Risk Assessment of Industrial Hazards, Resilience and Disaster Risk Reduction for Sustainability: A Case Study of Industrial Area in Ghaziabad District, NCR Delhi

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Abstract

The industrial area of Ghaziabad district of Uttar Pradesh is one of the vulnerable areas to industrial disasters. Keeping the above statement in mind, the present paper is written with the objective of identifying hazard prone and vulnerable zones of industrial areas in Ghaziabad district. Simple random sampling has been used to collect the primary data and the document has been enhanced by adding secondary data. Geospatial techniques have been used for map representation. The present research highlights those industrial surveys which are not conducted on a regular basis. This irregularity does not force the industrial authorities to look into proper maintenance, services, precautionary, and safety measures. Most of the workers had experienced hazards of minor or moderate types in the past. Even though the infrastructural facilities are available, essential facilities such as first-aid, paid medical expenses, safety apparel like gloves and boots, warning notices, direction boards, and regular mock drills are not available oftentimes. This points out a huge gap between the internal facilities and external facilities of the industry and its surrounding area. The study suggests possible ways and mitigating strategies to face such kinds of hazards in a sustainable manner.

Keywords: *Hazards, Industrial Area, Ghaziabad, Disaster Risk Reduction, and Sustainable Development*

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1. Introduction

Disaster is a sudden, calamitous event that severely disrupts a community's functioning, resulting in the loss of human, social, economic or environmental potential beyond the capacity of the community to effectively manage and use their resources for their sustainability (Roy and Pandey, 2016). The range of activities is designed to mitigate the effects of disasters and emergency situations and to provide a framework for helping people at-risk to avoid or recover from the impact of the disaster (Ministry of Home Affairs, 2011). Management of disasters includes steps to be taken prior to, during, and after the disaster, and involves preparedness, mitigation, response and recovery. As per the National Institute of Disaster Management (NIDM), industrial disasters are disasters caused by chemical, mechanical, civil, electrical or other process failures thanks to accident, negligence or incompetence, in a plant which can spill over to the areas outside the plant or within, causing damage to life, property, and environment (NIDM, 2007). Chemical disasters are the "occurrence of emission, fire or explosion involving one or more hazardous chemicals within the course of commercial activity (handling), storage or transportation or thanks to natural events leading to serious effects inside or outside the installation likely to cause loss of life and property including adverse effects on the environment (Quarantelli, 1984). According to the United Nations Environment Programme (UNEP) "chemical accident or emergency" refers to an event that results in the release of a substance or substances hazardous to human health and/or the environment. These events can cause illness, injury, disability, or death to citizens, often in large numbers, and may end in extensive damage to the environment with considerable human and economic costs (NDMA, 2006, & 2007).

Causes of industrial (chemical) emergencies, as per National Disaster Management Authority (NDMA) include manufacturing and installations during commissioning and process operations, maintenance and disposal, material handling and storage in manufacturing facilities, and isolated storages, warehouses and go downs including tank farms in ports and docks and fuel depots (Anon, 1999 and Disaster Management in India, 2004).

Off-site perspectives of chemical disaster management need multidisciplinary inputs and interdisciplinary coordination, effective information science and management system and integration with the holistic multi-hazard disaster management framework

along all stages starting from hazard/risk assessment, prevention & mitigation, preparedness, response, relief and rehabilitation and within the broader framework of planning and development at local/regional level (Sreeja and Gupta, 2007). The main responsible causes of chemical hazards are safety systems and human errors, or they will occur as a consequence of natural calamities or sabotage activities (Karthik, et.al, 2019). Chemical accidents end in fire, explosion and/or toxic release (Brock et.al, 2020). The nature of chemical agents and their concentration during exposure ultimately decides the toxicity and damaging effects on living organisms within the sort of symptoms and signs like irreversible pain, suffering, and death (Gupta and Nair, 2012). Meteorological conditions like wind speed, wind direction, the height of the inversion layer, stability class, etc., also play a crucial role by affecting the dispersion pattern of toxic gas clouds (Industrial Hazard Signs & Label, 2020).

According to the Sustainable Development Goals knowledge platform, the Yokohama Strategy and Plan of Action for a Safer World (1994), the first major international framework for disaster risk reduction, recognized the interrelation between sustainable development and DRR. Ever since, this close interrelation was continuously strengthened within the key global agreements, from MDGs to the Johannesburg Plan of Implementation (Johannesburg, September 2002), to the "Hyogo Framework for Action (2005-2015)" and to the "Future We Want" (Rio, June 2012), Sendai Framework for DRR (Sendai, Mach 2016) and therefore the 2030 Agenda for Sustainable Development (New York, September 2015 and UNISDR, 2000; 2015).

