of resources available to tackle, counter or merely survive through the event. With the onset of Pandemic in late 2019 and early 2020, the definition of a disaster was broadened up and its consequences can be reflected into the World Economic Forum report namely the Disaster Risk Report, where we can easily spot the changes that occurred in the top most disasters list. Usual top spots were occupied with natural disaster but the recent trend has been observed as biological, social, economic and natural resources scarcity & destruction have popped up in the report. As holding either strong likelihood of happening and causing harm or carry a strong impact locally and globally depending on geology, natural resources and events that happen at those places.

Generally seen, places like highly populated cities, spots that carry a huge floating population or places that are placed in a very fragile eco-system are under more threat to be stricken by disastrous events. The general formula of a risk becoming a disaster as discussed earlier involves the hazard, vulnerability and lack of adequate resources to tackle with it, all three factors sum up to release a catastrophic event on masses. Urban areas are being at the center of disasters like pandemic, social and economic due to high human interaction that they involve in a given geographical area, the upward trend in Urbanization throughout the world especially the Asian Regions has been observed lately.

Figure 1: Urban Spots, (PC - Cedar)

Urbanization is an important global change process, leading to changes in land-use patterns and intensity. These changes, concerning natural resource use, socio-demographic,

health, and global environmental change become increasingly important. In 1900, only 3 % of the world population lived in cities, which has risen to 47 % within a hundred years (Michaels *et al.*, 2012). In 1950 there were 33 cities with populations above one million, by 2010 this number increased to more than 460 (Haase D. *et al.*, 2018). At present, 55% of the population resides in urban areas, which is expected to increase to 68% by 2050 (Ritche and Roser, 2018). Much of this population shift will happen in low-income countries concentrated in Asia and Western Africa, with population growth rates of 3-5 % a year¯. Asian cities cater to more than half of the world's urban population. Asian cities are urbanizing rapidly and recorded the highest urban growth across all regions of the world (Dahiya, 2012). Projections show that Asia will reach 50% urbanization by 2026. The emergence and expansion of cities is a time taking process and the unavoidable result of our continued exploitation of earth's natural resources and environment (Ding and Peng, 2018). As a result, newly formed cities are not only locations of increasing population and consumption but also environmental pollution, natural resource depletion, economic, social and biological disasters.

The towns in the Indian Himalayan ecosystems that became tourist spots in last few decades have observed the same effect of getting turned into cities with high population, fragile eco-system and a huge floating population providing enough stress on natural resources and bringing the urban vulnerability towards the risks.

Figure 2: High Population and Tourism spots, (PC - Cedar)

Provided all these risks that a city is facing in the Himalayan like eco-system; that is rapidly growing but also falls under vulnerable areas that might see a disaster in the upcoming days. Similar situation can be conferred at other spots in the hilly regions, areas that have become well established or the areas that are on development stage.

Figure 3: Rapid Urbanization (Traffic) and infrastructure (Multi Lane roads) development,

(PC- Cedar)

Aim

The present study aims to provide a brief risk report where the risks associated with the study site have been identified and prioritized accordingly. The report aims to be useful for citizens of Nainital and raise awareness towards a more responsible citizenry. Finally, this study aims to encourage other vulnerable cities of Himalaya for preparedness and long-term sustainability of the cities.

OBJECTIVES

1. Identification of Risks, their sources, causes and threats faced in Nainital and its environment.
2. Risk Evaluation and prioritization based on survey among stakeholder groups.
3. Identification of perceived vulnerability by different pre-defined stakeholder's groups on the basis of analysis of Evaluated Risk Data.

CHAPTER 2

2. Review of literature

This section discusses several studies done by researchers on Nainital.

Rather than tackling these risks once they become disaster in multiple cities, it is better to prevent them or keep them in check so as to avoid any multi-level catastrophe on the cities.
As a result of high urbanization rates and changing climatic conditions, fragile urban centers are already facing several problems, including threats of natural disasters. The city that fulfils most of the prospects is Nainital city:
Nainital by the nature of its geological formations is a highly fragile city (Tiwari and Joshi, 2020). This fact has been scientifically established by eminent scholars through published research since Nainital was inhabited.
Several small and big landslides over the past 170 years have occurred, in some cases damaging life and property (the 1880 landslide took the lives of 151 individuals) (Gupta *et al*., 2016), it merits to be noted that the population of Nainital at that point was less than 10000 individuals. It is estimated that more than 100000, registered and non-registered individuals reside in this city (Shalini Gupta, 2014) inhabiting delicate slopes. Nainital falls under seismic zone IV (Rautela *et al*., 2015). The possibility of an earthquake of higher magnitude is warranted by scientists across the world.

Over the years unabated rampant construction has taken place in the city despite strict construction bylaws. The incessant rain for two days in October 2021 pushed the authorities on the back foot and exposed the ability to tackle situations (Sahu *et al*., 2021). The absolute mayhem created a fear psychosis in the minds of the residents. Climate change is believed to have led to this downpour, but many argue that the situation was largely aggravated due to the human alteration of the Nainital landscape.

Based on scientific assessments from India and worldwide the Himalayan region is likely to frequently experience such events of similar or more magnitude in the future. The COVID-19 pandemic also exposed the city to new dimensions of problems such as lack of medical infrastructure and supply of essential life-saving medicines. The high influx of tourists during the peak season increases the vulnerability; a place meant for less than 1000 people at a time is now inhabited with more than 100,000 individuals living permanently in the city.
On top of that Nainital receives more than 80,000 people during the peak season, bringing the natural resources of the city under huge pressure.

Nainital is one of such towns in Himalayan geology that faces the situation as explained, Nainital and mythologies have always been together, it has been referred in 'Skanda Purana' as the Tri-Rishi-Sarovar as well as it is said to be one of the 64 shakti peeth, the one where Goddess Sati's eye fell thus a lake (tal) formed named after her 'Nain' creating a crater.

If we are to see the documented information, it was unknown and religiously sacred place until Mr P. Barron; a British Businessman found it and started British settlement around the lake. The modern day Naini city is the outcome of that settlement which was once a summer capital and destination for many British officers.

Nainital has always been a city that is famous for:

- Scenic beauty and tourism
- Naini lake
- Naina-Devi temple
- Pleasant weather
- Educational institutes

Nainital has been in limelight for being a place with risks that include:

- Hydrological issues – inconsistent water supply, declining lake level, water quality, drying of springs, water resource crisis.
- Rapid expansion – urbanisation, rapid land-use land-cover change.
- Frequent natural disasters – earthquake, landslides, flash floods.
- Loss of bio-diversity, livelihood crisis, in-migration.

To date, the response to disasters has largely been reactive. Given the significant impact that natural risks and climate change will have on urban investments, increasing priority is now placed on proactive, adaptive planning to reduce and manage the potential for disasters and climate change. With this recognition, the value of identifying, diagnosing, and mapping high-level risks is gaining visibility and importance (Aubrecht, 2013). Thus, a risk Prioritization is important before availing any scheme/planning for the approach discussed earlier (Mona Nasser, 2020). The Risk Prioritization (RP) is targeted towards city managers and citizens of Nainital for their use to identify feasible measures to assess the city's risk and bring in priority towards high risks areas that require immediate action. The objectives for the study involve identifying the risks associated with Nainital city and its natural surroundings. Analysing and prioritising the risks based on the risk level relayed by the matrix method which will be elaborated further. Also, the risks pertaining to specific stakeholders are to be identified and prioritised accordingly.

The purpose of Sharma (2006) was to divide the area around Nainital in Kumaon Himalaya into zones of relative sensitivity to landslides. The geological characteristics employed in the study include slope forming material, structural features, tangent of slope angle, slope direction, spatial distribution of landslides, and land use pattern. Thematic maps of slope morphometry, slope forming material, and landslide occurrence are created, and their interlayering yields multiple parametric inputs. The town's micro-zoning of landslide danger has been undertaken, with the development of a failure probability model that assesses the failure of slopes out of the total number of slopes in a specified domain of geo-factors. The crucial zones were then subjected to slope mass assessment based on the bedrock lithology, bedding-dip relationship, and state of structural discontinuities, among other factors. Slopes with more than 80% failure probability were categorised as very high landslide hazard prone, while slopes with 80% to 50% failure probability, 50% to 20% failure probability, and less than 20% failure probability were classed as High, Moderate, and Low on the map, accordingly. The micro-zonation model of the landslide danger around the town demarcates the terrain with the relative severity of the hazard that has been employed for town urban design. Such a micro-zoning concept could be useful for urban planning in mountainous areas.

Nainital is a prime example of a Lake Township that has been adversely damaged by human activities as urbanisation has spread. The consequences of these pressures are felt in a variety of ways and from a variety of sources. Increasing local population from 6903 in 1901 to 38559 in 2001, as well as a logarithmic growth in tourist intake into the watershed, has impacted the area's water supplies and biodiversity. In the last two to three decades, a large number of water supplies have dried up. The study by (Shah *et al*., 2009) is an attempt to document and relate the population rise and increase in the concrete jungles in the Nainital catchments over the last 50 years to its influence on forest cover, forest density, biodiversity, and water resources. Certain herb and shrub species once common in oak woodlands (*Q. leucotrichophora* and *Q. floribunda*) have now become extinct. The tree richness in the Nainital catchment region is 11, the shrub richness is 19, and the herb richness is 51, whereas the richness in disturbed forest is dropping and is 7 for tree species, 19 for shrubs, and 31 for herb species. The work done in this study is significant because it demonstrates the changes that are occurring in forests that are declining due to constant biotic pressure.

Nainital, a popular tourist destination in Uttarakhand's Lesser Himalayas, has been frequently ravaged by natural disasters since 1866, despite the fact that habitation began only after 1841. The area is seismically active and is located in Zone IV of India's Earthquake

Zoning Map. The area's vulnerability was heightened by tectonically active, brittle mountains and the rapid rate of urbanisation. Aside from rainfall, the same region is mostly responsible for the onset of slope instability and landslides. (Khanduri, 2019) made an attempt to compile a list of natural disaster events and their consequences from 1866 to the present. Some of the most recent slope instabilities and landslides are also discussed.

Jain *et al*., (2021) attempted to study changes in land utilization/land cover from 2006 to 2019 in Nainital using Google Earth. Images from a different era are used as a foundation map for developing land utilization/coverage. The study area is divided into five categories: open space, agricultural land, vegetation, water bodies, and built-up areas. The findings show that over the last fourteen years, there has been a significant decrease in open space, vegetation, and agricultural land of approximately 19 percent (i.e., 0.03 square kilometres), 22 percent (i.e., 1.83 square kilometres), and 18 percent (i.e., 0.03 square kilometres), respectively, while the built-up area of Nainital town has increased by approximately 68 percent (i.e., 1.89 sq.km).