1.1 Causative Factors Leading to Chemical Disasters

There is a long list of toxic chemicals like asbestos, lead, arsenic, formaldehyde, PVC vinyl, having vast uses in industry and also leading to harmful disasters (Figure 1). Our society is hooked on chemicals of its own making. These toxic chemicals are highly toxic, explosive, flammable, poisonous or have a combination of all these characteristics (Raj et.al., 2007). Their impact is extremely high and causes harm to humans, living creatures, plants, property and the environment. It is emphasized that the strengthening of preventive measures like fire services, medical authorities' team, paramedics, and local administration has a vital role in formulating the mitigation plans (Khayal et.al., 2015). To mitigate chemical disasters, stress is given to create appropriate infrastructure i.e., on-site and off-site plans including public address systems (Zio and Aven, 2013).

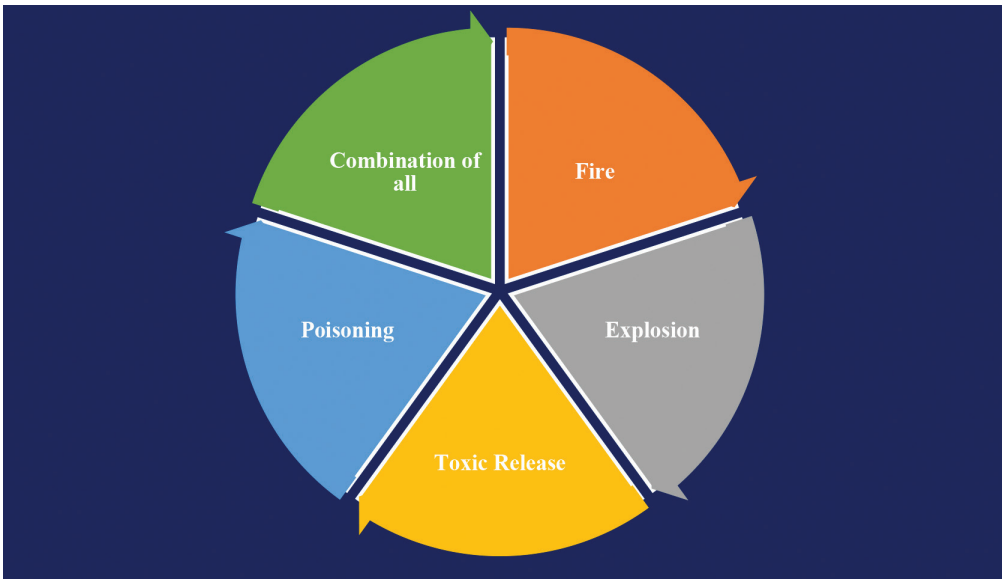

Figure 1: Causative Factors of Industrial Hazard

Source: National Disaster Management Authority
Guidelines on Industrial Disaster, modified by Authors

Coping up with the matter of chemical disasters may be a challenging task. There is a need to generate awareness programs regarding chemical risk and its expected role during emergencies. It is essential to spot various mechanisms of managing chemical accident risk and wish for preparedness and capacity building needs. Regular statutory inspection and testing of emergency plans must be practised. Need to prepare mechanism of chemical waste management, disposal of chemical waste and organize awareness program regarding chemical disaster management plan (Reniers et.al., 2018).

A paradigm shift has occurred in the government's focus from rescue, relief, restoration-centric approaches to planning, prevention/mitigation and preparedness approaches. The designing of safer engineering practices, standard operating procedures, well-rehearsed on/off-site emergency plans, community awareness, resource and risk inventory built up, training, education, capacity built up, are important practices that may eventually help in the development of community mindset to bravely face disasters and so on reduce their impact (United Nations Hyogo Framework for Action, 2015).

2.0 Study Area

Ghaziabad City is the fastest-growing city in the Indian state of Uttar Pradesh. Its coordinate lies between 28°30'N and 28°59'N latitude and 77°26'E and 78°10'E longitude and total area is 1,034 km2 Ghaziabad serves as the headquarters of the Ghaziabad district (Figure 2). The city can be tracked in the north-eastern part of the National Capital Region, about 20 km east of Delhi. Sprawling along both the edges of Hindon river, Ghaziabad is the third-highest district in U.P in terms of population (The total Population of Ghaziabad city is 1,648,643). The city bridges the link with other cities like Delhi, Meerut, Aligarh, Bulandshahar, Hapur, Moradabad and Lucknow.