Chauhan *et al*. (2021) analysed water vulnerability across multiple wards of a Himalayan tourist city, Nainital, using the IPCC approach, taking into account three dimensions: exposure, sensitivity, and adaptive capability. Seven indicators, principally geographical (aspect, elevation) and climatic (land surface temperature), as well as some water infrastructure (distance to water distribution) and population, were evaluated for the construction of a vulnerability index utilising the Analytical Hierarchy Process to allocate weights. These indicators were straightforward to extract and obtain, largely from secondary sources, and were capable of accounting for variability at the micro-level. Furthermore, the existing adaptive methods for water security were generated from surveys of randomly selected households across the wards. The most vulnerable wards were Staff House and Harinagar. According to the survey results, the adaptation mechanism should be handled at both the person and organizational levels. Policy initiatives such as optimum water use, grey water recycling, spring rejuvenation, rain water harvesting, and leakage proof infrastructure with the involvement of new technologies, as well as public participation, may be considered and implemented to reduce water vulnerability in the city. Appropriate water vulnerability measures would also give support for improving tourist amenities in the city, resulting in increased economic prospects for inhabitants.

CHAPTER 3

3. Materials and Methods

3.1 Study area

Nainital, one of the major cities in Nainital district, the 'Lake district' of Uttarakhand is located at about 280 km distance from the capital city Dehradun and about 320 km from the National capital New Delhi by road. Situated between 28º58' N & 29º36' N and 78º51′ E & 79º58' E (Nainital geography database) at an average elevation of 1938 m amsl, Nainital faces pleasant weather conditions of Avg. Min temp -2 ˚C, Max temp 29.3 ˚C and an Avg. Rainfall of 1744mm. The area of the township 'the study area' is 11.73 sq. km with a population of 41377 (India census, 2011).

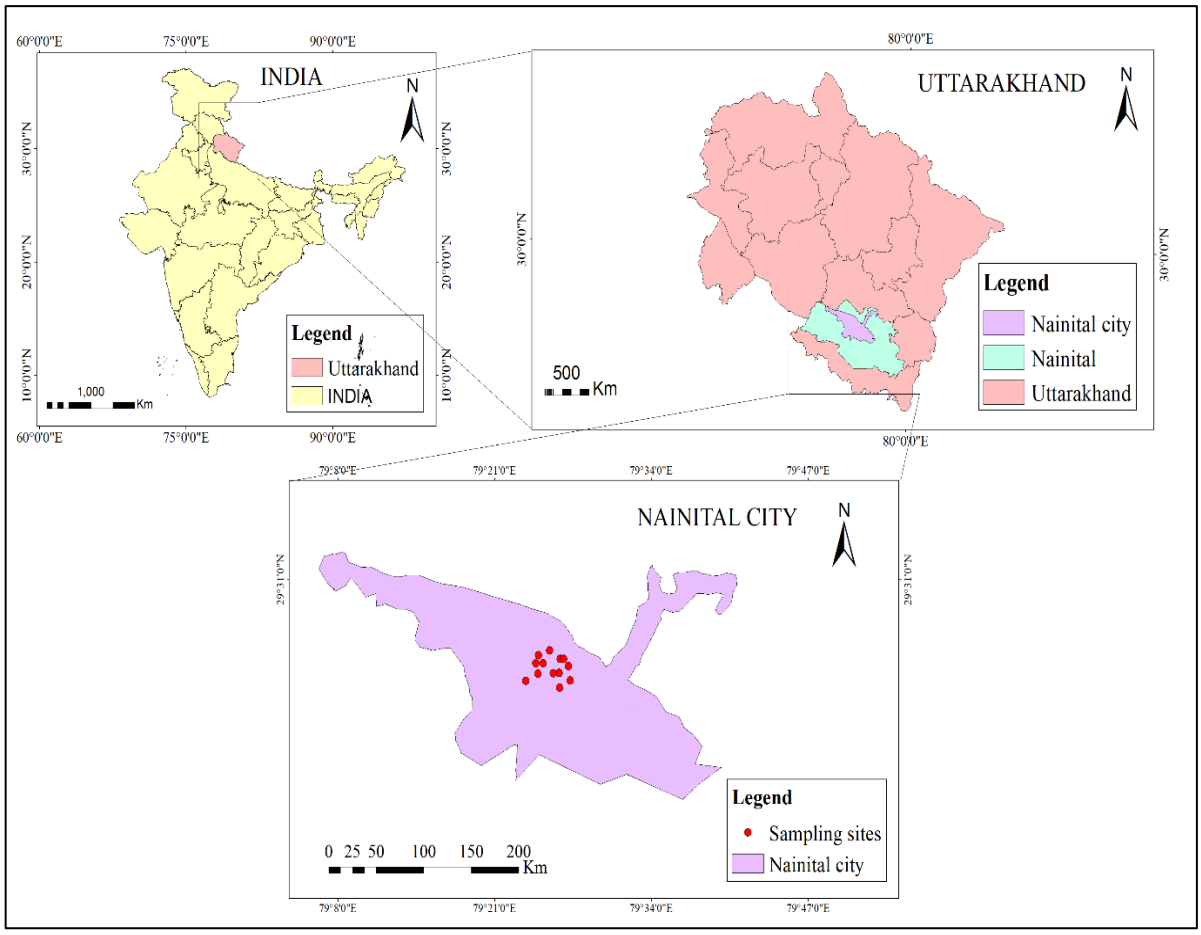

Figure 4: Map of Study Area (Source: self)

3.2 Research Philosophy

Interpretivist research philosophy is associated with the current study that involves the understanding and interpretation of social world in a subjective manner. It deploys the

philosophy of how people experience and interact with the social world. Researcher inculcates focused attention to how the social world unravels itself, the researcher's interest dwell and lead the research questions and observation made during the research tend to outlay the required answers interpreted from people and their interaction with the world around them (their surroundings) (Zukauskas *et al*. 2018).

3.3 Research Approach

3.3.1 Deductive Approach

Deductive approach refers to the one where a thesis is provided followed by experiments and observations to support the thesis or provide a relatable finding (Soiferman *et al.*, 2010). A mixed research approach was availed to make the most out of the research question with the collection of:

3.3.1. A Primary Data

It is any form of evidence that we collect ourselves through our own research in the form of surveys, questionnaire, interviews, focus groups, experiments and observations (Victor and Ajayi, 2017) (research guides database). This was followed in the context of preparing stakeholder groups and preparing questionnaire for them and collecting data by conducting surveys. Photos were captured by Poco X3 Pro camera Phone by self and Mr. Hardik Shah both interns at Cedar Himalaya, Dehradun.

3.3.1. B Secondary Data

It is the collection of evidence and results from previous researches (research guides database). Several Disaster management reports, incidents and their studies were skimmed through to identify risks their causes and threats faced by people in Nainital, Nainital city and its natural surroundings.

Thus, the combined research approach was used where secondary data provided with the basis of research and gave one end of the thread that was followed by the primary data research which allowed us to get through the barrier of focusing on one or a fixed category of risks, rather a large number of risks could be looked upon all the while preparing a stakeholder groups list which theoretically provided us a different perspective to risk assessment to different people in growing towns and cities.

3.4 Research Data

Out of the two types of research data designs namely qualitative and quantitative, the latter was chosen to initiate quantitative research as it provides results on the specific issue that is in the limelight and the use of statistical, mathematical formulae and computational programme are involved to produce the same (Babbie and Earl, 2010). A closed end questionnaire was provided to the respondents, wherein the answers would be compiled so as in to see specific patterns (qualitative) that can be relatable to the thesis or a new finding.

3.5 Research Framework

Theoretical Framework for the study involves risk Identification and risk evaluation as major points of research as both are at the ends of the research thread involved in the study.

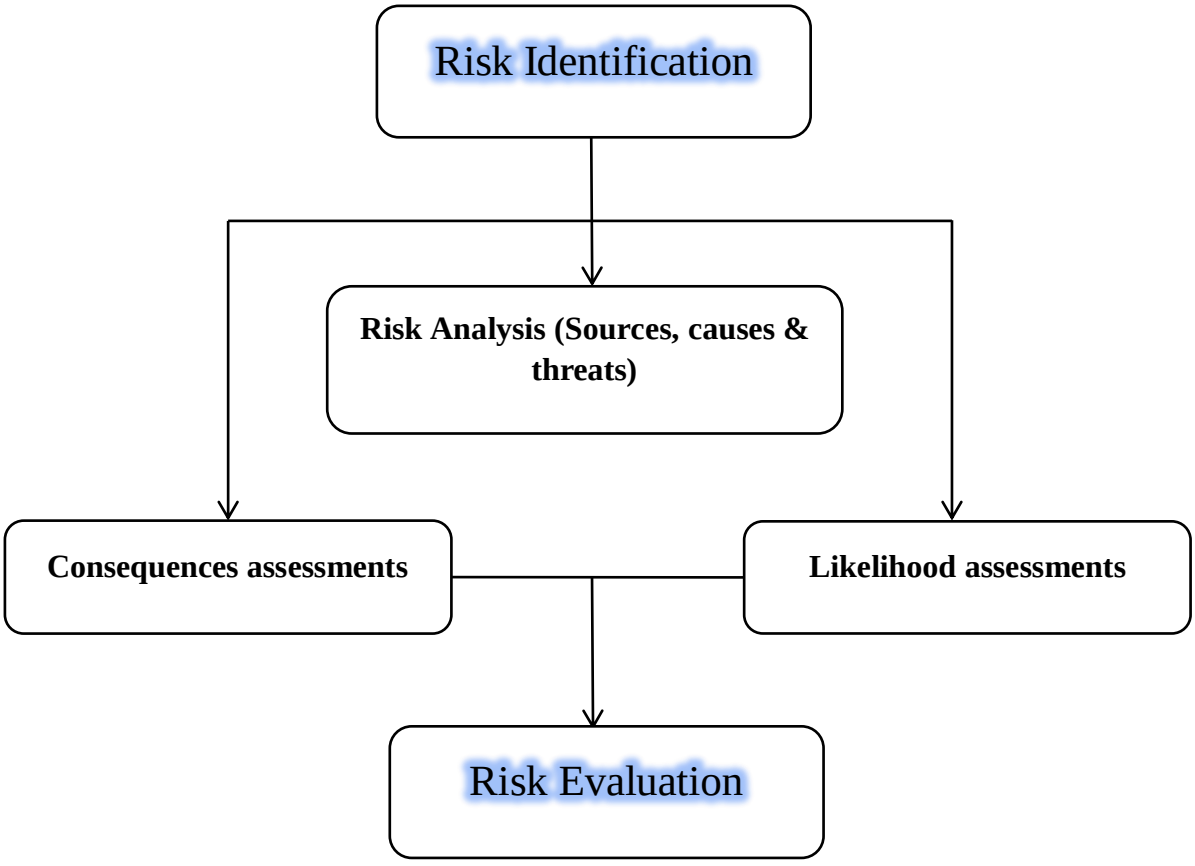

Figure 5: Theoretical Research Framework, courtesy – Team Cedar

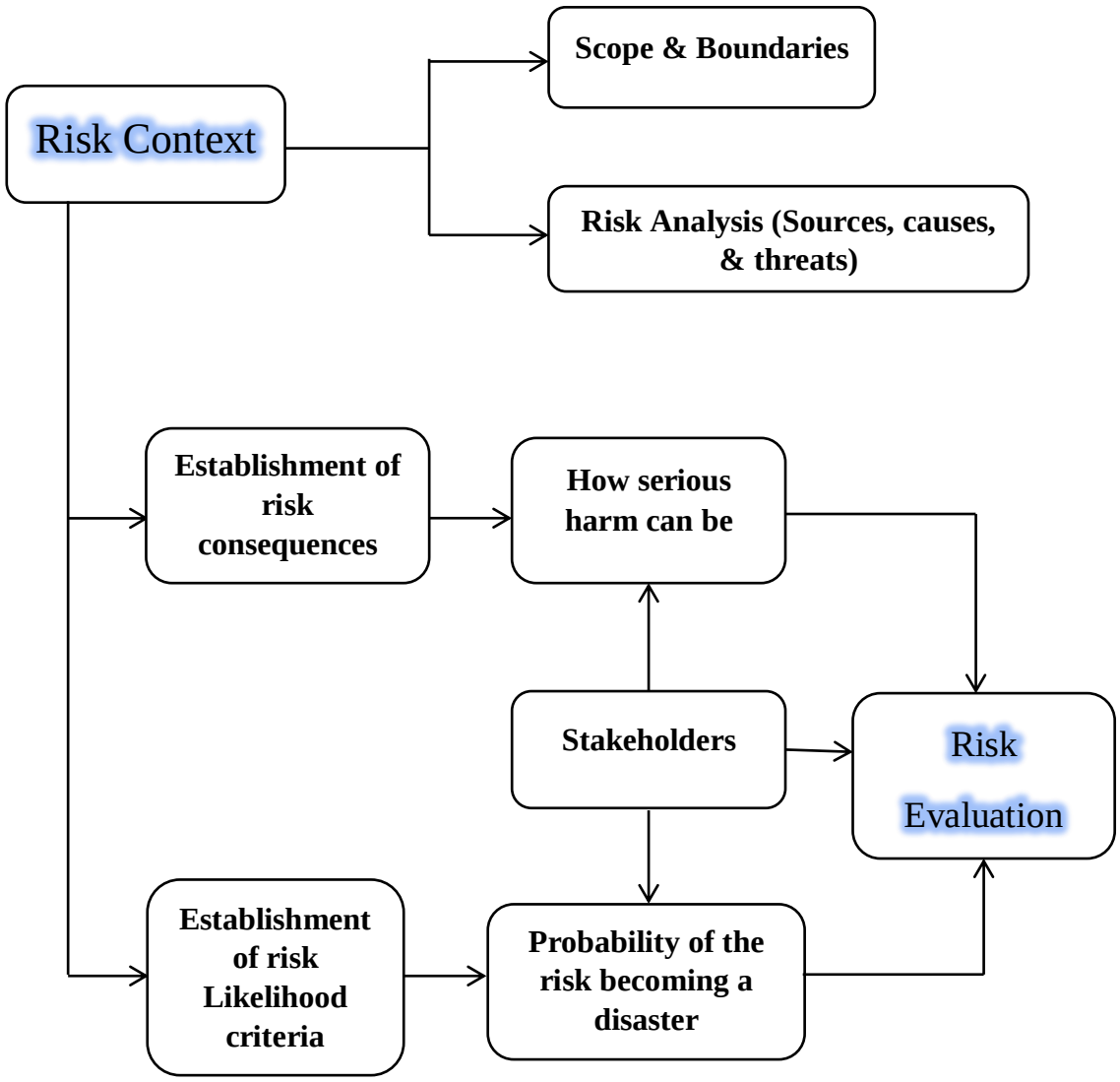

Figure 6: Conceptual Research Framework, Team Cedar

3.6 Sampling Method

The sampling method availed to meet the requirements for the research was Purposive where choosing the sample stakeholders groups and their sample size was totally reliant on the self and research experts' judgements (Palinkas *et al*., 2013). This selective approach for the sampling was to track the thesis provided for the research in social conditions that prevail in Nainital at ground zero. The motive was also to get as many variations from the possible stakeholders groups so as to observe biased perspective which is very important for the possible outcomes of the research and have a wider outreach for the study.

These Stakeholder groups hold individuality when fixing sample sizes and collecting samples, sub-sampling of the groups were purposive and convenient (Sedgwick P., 2013) as mentioned in the fore-coming tables. The stakeholders were divided in 8 groups as follows:

Table 1: Stakeholders Groups *(R) – Random **(S) – Selective

S.no	Stakeholders group	Group members	Sub-sampling	Sample size
1.	Residents of city	Local population living in different wards	Purposive	50 **(R)***
2.	Government Departments	Irrigation Department, Jal Sansthan, Jal Nigam, Nainital Nagar Palika Parishad, Lake Development Authority (LDA), District Magistrate Office (DMO)	Convenient	5 **(S)****
3.	Educational Institutes	Schools, College, University	Convenient	5 **(S)**
4.	Hospitality Industry	Hotels, Restaurants, Café shops	Purposive	30 **(R)**
5.	Lower business group	Boatmen, Rickshaw pullers, Horse riders	Purposive	50 **(R)**
6.	Trade Association	Shop owners, petty shop owners and vendors Taxi drivers	Purposive	25 **(R)**
7.	Tourists	People of different state, age group with different economic strata	Purposive	30 **(R)**
8.	Others	Lawyers, NGO, Social worker group	Convenient	5 **(S)**
	Sum Total			**200**

3.7 Methods and tools used in process

To initiate and complete the study, several methods were opted from a general risk assessment process. To start off with risks, their sources, causes and threats were identified followed by the scaling of likelihood, consequences (Agarwal, 2018) leading to the Matrix method which provided an insight on the risk level of each risk perceived by every stakeholder.

3.7.1 Identification of risks, their sources, causes and threats

Risks were identified, followed by the associated sources, causes and threats which were concluded by Brain storming, Literature review and following Expert advice.

Figure 7: Balia Nala, Nainital (PC- Cedar)

3.7.2 Questionnaire –

(**Inserted in Appendix I)**

The questionnaire has two sections, where section 1 involves basic Identification and Consent of the stakeholders involved. The second section is the Risk Assessment forms where 15 risks have been stated with threats of the risk awaiting to concurred by stakeholders according to their perception and provide with the Likelihood and Consequences scale for the risks.

3.7.3 Likelihood Scaling

The probability of the hazard causing an Impact and becoming a disaster is called the likelihood of the risk becoming a disaster (Karuppusamy *et al.*, 2021). This can also be associated with the frequency at which a hazard has caused disaster in the study area. The scaling was done after some literature reviewing and brain storming, where we winded up getting the following scale for Likelihood scale in this risk analysis.

Table 2: Likelihood assessment scale (Karuppusamy *et al*., 2021).

No.	Scale	Likelihood of harm
1.	Highly unlikely	Harm may occur only in very rare circumstances
2.	Unlikely	Harm could occur in some limited circumstances
3.	Likely	Harm could occur in many circumstances
4.	Highly likely	Harm is expected to occur in most circumstances

3.7.4 Consequences scaling

The Scale measures the magnitude and severity of risk, the consequences involved several aspects like illness/injury to people, damage to desirable components of Environment, impact on lives in direct/indirect ways. The consequences scaling is as follows:

Table 3: Consequence assessment scale

No.	Scale	Degree of harm to the environment, health and living standard of people
1.	Negligible	Minimal or no increase in illness/injury to people. Bearable impact on living standard of people. Minimal or no increase in harm to desirable components of the environment due to availability of resources to tackle it.
2.	Minor	Minor increase in illness/injury to people that is readily treatable. Minor increase in damage to desirable components of the environment that is reversible and limited in time and space or numbers affected. Life is not at risk.
3.	Intermediate	Significant increase in illness/injury to people that requires specialized treatment. Significant increase in damage to desirable components of the environment that is widespread but reversible or of limited severity. No life loss but slowly affecting lives in direct/indirect ways.
4.	Major	Significant increase in severity of illness/injury to people or large numbers of people affected and generally not treatable. Major increase in damage to desirable components of the environment, with extensive biological or physical disruption to whole ecosystems and communities, which persists over time. Heavy property and life loss.

3.7.4 Matrix Method

Risk level was determined using Matrix method, keeping likelihood and consequences as the factors of assessment. The scaling done earlier holds the reference in the numbers that were fed in the Matrix to find out respective risk level of each risk. The matrix also defines the risk level according to the final score of each risk. For e.g. if a risk has likelihood factor as Highly likely (4) and Consequences factor as Intermediate (3), then according to the matrix the risk score would be 4x3 = 12 i.e. the risk taken up falls in very high level of risk category and needs to be attended as a priority (Kaya *et al.*, 2018).

Table 4: Matrix Method for Risk Analysis (Kaya *et al.*, *2018,*Courtesy – Team Cedar)

Consequences scale – → Likelihood scale ↓	**Negligible 1**	**Minor 2**	**Intermediate 3**	**Major 4**
Highly Unlikely 1	1 LOW	2 LOW	3 MODERATE	4 MODERATE
Unlikely 2	2 LOW	4 MODERATE	6 MODERATE	8 HIGH
Highly Likely 3	3 MODERATE	6 MODERATE	9 HIGH	12 VERY HIGH
Likely 4	4 MODERATE	8 HIGH	12 VERY HIGH	16 VERY HIGH

Table 5: The scaling of risk level (Team Cedar)

Keeping the work of (Astles, 2014) in accordance, the ground zero scenario in Himalayan cities the following risk level scale was devised with 9-16 kept at very high risk level because of the multi-fold increase in the impact as the score keeps on increasing linearly.

Low	**1-3**
Moderate	3-6
High	6-9
Very High	9-16

3.8 Data collection and Analysis

Figure 8: Data Collection via stakeholder interviews (PC- Team Cedar)

Data collected through Primary data collection method was fed into the matrix to provide the relevant risk level to the risk in context. This data and responses were analysed using computer software; the data supplied to the computer software MS excel. Thus, complex patterns were simplified by software analysis showing certain trends among the responses collected from different stakeholders. The results were converted to graphic digestible information using online sources like scatterplotonline.in, rapidtables.com etc.