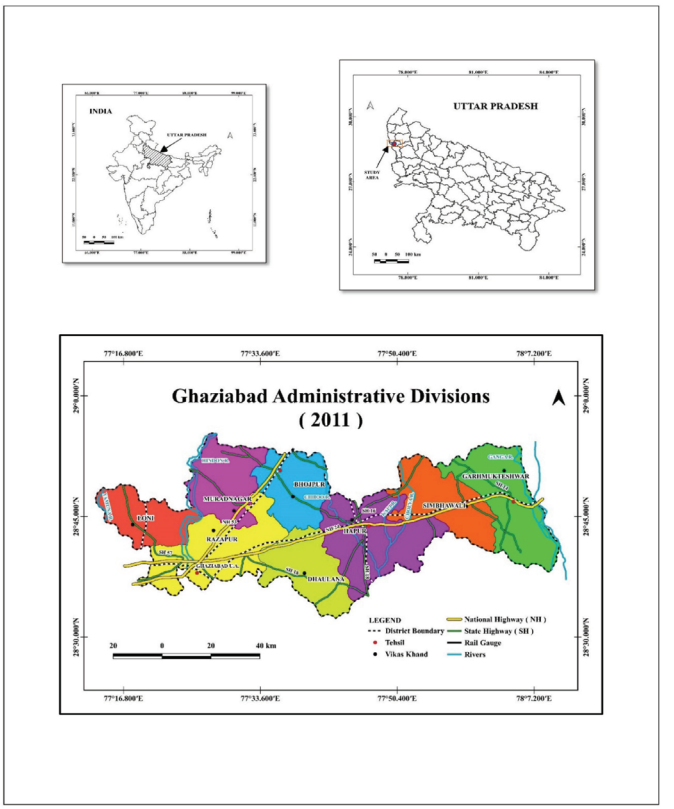

Figure 2: Ghaziabad District Administrative Divisions (2011)

Source: Based on https://censusindia.gov.in/2011

Ghaziabad district falls under the Meerut Division of U.P. It consists of 5 districts headed by Divisional Commissioner with its headquarters at Meerut. The headquarters of the district is in Ghaziabad. For administrative purposes, the district has been divided into 4 sub-divisions, 4 Tehsils and 5 Panchayat Samities. There are 74 Gram Panchayats, 529 inhabited villages, and 38 are uninhabited (Table 1).

Table 1: Ghaziabad District Sub-divisions

Name of District	Name of Sub-divisions	Name of Development Blocks	Inhabited Villages (No.)
Ghaziabad	Ghaziabad	1. Rajapur	33
		2. Loni	46
	Hapur	1. Hapur	111
		2. Dhaulana	64
	Garhmukteshwar	1. Garhmuktesh-war	81
		2. Simbhaoli	76
	Modinagar	1. Bhojpur	57
		2. Muradnagar	61
Total	**4**	**8**	**529**

Source: District Industrial Centre (DIC), Uttar Pradesh, 2020

It is a crucial station of the Northern Railway where railway lines from Delhi, Calcutta, Moradabad and Saharanpur meet, connecting it with many important cities of India. Ghaziabad is also named as the "Gateway of Uttar Pradesh" as it its boundary is adjacent to Delhi, making it the entrance of Uttar Pradesh.

Objectives

There are the following objectives of this paper:

1. To identify the hazard-prone areas, causes of hazards, hazardous activities, and past accident records for hazard vulnerability assessment.
2. To identify vulnerable areas and the impact of the disaster on them in the study area.
3. To analyze the government initiatives programs and suggest the management strategies for disaster risk reduction in the study area.

3.0 Research Methodology

In the field, the most appropriate course of action is the establishment of a measurement or monitoring program where a hazard is suspected. Ideally, hazard identification and assessment of potential magnitude have been based on (1) historical records, (2) local knowledge, (3) field mapping, (4) inspection of maps and imagery, and (5) literature reviews. Unless a majority of these sources combine to indicate the presence of a hazard, the existence of a credible threat to villages, roads and activities will remain questionable. Both in identifying hazards and in assessing strategies to deal with the hazards identified, the range of options must be factored into the evaluation.

A sample size of 100 respondents was chosen b the study is also based on observation. Sampling was done based on simple random sampling. Google forms were used to make questionnaires. Most of the questions were close-ended and were based on a rating system. A structured questionnaire was prepared to record relevant information. The households were selected based on Stratified Random Sampling (SRS). Simple Random Sampling was used to select the students, teaching, and non-teaching staff, administrative staff, and employees working in the industries, and local communities which have been able to represent the whole scenario of the industrial area of Ghaziabad district. A well-prepared questionnaire was accustomed to collect the primary data. The observation method was additionally utilized in the study. The interviewer, as well as respondents both, were involved in the collection of data. The questionnaire was designed according to the title of the Disaster Management Project Work. The information was recorded by the interviewers. To analyse these raw data, we have chosen cartographic techniques (thematic) such as bar graphs, pie charts etc. The data has been analysed and processed with the help of statistical techniques. Excel was used for creating various graphs and pie charts. Most importantly observation skills were used while conducting the survey for analysing the surroundings and problems related to the topic.