CHAPTER 4

4. Results and Discussion

4.1 Risk Identification

Secondary data collection was used and the risks identified for the Nainital city were formulated in a table as:

Table 6: Identification, Sources, Causes and threats of a risk

Identified Risks	Source of risk	Cause of risk	Threats	Source
1. Natural Risks				
i. Earthquake	• Adverse Geological settings • Ecologically sensitive zones • Tectonic plate boundaries	• Geomorphic characteristics of the area • Population pressure	• Loss of life & property • Surface faulting, • Ground shaking • Structural damage to buildings • Landslide • Soil liquefaction	Tapish Yadav Feb 08, 2021
ii. Landslide	• Fragile geology • Heavy precipitation	• Unsystematic development construction activities • Deforestation and degradation	• Loss of life & property • Destruction of infrastructure • Damage to land and loss of natural resources • Geographical change can block river and cause floods • Destruction of agriculture and ecosystem	Pande and Pande (2008)
iii. Flash flood	• Localized and abnormally heavy precipitation (cloud burst)	• Unscientific land use planning	• Damage of infrastructures • Death or serious injuries • Deposition of sediment & slit • Economic loss	Pandey & Vishwakarma (2019).
Identified Risks	**Source of risk**	**Cause of risk**	**Threats**	**References**
2. Socio-Economic Risks				
i. Urbanization	• Population growth • Growth in Tourism	• The extension of the road network • Commercialization and economic globalization • Pull factors	• High population density • Inadequate infrastructure • Lack of affordable housing • Increased level of pollution and congestion • Land-use change • Over-exploitation of resources • High energy consumption	Pant, & Chand, 2020

ii. Lack of Medical & Healthcare facilities	• Pandemic • Contagious diseases	• Less no. of hospitals • Shortage of efficient and trained manpower • Lack of infrastructure	• Life loss • Physical and mental fitness • Directly/Indirectly affecting daily life	UK government health database Prashant Jha, 2021.
iii. In migration	• Rural urban transformation	• Lack of basic amenities in Rural areas • Employment Opportunities • Social Benefits and Services • Pull factors	• Over exploitation of resources • Pressure on public services such as schools, housing, and healthcare • Slum creation and encroachment • Overcrowding • Language and cultural barriers can exist. • Increased levels of pollution. • Increased pressure on natural resources. • Racial tensions and discrimination	Uttarakhand's 'ghost villages' Prashant Jha, 2020.
iv. Livelihood crises	• Pandemic (COVID – 19) • Major disaster (Landslide, flash floods)	• Tourism driven livelihood • Less diversity in livelihood	• Short term threat as reduced working hours or loss of job • Basic amenities and right to life at stake	Hindustan times, 2021 Negi *et al.* 2013
Identified Risks	**Source of risk**	**Cause of risk**	**Threats**	**References**
3. Natural Risks				
i. Biodiversity loss	• Land use change • Rapid urbanization	• Climate change • Pollution • Destruction of habitats	• Habitat loss • Ecosystem disturbance • Loss of Ecosystem Services	Global forest watch land cover database
ii. Water resource crises	• Lack of governing body	• Over exploitation of water resources • Unwanted construction in recharge areas	• Inadequate water supply • Lack of access to clean drinking water. • Life at all levels severely affected	Neeraj Santoshi, 2019
iii. Lake level decline	• Increasing water demand	• Over abstraction • Poor management of sewage and urban runoff • Drying of natural springs • Mixing of construction debris into the lake	• Existence of lake as well as city in danger • Disrupted water supply • Negative impact on tourism and economy	Sushmita Senggupta, 2017

iv. Pollution	• Excessive Tourism • Water recreational activities	• Poor Sewerage System • Poor Solid Waste Management	• Negative impact on health • Adverse effect on Eco-system (lake, forest, springs) • Climate change • Introduction of heavy metal into environment	Sharma, (2014). Neeraj Santoshi, 2019
Identified Risks	**Source of risk**	**Cause of risk**	**Threats**	**References**
4. Regulatory Risks				
i. Inconsistent Water supply	• Consistently changing demography with floating population • Increasing water demand	• Overlapping of governing institutions • Lack of alternative source other than lake and its catchment	• Leads to water scarcity • Inadequate sanitation • Spread of water borne diseases	Neeraj Santoshi, 2019
ii. Solid waste disposal	• Demographic pressure • Less effective rules and regulatory system	• Lack of awareness • Non-compliance of rules strictly by Department as well as people	• Pollution • Loss of aesthetic value • Spread of diseases and infections • Introduction of heavy metal into environment	Tewari, Geeta *et. al.* (2013). Municipal Solid Waste Management in Nainital, UK
iii. Land use land cover (LULC) Change	• Population Growth (increasing demand and supply of land in different activities)	• Illegal encroachment • Less effective rules and regulatory system	• Loss of Bio-diversity • Increased surface run-off • Distresses in hydrological cycles • Promote landslide	Rautela *et. al.* (2014).
iv. Inadequately managed storm water	• Blocked/choked drains	• Old rainwater drainage system	• Pollutes lake water • Flood roads and homes • Negative effects on movement and health • Promote landslides	Efficient rainwater disposal for safety of Nainital, Nov 30 2021

4.2 RP – Risk Prioritization

All the data collected from surveys were fed into MS Excel and matrix scores were taken as output; the mean averages were taken for respective risks; their mean of likelihood and consequences were also taken out so as to understand which risks have more probability of happening and which all can cause major impacts once they turn into a catastrophic event. The matrix scores for risks were also put up against each stakeholder groups to find out about which risks are perceived at higher level by respective stakeholder group. Graphs were plotted

as risks against their likelihood mean scores, consequences mean scores, matrix mean scores providing with the graphs as given below:

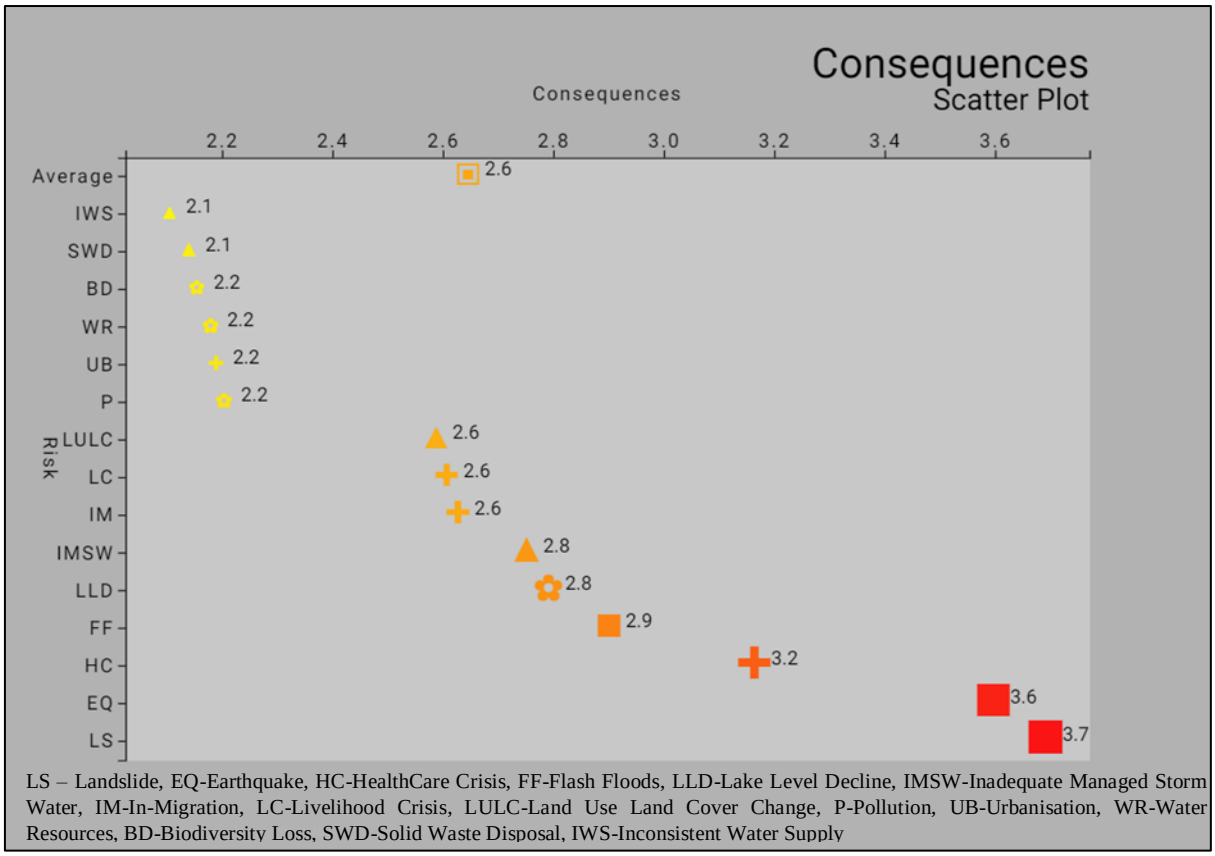

Figure 9: Consequences scatter plot (shows average consequences score of risks)

Natural risks in general held the high risk-level spots in terms of consequences because of the calamity they can become; Landslide, Earthquake, Flash flood at 3.7, 3.6 and 2.9 out of 4 respectively, all dues to the instability in the infrastructures, the geology and the vulnerability of illegal building and over stressed environment and land of Nainital. Other major consequences oriented risks are Health Crisis (3.2), Lake level decline (2.8), Inadequately managed storm water (2.8), In migration (2.6), Livelihood crisis (2.6), Land use land change (2.6) implying on the poor level of secondary healthcare services; the ever increasing water requirements of the population of Nainital; the clogged, closed, built-over drains; high in-migration rates from Rampur, Bareilly and several other social-economic mix ups that have taken place in the last few years of Nainital. Due to all this mix-up, cultural, behavioural, language issues seem to have taken place several times that have questioned the social construct of Nainital, popped up crimes, petty issues over business and tourism related issues and money-backed up competition for spots, shops and licenses.