4.0 Result and Discussions

From this study, it was found out that most of the workers had experience of minor or moderate levels of hazard. Correlation between hazard frequency and severity revealed that hazard frequency is moderate hence the severity of the hazard is moderate. Better

precautionary actions like well-displayed evacuation plan, provision of safety apparel like gloves and boots, warning notices and first aid kit, awareness related to nearest hospitals and police stations and regular mock drills and training can reduce or eliminate the chances of risk

5.0 Main Causes of Industrial Hazard

According to the given graph (Figure 3), it is visible that 90 percent of respondents feel that material handling and storage can be the major source of industrial (chemical) disasters in factories because of neglect in material handling or explosion. It can cause major disasters like the one that occurred in the Bhopal Gas Tragedy in 1984 due to neglect in handling and storage of methyl iso-cyanate (Chouhan, 2005).

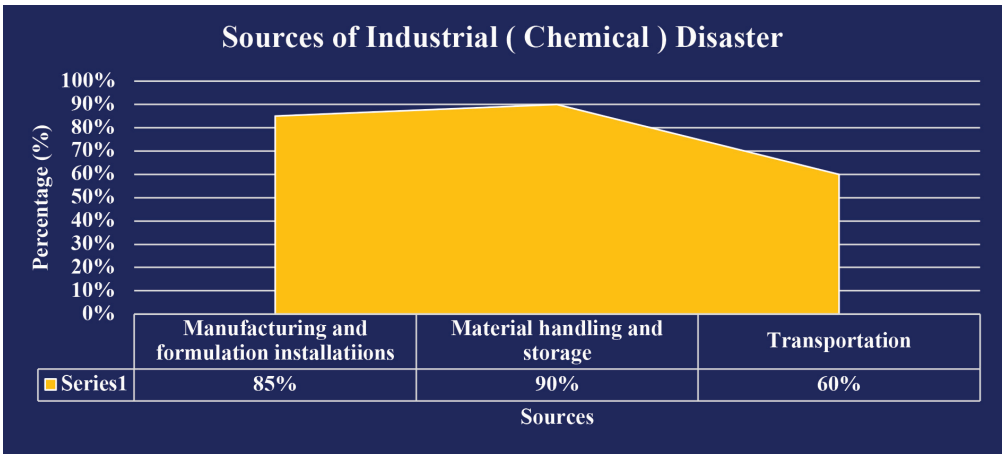

Figure 3: Sources of Industrial Disaster

Source: Based on Primary Survey, 2020-2021

About 85% of respondents feel that manufacturing and formulation installations of products in which chemicals are majorly used can cause great injuries to labourers while working upon the product. For instance, splitting of chemicals while polishing metals cause skin burns to employees. While 60 percent of respondents feel that proper precautionary measures are not taken while loading or unloading material for say unloading tonnes of aluminium, according to a respondent it causes hearing problems to labourers and there have been times that while loading or unloading the material

the employee has not been able to cope up with the weight of load and imbalance in handling of material has caused injuries to employees (Figure 3).

As per the respondent's replies in the primary survey, about 95 percent of people feel that fire and all responsible factors (explosion, toxic release, poisoning) could be a major causative factor leading to the industrial hazard (Figure 4).

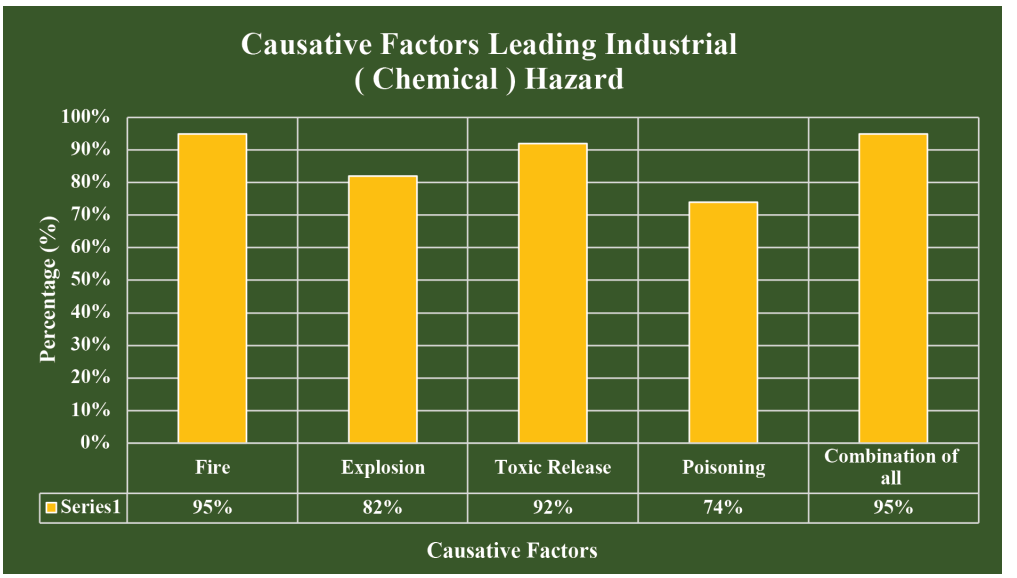

Figure 4: Causative Factors Leading to Industrial (Chemical) Hazards

Source: Based on Primary Survey, 2020-2021

According to one of the respondents, fractions of electrical wires spark short circuit, igniting and spreading fire in electrical equipment and machines and the area surrounding the hazard (Figure 4).

According to Figure 5 and Table 2; it is perceptible that 30% of the respondents neither agreed nor disagreed that unsafe conditions can lead to hazards which indicates that there is a 50-50 possibility of hazard occurrence due to unsafe conditions like workplace congestion, poor housekeeping, defective conditions of hand tools and equipment and other such conditions which have the potential to cause injury or death to an employee. About 30% of the respondents strongly agreed that unsafe acts such as the performance of a task or other activity are conducted in such a manner that it may

threaten the health and safety of workers. Unaccepted acts of employees such as drug/alcohol consumption at a workplace or while doing work can lead to a major disaster.

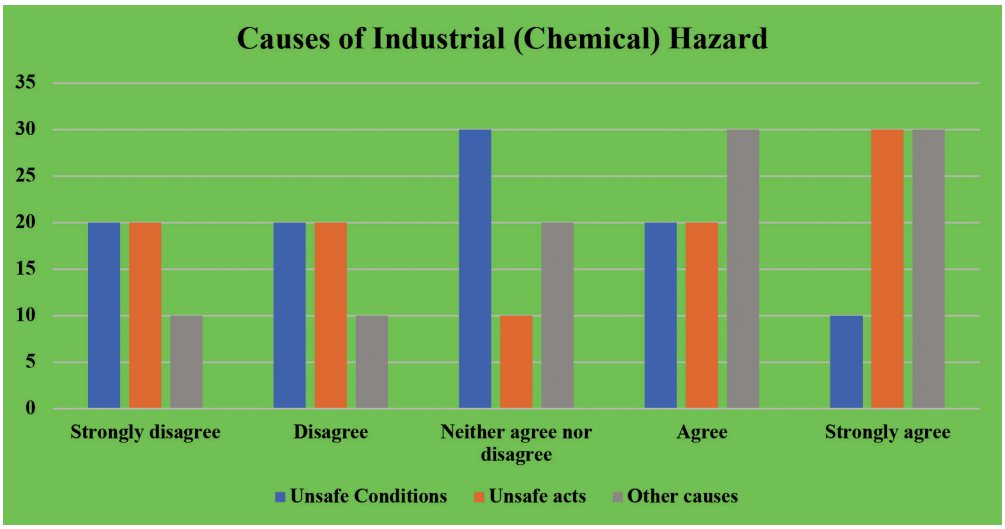

Figure 5: Causes of Industrial (Chemical) Hazard

Source: Based on the primary survey, 2020-2021

Table 2: Causes of Industrial (Chemical) Hazard

Causes of Hazard	Strongly disagree (In per cent)	Disagree (In per cent)	Neither agree nor disagree (In per cent)	Agree (In per cent)	Strongly agree (In per cent)
Unsafe Conditions	20	20	30	20	10
Unsafe acts	20	20	10	20	30
Other causes	10	10	20	30	30

Source: Based on The Primary Survey, 2020-2021

Given table 3 and figure 6, The researcher was able to observe that the respondents adopted a diplomatic answer by remaining in a neutral position when it was asked how much the nature of job could be an unsafe condition for the hazard-related issue. Past experiences of deaths and injuries while working over machines have given a strong reaction of 70% respondents, strongly agreeing about the nature of machinery/types of equipment as one of the major cause of unsafe conditions.

Table 3: Causes Related to Unsafe Conditions

Unsafe Conditions	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Nature of job	0	0	40	40	20
Nature of machinery/ equipment	0	0	0	30	70
Poor physical conditions	0	20	40	3	10
Psychological Conditions	0	60	2	10	10
Work schedules	50	30	1	10	0
Others	0	20	30	20	30

Source: Based on Primary Survey, 2020-2021

About 60 percent of respondents disagreed that psychological conditions cause an industrial hazard. It gives a sneak peek of the psychological conditions of workers of the industries who have adapted to the industrial environment, stating reasons like the burden is not put over the employee by the authorities or they are not ill-treated.