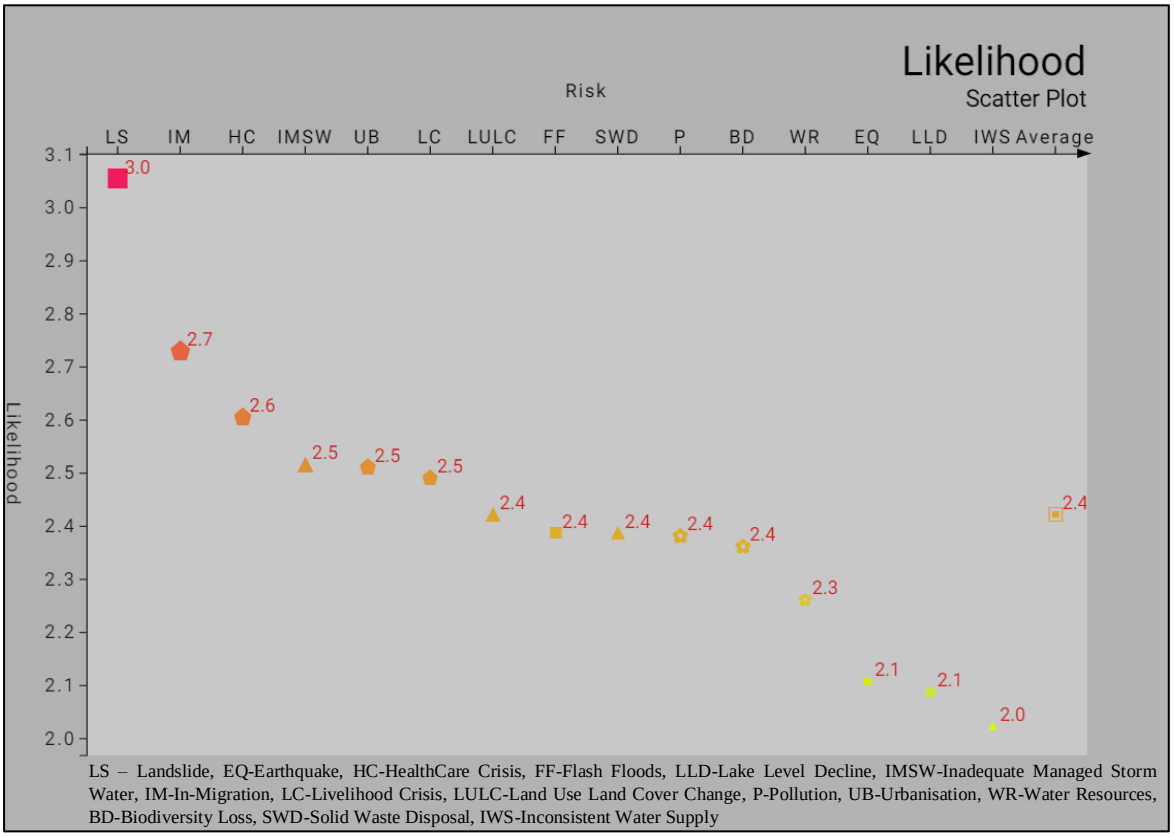

Figure 10: Likelihood consequences plot (shows average likelihood score of risks)

The highest likelihood among all the risks identified were landslide (3.0), in-migration (2.7), health crisis (2.6), inadequately managed storm-water (2.5), urbanization (2.5), livelihood crisis (2.5); urbanization and in-migration further give route to crisis like land use land change, pollution, solid waste disposal and bio-diversity loss.

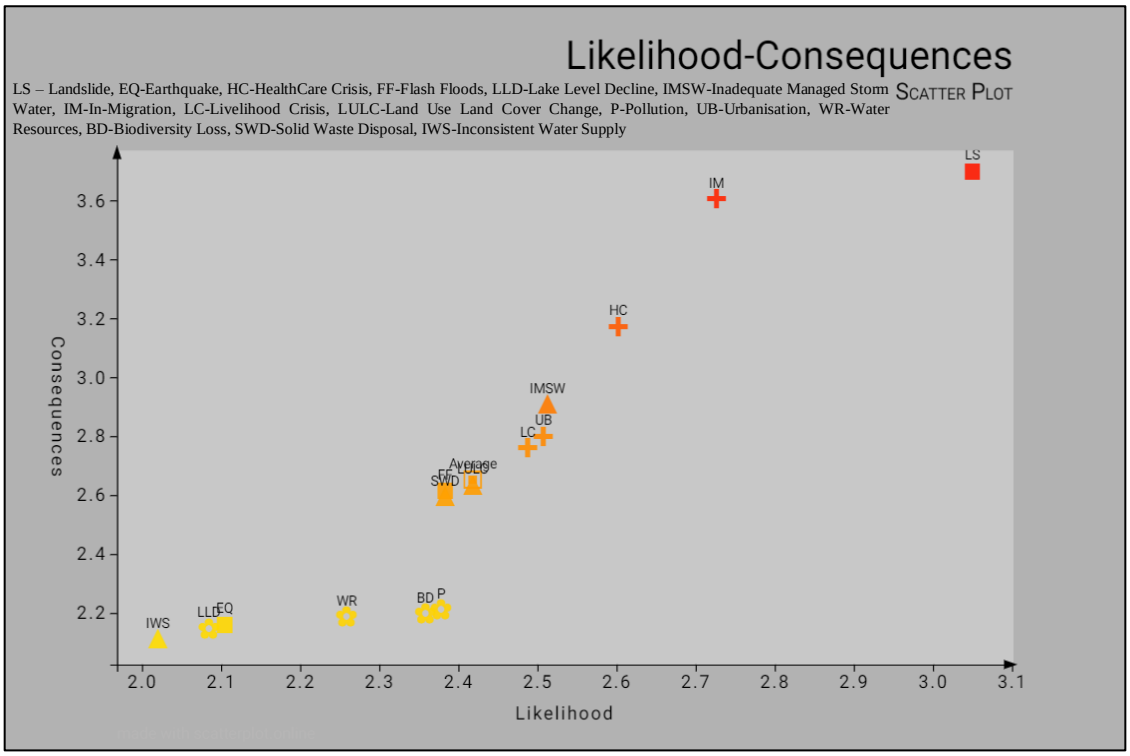

Figure 11: Likelihood-consequences scatter plot (combined)

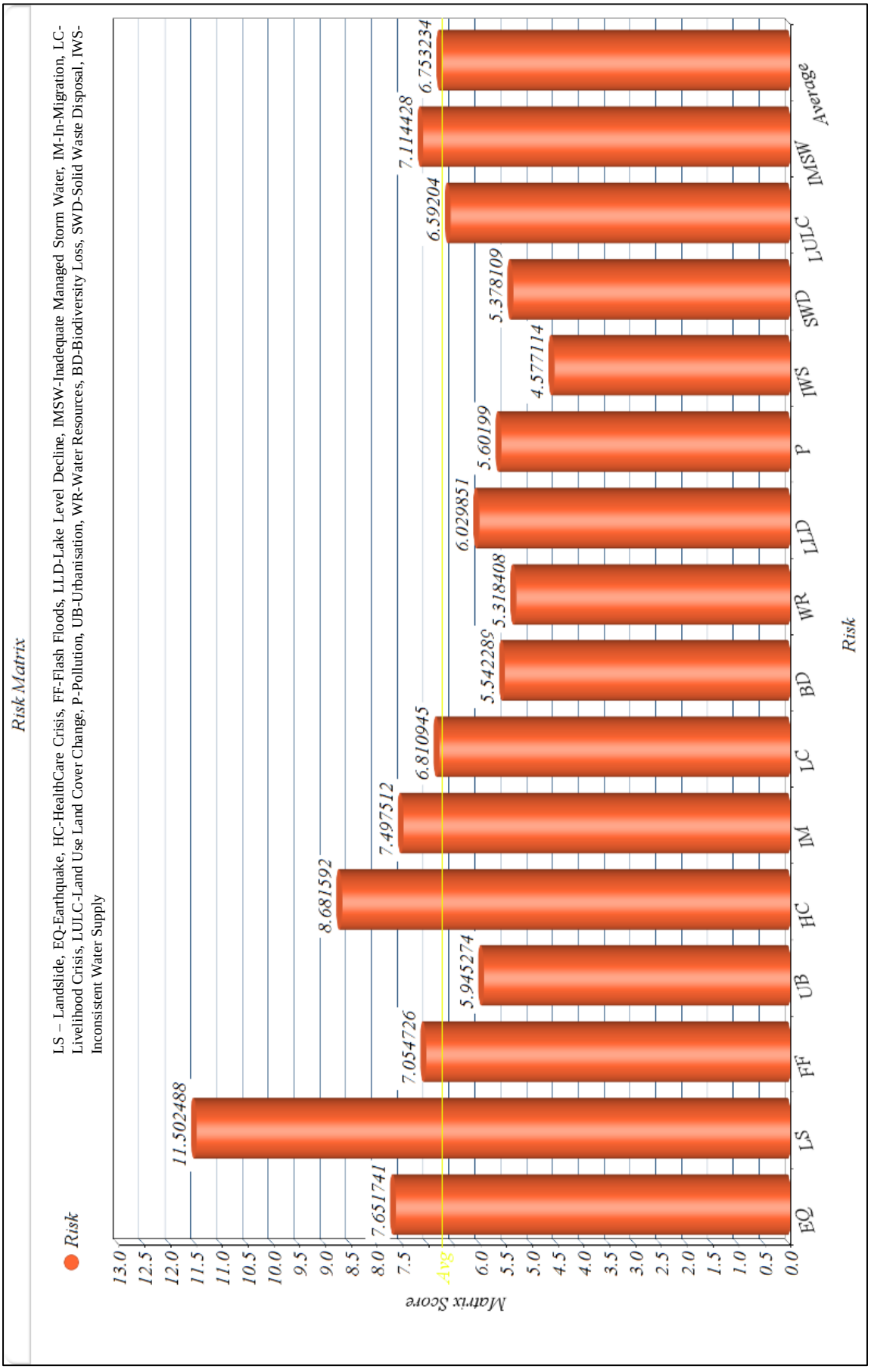

Figure 12: Risk Matrix Score (RMS) of risks

All the risks that were found to be higher than the average in the risk matrix are: Landslide, Health crisis, Earthquake, In-Migration, In-adequately managed stormwater, Flash Flood, Livelihood Crisis; the below average risks are Land-use Land-cover change, Lake-level decline, Urbanization, Pollution, Bio-diversity loss, Solid waste disposal, Water resource crisis, In-adequate water supply as represented below on the scatter plot in ascending order

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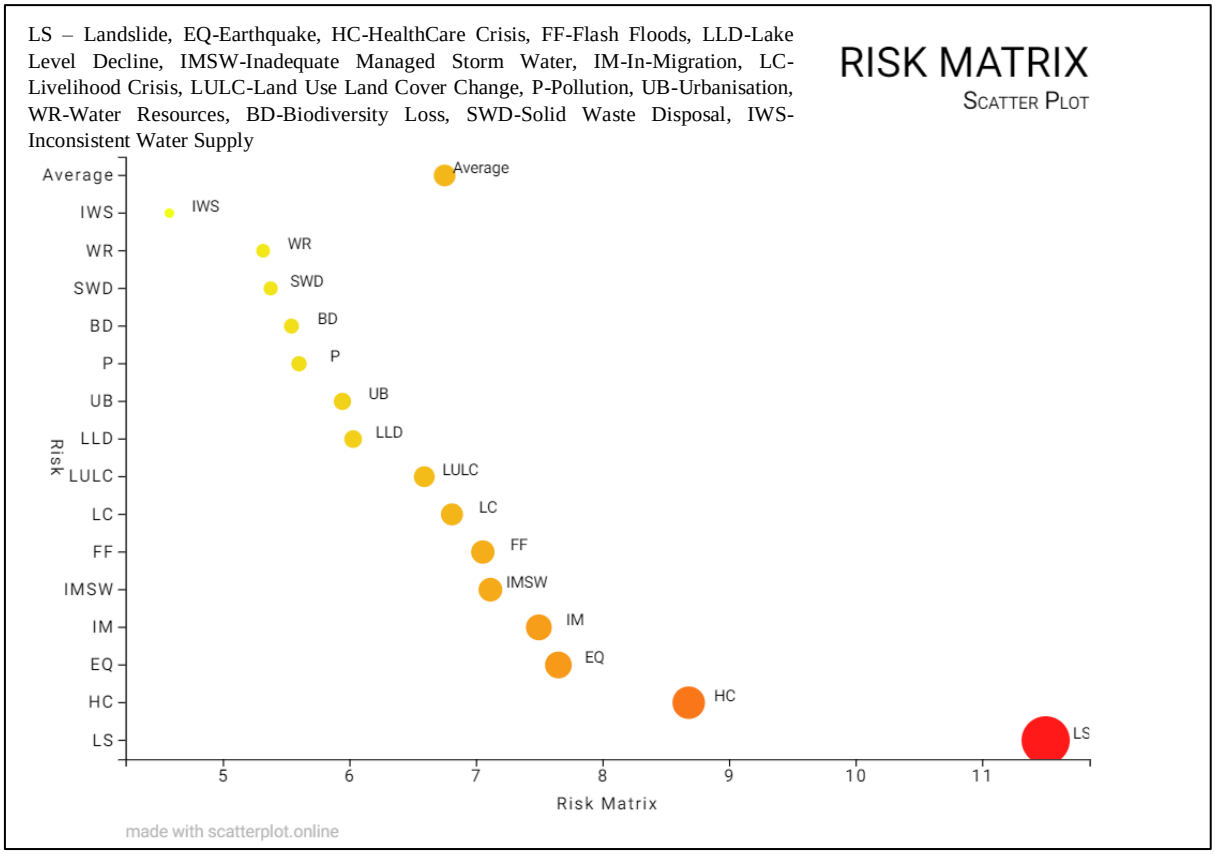

Figure 13: RMS scatter plot

These results based on the perception of the people have provided with the Prioritization of the risks in Nainital City. Furthermore the characterization of stakeholder groups has also been done and the perception of individual groups towards certain risks has been compiled from the collected data. Where the stakeholders participation has been marked in terms of percentages and a compiled Radar map for individual group's risk matrix scores have been represented; might be a but difficult to decipher the same thus major stakeholder groups and their data has been representated in basic bar graphs showing the perceived risk level for the risks identified by the stakeholder groups.

4.3 Stakeholder Groups and their Perception

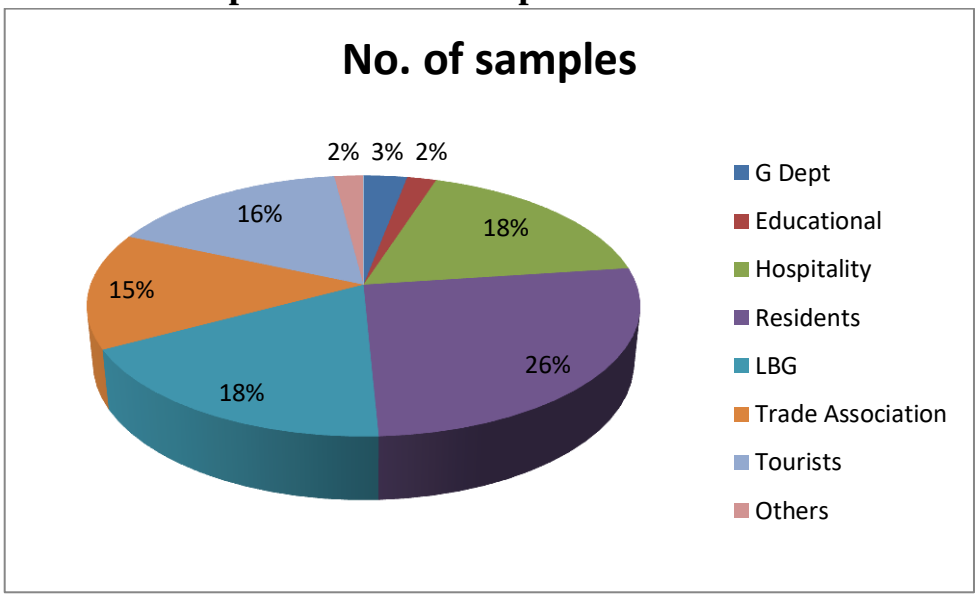

Figure 14: Stakeholder groups' participation

The no. of samples collected were 26% of residents, 18% tourists, 18% of hospitality industry, 16% lower business group, 15% of trade association around the lake, 3% govt dept, 2% educational institutes and 2% others (a sum total of 201).

Figure 15: Stakeholder groups' matrix score Radar graph

The above radar graph has been simplified as bar graphs for major stakeholder groups that have prioritsed the risks according to the group's cumulative perception.

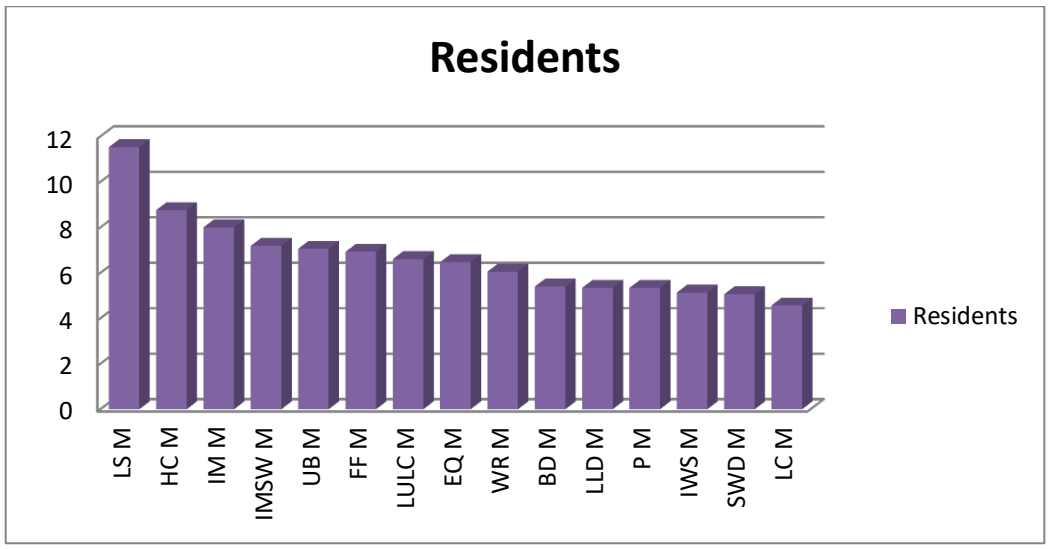

Figure 16: Residents' Risk Matrix Score

The residents have identified with the risks as shown in graph in descending order from the left, providing us with the perceived risks by residents in Nainital city. Landslide, Health crisis In-Migration, IMSW, Urbanization, Flash Floods, LULC change and Earthquake were among the high risk levels by the Residents of Nainital City.

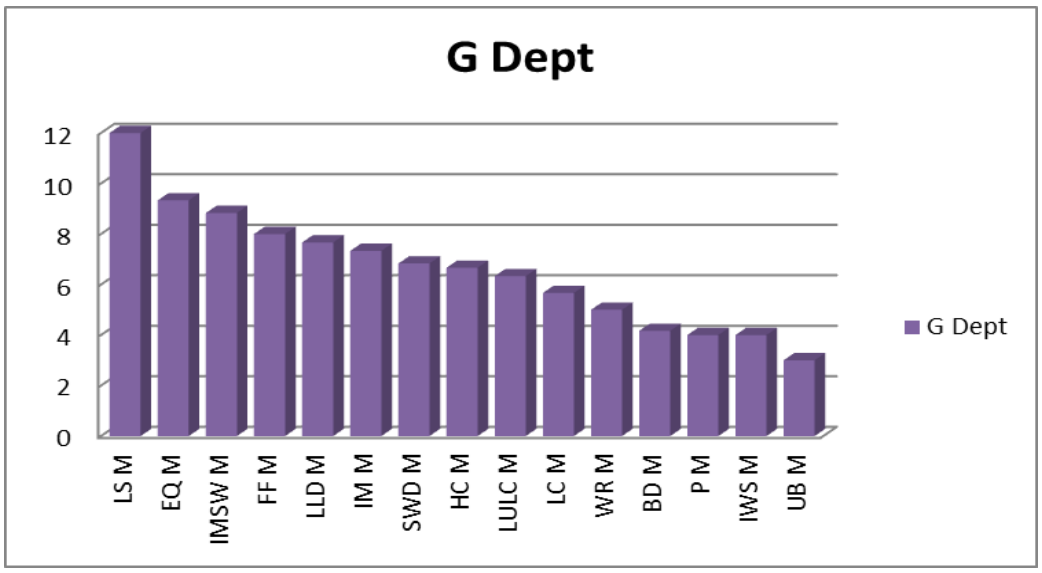

Figure 17: Government Department's RMS

The government department surveys provided the risk Prioritization as Natural risks are more of a menace to the official works that they have to carry, other than that Lake level decline was identified as a major risk by them because of the awareness about how much it can affect Nainital. In-Migration, Solid waste management, Health crisis and LULC change were other risks that attained higher Prioritization in this group.