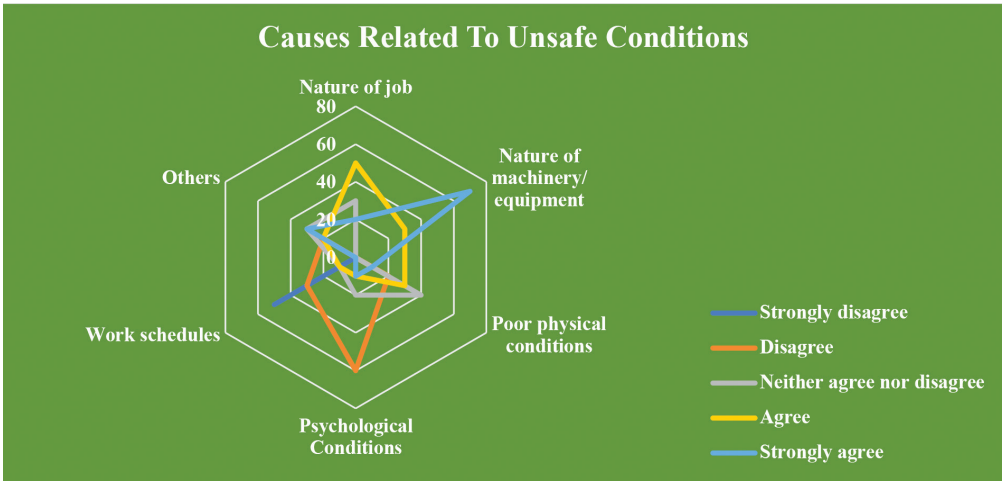

Figure 6: Causes Related to Unsafe Conditions

Source: Based on Primary Survey, 2020-2021

According to the given table 4, it is clear that most of the respondents moderately disagreed that lack of awareness or insufficient knowledge is a major cause related to unsafe acts. This is because according to the workers, they are trained earlier and then recruited. Most of the respondents highly disagreed that the draining physical or mental condition of employees causes a major hazard. However, as per respondents, the burden is not put over the workers and rather they are given leave in case of physical or health issues.

Table 4: Causes Related to Unsafe Acts

	Disagree	Neutral	Agree
Lack of Awareness or Insufficient Knowledge	50	30	20
Draining Physical or Mental Condition of Employees	70	20	10
Wrong Attitude of Employees	10	40	50
Others	40	30	30

Source: Based on Primary Survey, 2020-2021

Most of the respondents agreed that the wrong attitude of employees such as drug or alcohol consumption while working in factories can lead to a major hazard.

Hazard Prone Areas: Ghaziabad District, NCR Delhi

The risk zones were demarcated by categorising low-risk, moderate-risk, and high-risk zones. Likert scale was employed to categoried the risk zonation's as per respondents' replies. It is based on a primary survey and categorized into three zonations. Wherein ward numbers 16, 17, 25, 30, 74, and 22 have been plotted under high-risk zones where all the major industrial units of the district are located (Figure 7).

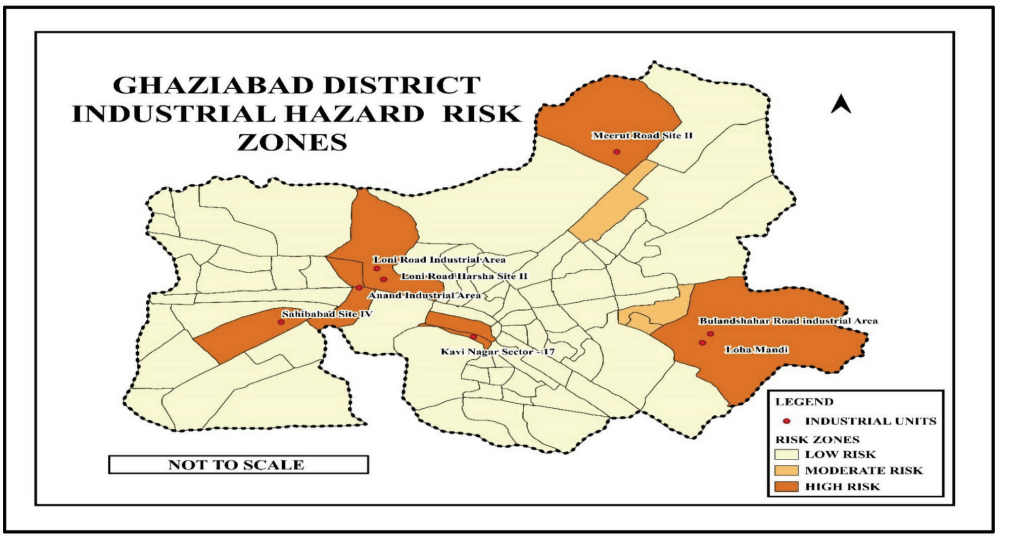

Figure 7: Hazard Risk Zones

Source: Based on Primary Survey, 2020-2021

Ward numbers 24 and 36 attached to ward 16 have been categorized into moderate-risk zones and ward 59 near 22 wards is also categorized into moderate-risk zones. While other wards were categorised into low-risk zones.

Table 5: Coefficient of variation between Frequency of hazard, Severity of hazard, Measures of Safety and Awareness about government policies

Frequency of hazard	Severity of hazard	Measures of Safety	Awareness about government policies	Standard Deviation	Mean	Coefficient of Variation
0	10	30	70	2.68095132	2.75	0.974891
0	20	60	20	2.17944947	2.5	0.87178
80	50	10	10	2.94745653	3.75	0.785988
20	10	0	10	0.70710678	1	0.707107
0	10	0	0	0.4330127	0.25	1.732051

Sources: Based on Primary Data, 2020-2021

As the given table 5 it was found that the frequency and severity of hazard is moderately high but the awareness and safety measures are very low in comparison to the risk of the hazard. Carelessness and neglect in conducting and organizing mock drills and awareness campaigns increase the risk hazard many times. Even though hazards do not occur frequently, but there is a very high possibility of the occurrence of hazard. If the situation persists with the unavailability of preparedness plan and prevention strategies the hazard will occur on a large scale.

Correlation between Frequency and Severity of Hazard: Ghaziabad District, NCR Delhi As per figure 8 and Table 5, 6 of the chart it is visible that a positive correlation of 0.916667 has been made between frequency of hazard and severity of hazard which means as the frequency of hazard will increase the severity of hazard will also increase.

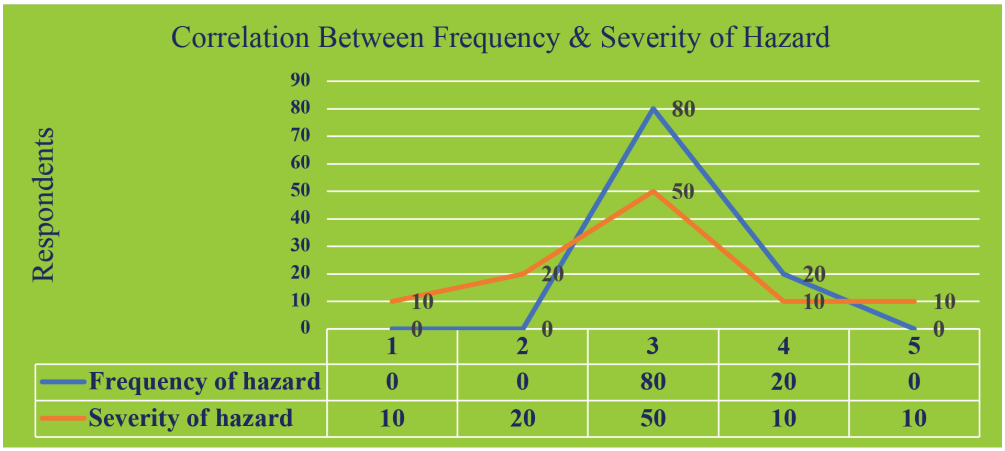

Figure 8: Correlation Between Frequency & Severity of Hazard

Source: Based on Primary Survey, 2021

Table 6: Correlation Between Frequency & Severity of Hazard

Scale	1	2	3	4	5
Frequency of Hazard	0	0	80	20	0
Severity of Hazard	10	20	50	10	10

Source: Based on Primary Survey, 2020-2021

Respondents were asked to rate the severity of the occurrence of hazard in the past on a scale of 1-5. None of the respondents rated scales 1 and 2, while 80 respondents rated scale 3. 20 respondents rated scale 4. Most of the respondents gave a rating of 2 and 3 for the severity of the hazard (Table 6). This explains that according to respondents' opinion though hazards occur in the industry, but their frequency is low. However, there is a high possibility of occurrence of major hazards in these industries if precautionary measures are not taken.

This also points to the need to resolve the failure issues and take strong precautionary measures as a prevention strategy to mitigate the effects of hazards that would have the potential to become a major disaster causing huge loss of life and property. For ex: when machines are connected to power, sometimes the electric load is so much so that

if connection is not cut it may result into a big disaster. This indicates some measures are taken immediately so that the hazard dosen't turns into a disaster. However, this also points out that if failures are not tackled on time, then hazards of minor or moderate level it can turn into a big disaster. Also, situations like these as quoted in the example are very much frequent which shows that major actions are not taken to resolve minor issues that can lead to a disaster. Neglect of minor causes should be avoided to minimize the risk of hazard.