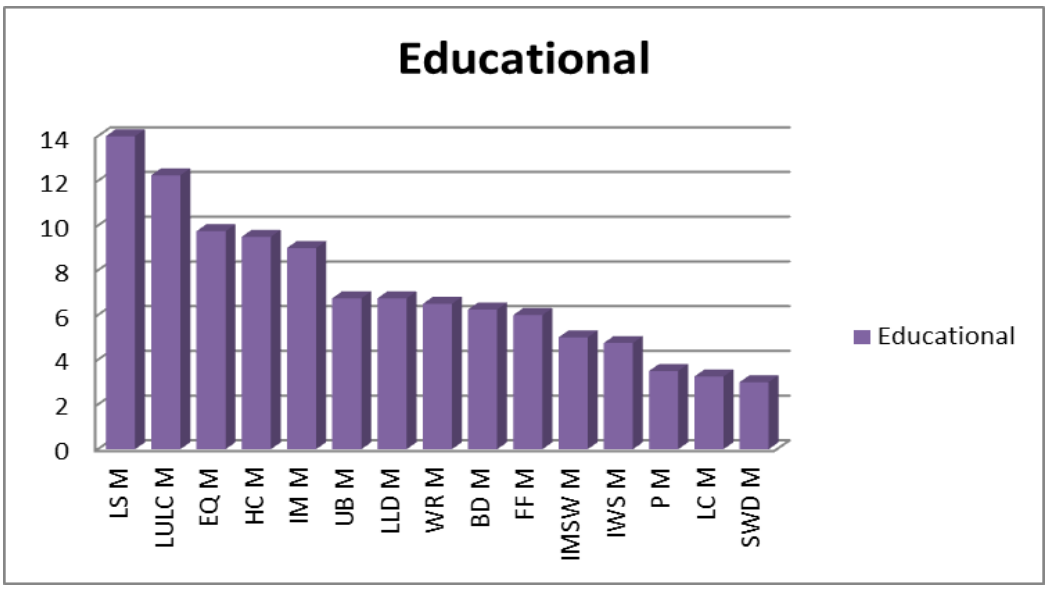

Figure 18: Educational Institutions' RMS

The educational institutes in Nainital municipality refer to Landslide, LULC change, Earthquake, Health crisis, In-Migration, Urbanization, Lake level decline, Water resources, Bio-diversity loss, Flash flood are the major perceived risks in descending order.

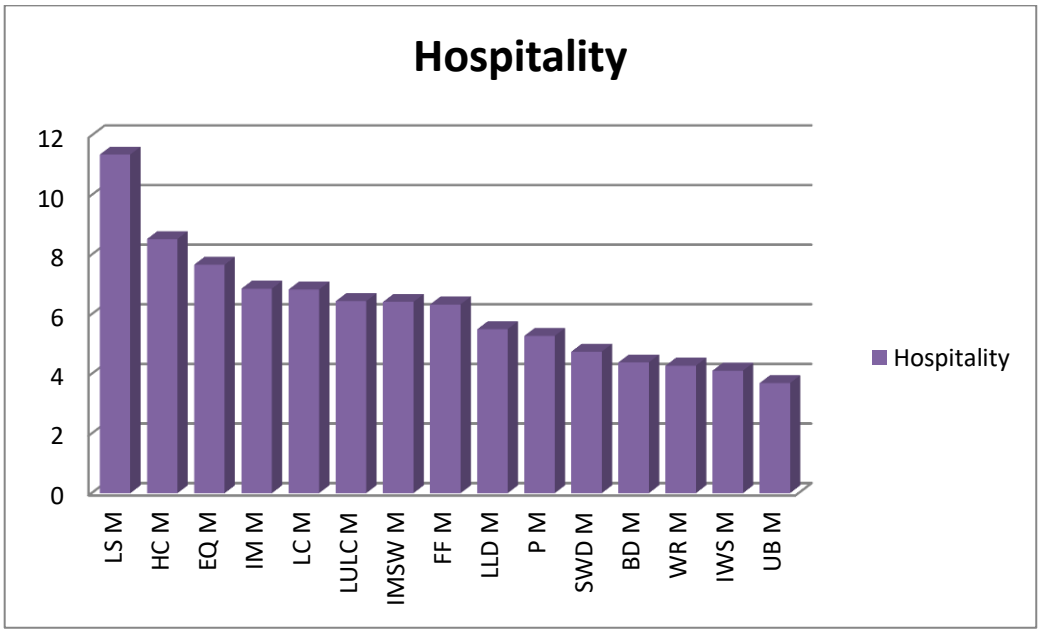

Figure 19: Hospitality Industry's RMS

Major risks perceived by hospitality industry are Landslide, Health crisis, Earthquake, In-Migration, Livelihood crisis, LULC change, Inadequatly managed storm water, flash flood (Major café, hotels, restaurants are around the mall road, where storm water, flash floods cut off tourism count or bring in slurry waters from drains during monsoon often).

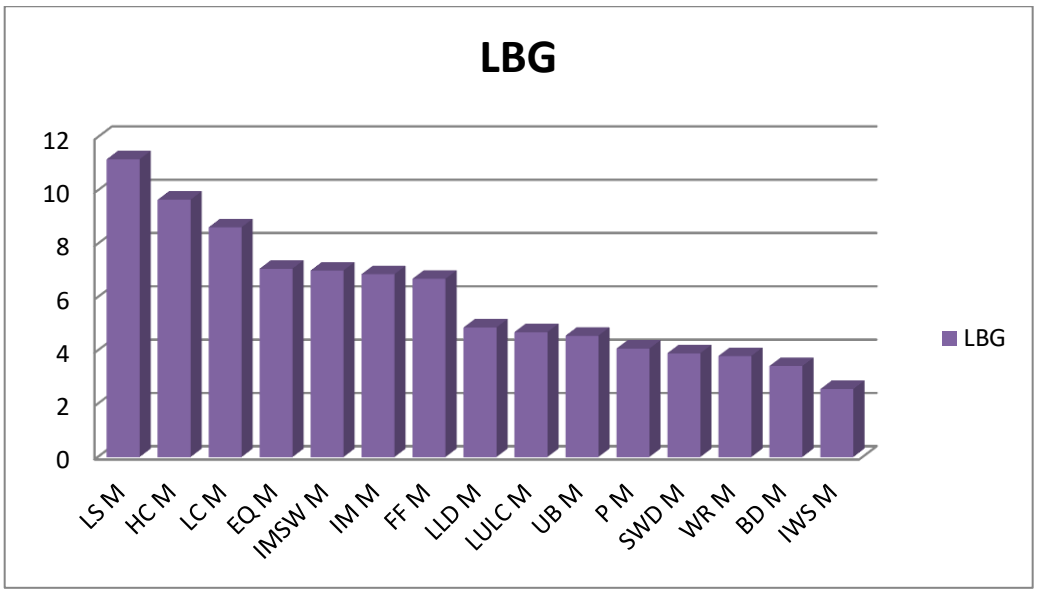

Figure 20: LBG's RMS

The lower business group or LBG identifies Landslide, Health crisis, Livelihood crisis (instable work hours and season based income), Earthquake, Inadequately managed storm water (as areas where LBG people generally stay are either kacha houses or in lower slopes), In-migration and Flash floods as the major risks associated to Nainital city.

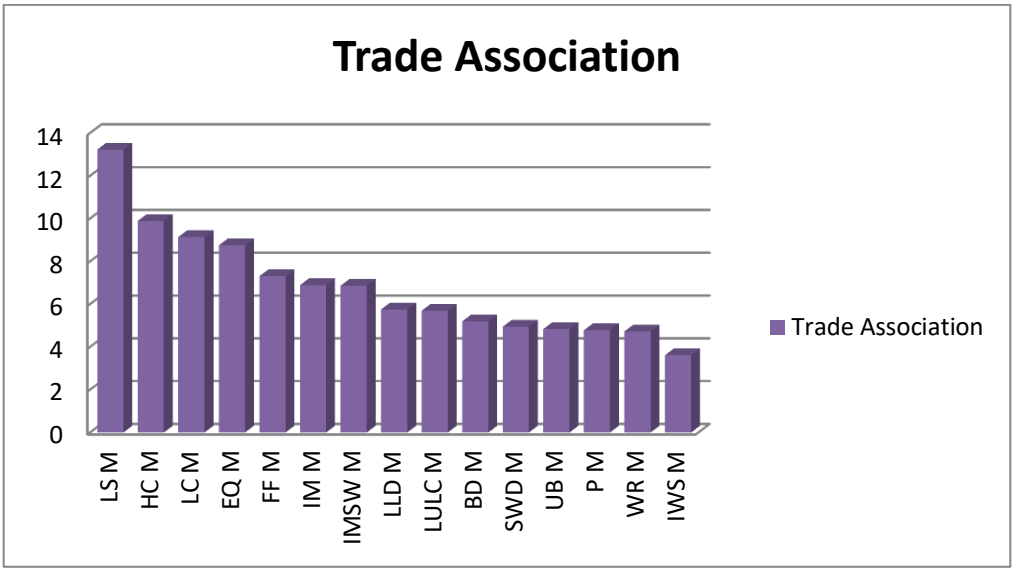

Figure 21: Trade Association RMS

The trade association invloving petty shop owners, vendors, taxi drivers perceives Landslide, Health crisis, Livelihood crisis, Earthquake, Flash Flood (Lake periphery area most affected during heavy rainfall), In-migration (Business affected, License issues), Inadequately managed storm water, Lake level decline, LULC change as risks that require prior attention of the government and citizens.

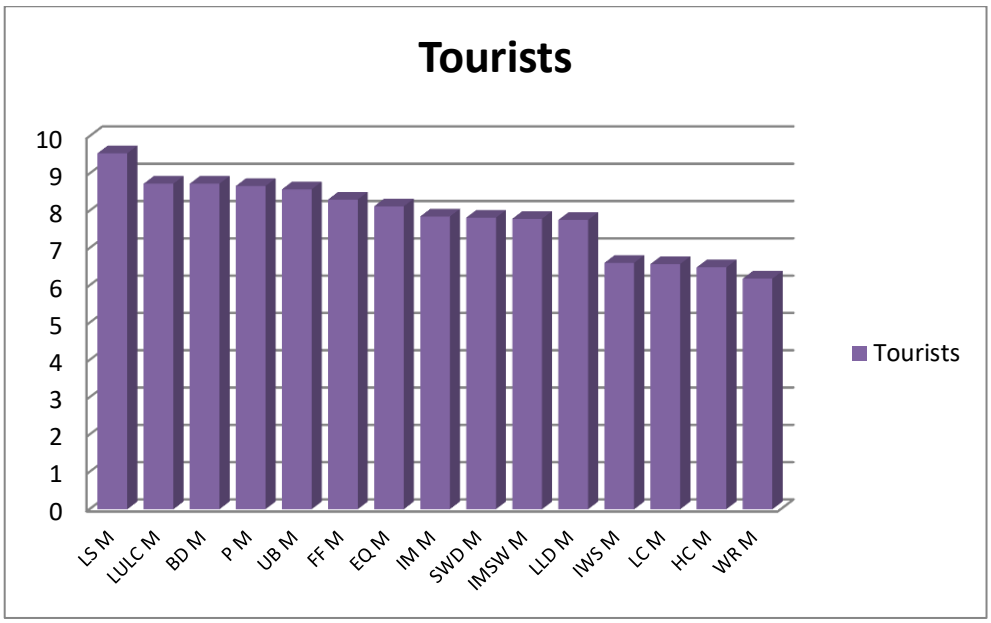

Figure 22: Tourists' RMS

The tourist as one of the major stakeholders in Nainital perceive LULC change, bio-diversity loss, Pollution (incrasing congestion and traffic during tourist season), Urbanization as major threats for a place like Nainital where tourists prefer things that are different from usual urban scenarios. Since the rapid rise in Nainital population, urbanization and number of vehicles that have increased in the past decade have involved.

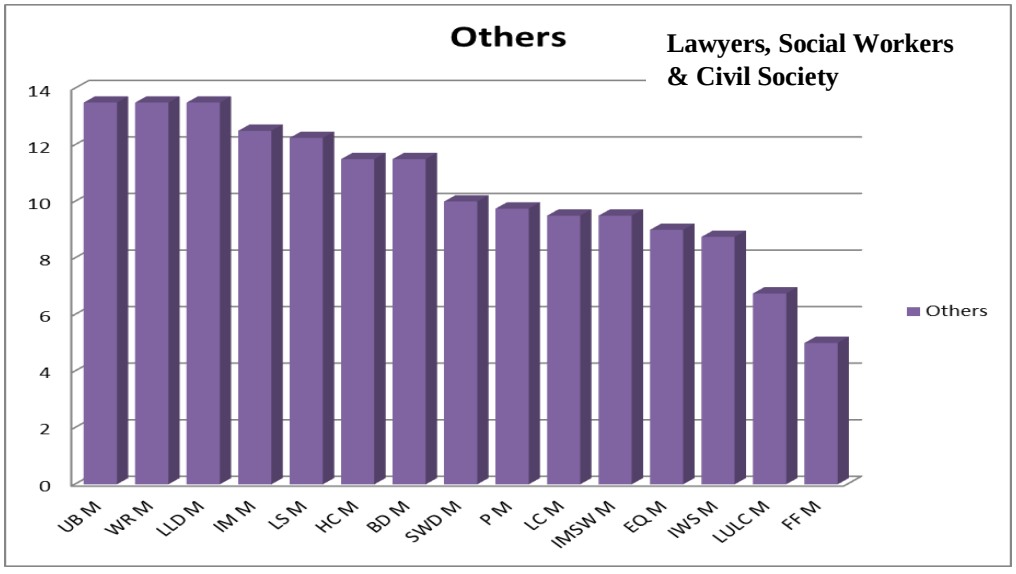

Figure 23: Others' RMS

The others stakeholder groups that involves Social workers, lawyers and civil society. This group perceives Urbanization, Water resources, Lake level decline, In-Migration, Landslides, Health crisis, Bio-diversity loss are one of the major risks in Nainital that might bring disaster to the city in the coming times.

CHAPTER 5

5. Conclusion

5.1 Abstract of significant findings

The following study explores the risk associated with a Himalayan tourism oriented city – Nainital. The risks are associated with natural, socio-economic, environmental and regulatory aspects. These risks mostly cover all the aspects associated with other himalayan cities and towns or tourist places.

1. Risks and their causes, sources and threats have been identified for Naintal city.
2. Risk Prioritization list for the Nainital city has been compiled by the input from all the significant stakeholders (Figure 12).
3. Risks assocaited with particular stakeholders have been identified.

This study has provided how certain stakeholders involved might face different risks in same area depending on all the aspects discussed above; some groups find livelihood crisis as a higher risk than others whereas some find that the In-migration should be handled before handling any other task, whereas health crisis might be affecting people at random where there experiences with the PHC were not as profound as others, might have led to deceased realtives or known people. An increase in population involves urbanization, loss of bio-diversity around also higher waste production with instable, illegal and encroached housings are involved which affect the lake level, solid waste management, water supply and livelihood crisis. Further, all these risks cause a synergic affect on the level of impact from natural risks, causing more damage than anticipitated for the same scenario with less population.

5.2 Utility of Research for stakeholders

All the stakeholders like the trade association, hospitality industry, residents, tourists, and government authorities etc. can get following information from this study:

1. Baseline information that is easy to digest because of Prioritization.
2. It can redefine how they look at this prospect of disaster and risk management in Nainital.
3. This research provides data that is presentable and can be advertised among them for the benefits of stakeholders involved.
4. The awareness about this proactive approach before involving steps for better disaster management can allow the stakeholders to understand the Proactive approach that would

be helpful for the future prospects; all the while availing the stakeholders confidence in the authoritarian actions required for the same.

5.3 Limitations

The limitations of the study include various aspects that firstly start off with time constrictions and consistent silver clouds of covid-19 that are always ready to hamper the pace and feasibility of the study. Secondly, the data collected might only represent a very small fraction of the actual number of stakeholders in the study area, but still a generalized social reaction is expected from the study that might not be absolutely accurate but provides a precise insight about the situation in the study site. Considering ethical issues, consent of every respondent was taken before the filling of the survey questionnaire as well as the identity and privacy of the respondents was kept in mind and precautions were taken in order to keep the data source as validated as possible all the while keeping the respondents' identity safe by keeping personal details to the minimal possible.

5.4 Future Aspects

The general Prioritization of these risks and the peculiar methodology used can be found useful for further studies that might be conducted for similar places. The approach associated with this study tends to provide proactive insight for as to aware people about the risks and their risk levels in the area as well as the authorities to converge their resources and focus towards risks that have been prioritized accordingly. Just like this study has provided an insight on how certain risks require more attention than the other depending on the risk level involved and how it might affect the local zones/areas; other places can also follow the similar studies before planning out the city, the tourist spot or disaster management plans.

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APPENDICES

Appendix I – Questionnaire

Quantitative survey for risk Priorisation and its significance in lesser Himalayan city, Nainital

Consent Statement

I am an intern pursuing M.Sc. in Environment Management from Forest Research Institute (FRI) and doing dissertation with CEDAR (Centre for Ecology Development and Research), a research organization located in Dehradun under the project - "Hydro-geological Assessment and Socio-Economic Implications of Depleting Water Resources in Nainital", funded by Ministry of Jal Shakti, MOWR, Dept. of Water Resources RD and GR. In this context, I am interviewing different stakeholders in Nainital to evaluate and prioritize the major risks (by analysing their likelihood and consequences) faced by the people and environment of the city. Your participation as a stakeholder is completely voluntary and information shared by you will only be used for research purpose.

Section – I: Identification of Stakeholder

Date of interview:

S. No.	Stakeholder Particulars	Response				
1	Consent Agreement (Yes/No)					
2	Age					
3	Gender					
4	Ward No/Locality					
5	Occupation					
6	Qualification	illiterate	high school	intermediate	degree & above	Others
7	How long have you been living in Nainital	by birth	around 5 +years	10+ years	20+ years	Tourist

Section – II: Risk Evaluation Form

Identified Risk	Threats	Likelihood*	Consequence**	Level of Risk
1. Natural Risk				
1.1 Earthquake	**1.** Loss of life & property **2.** Surface faulting, **3.** Ground shaking **4.** Structural damage to buildings **5.** Landslide **6.** Soil liquefaction	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
1.2 Landslide	**1.** Loss of life & property **2.** Destruction of infrastructure **3.** Damage to land and loss of natural resources **4.** Geographical change can block river and cause floods **5.** Destruction of agriculture and ecosystem	**1. H U** **2. U** **3. L** **4. H L**	**1. N** **2. MI** **3. I** **4. M**	
1.3 Flash flood	**1.** Damage of infrastructures **2.** Death or serious injuries **3.** Deposition of sediment & slit **4.** Economic loss	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
2. Anthropogenic Risk				
2.1 Socioeconomic Risk				
Identified Risk	**Threats**	**Likelihood***	**Consequence****	**Level of Risk**
i) Urbanization	**1.** High population density **2.** Inadequate infrastructure, Lack of affordable housing **3.** Increased level of pollution and congestion **4.** Land-use change **5.** Over-exploitation of resources, High energy consumption	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
ii) Lack of medical& healthcare facilities	**1.** Life loss **2.** Physical and mental fitness **3.** Directly/Indirectly affecting daily life	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
iii) In migration	**1.** Over exploitation of resources **2.** Pressure on public services such as schools, housing, and healthcare **3.** Slum creation, encroachment and overcrowding **4.** Language and cultural barriers can exist. **5.** Increased levels of pollution, pressure on natural resources **6.** Racial tensions and discrimination	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	

iv) Livelihood crises	**1.** Short term threat as reduced working hours or loss of job **2.** Basic amenities and right to life at stake	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	

2. Anthropogenic Risks

2.1 Environmental Risk

Identified Risk	Threats	Likelihood*	Consequences **	Level of Risk
i) Biodiversity loss	**1.** Habitat loss **2.** Ecosystem disturbance **3.** Loss of Ecosystem Services	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
ii) Water resource crises	**1.** Inadequate water supply **2.** Lack of access to clean drinking water. **3.** Life at all levels severely affected	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
iii) Lake level decline	**1.** Existence of lake as well as city in danger **2.** Disrupted water supply **3.** Negative impact on tourism and economy	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
iv) Pollution	**1.** Negative impact on health **2.** Adverse effect on Eco-system (lake, forest, springs) **3.** Climate change **4.** Introduction of heavy metal into environment	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	

2. Anthropogenic Risks

2.2 Regulatory Risk

Identified Risk	Threats	Likelihood*	Consequences **	Level of Risk
i) Inconsistent Water supply	**1.** Leads to water scarcity **2.** Inadequate sanitation **3.** Spread of water borne diseases	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
ii) Solid waste disposal	**1.** Pollution **2.** Loss of aesthetic value **3.** Spread of diseases and infections **4.** Introduction of heavy metal into environment	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
iii) Land use land cover (LULC) Change	**1.** Loss of Biodiversity **2.** Increased surface run-off **3.** Distresses in hydrological cycles **4.** Promote landslide	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	
iv) Inadequately managed storm water	**1.** Pollutes lake water **2.** Flood roads and homes **3. Negative effects on movement and health** **4.** Promote landslides	**1. HU** **2. U** **3. L** **4. HL**	**1. N** **2. MI** **3. I** **4. M**	

Google Form Link for the Questionnaire

https://docs.google.com/forms/d/e/1FAIpQLSdev4HLSHti2qDkf4Lb40EGF7MktoXVfvlMfXYPIEBBX_x8vQ/viewform?pli=1&pli=1

Appendix 2 – Field Data Photographs

1. **Harinagar – Balia Nala Landslide, Urbanization Pressure, Waste Disposal**

2. Tallital – Unsafe Unhygenic housing

3. Sukha-tal and Ghoda Stand

4. Solid waste disposal for waste

5. Urban Concerns

6. The Lake vicinity

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