6.0 Vulnerability and the Socio-Technical Approach in Disaster Risk Reduction

The following gives a description of the major industrial pockets of Ghaziabad City:

Bulandshahr Road Industrial Area of Ghaziabad, Uttar Pradesh is a large industrial area encompassed by developing regions nearby. This region includes *Loha Mandi, South Side of G.T Road industrial unit and Bulandshahr road industrial unit*. This indicates the vulnerability of the zone because most of the industries are compactly settled. A hazard in one industry can trigger a huge loss on a wide scale leading to a large-scale disaster. On the backside of the *Bulandshahar road* industrial area railway tracks are spread, if a major explosion occurs in the nearby industry to railway tracks it will lead to devastation to not only in that particular area but railways would also have to be stopped for some time so that more people are not affected by the disaster.

Meerut Road Industrial Area is a long chain of the area a highway. Most of the industries in this area are based on vehicles and vehicle parts production. Nearness to road infrastructure also helps industries to export their goods. But as this region has its advantages it also has disadvantages too because in this region industries are scattered and are in close contact with residential areas. Though industrial units are not very near to the residential areas, their impact can be felt if a major hazard occurs.

Loni Road industrial area is compactly settled with minimal ventilation systems. There are possibilities of a minor hazard turning into a moderate hazard if precaution is not taken care of.

Sahibabad Site IV encompasses industrial units of medium and majorly large-scale industries. This region holds a population of 135096 persons. Its area is about 10.56 square km. The industries are 2-3 km far from residential areas so the scope of spread of disaster to residential areas is less but the region in itself holds major industries hence

the implementation of proper safety measures is the key to avoid any unavoidable situations.

7.0 Vulnerability Assessment for Disaster Risk Reduction (DRR)

In order to do the vulnerability assessment, the researcher chose Socio-economic indicators of vulnerability wherein three indicators such as Demographic & social indicator, economic damage indicator and preparedness and response indicator (Karthik et.al., 2019). In Socioeconomic vulnerability, it was found that about 30-40 percent of respondents agreed that workers who are exposed to damage will be highly vulnerable as they will be the first responder (Figure 9).

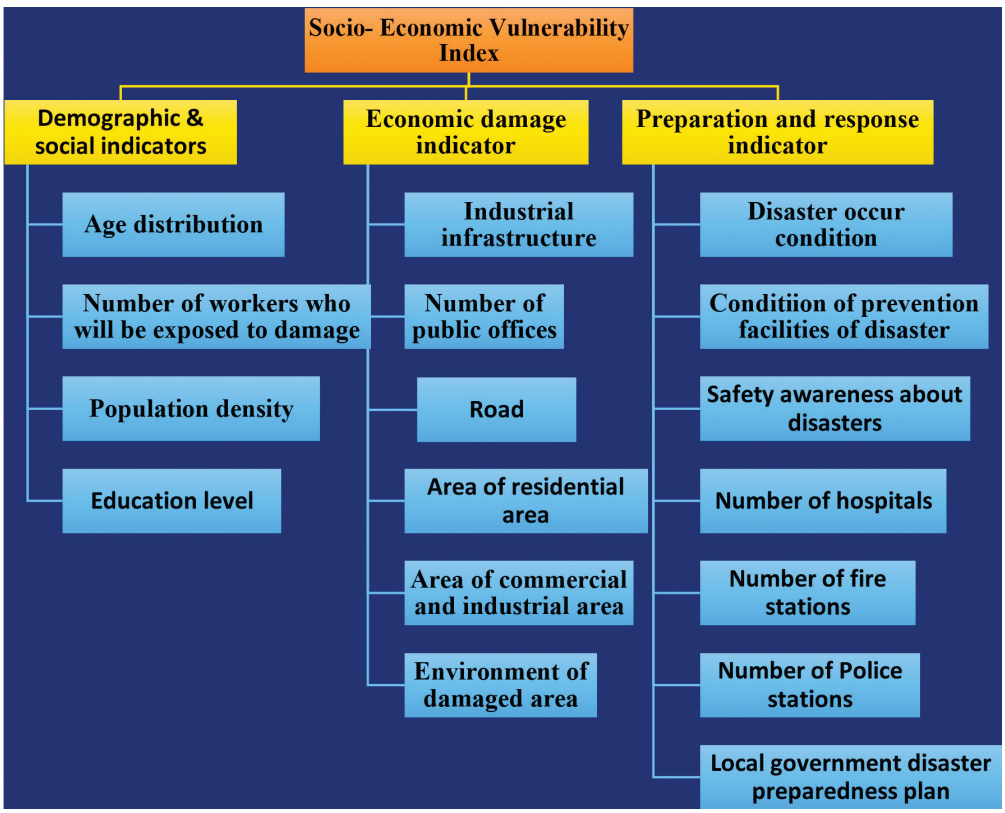

Figure 9: Socio-Economic Vulnerability Index

Sources: Based on Primary Data, 2020-2021

According to the disaster preparedness and response indicator, about 26 percent of respondents had awareness about safety measures but according to the respondents those facilities were not available and if they were available, it was in a poor condition (Figure 10).

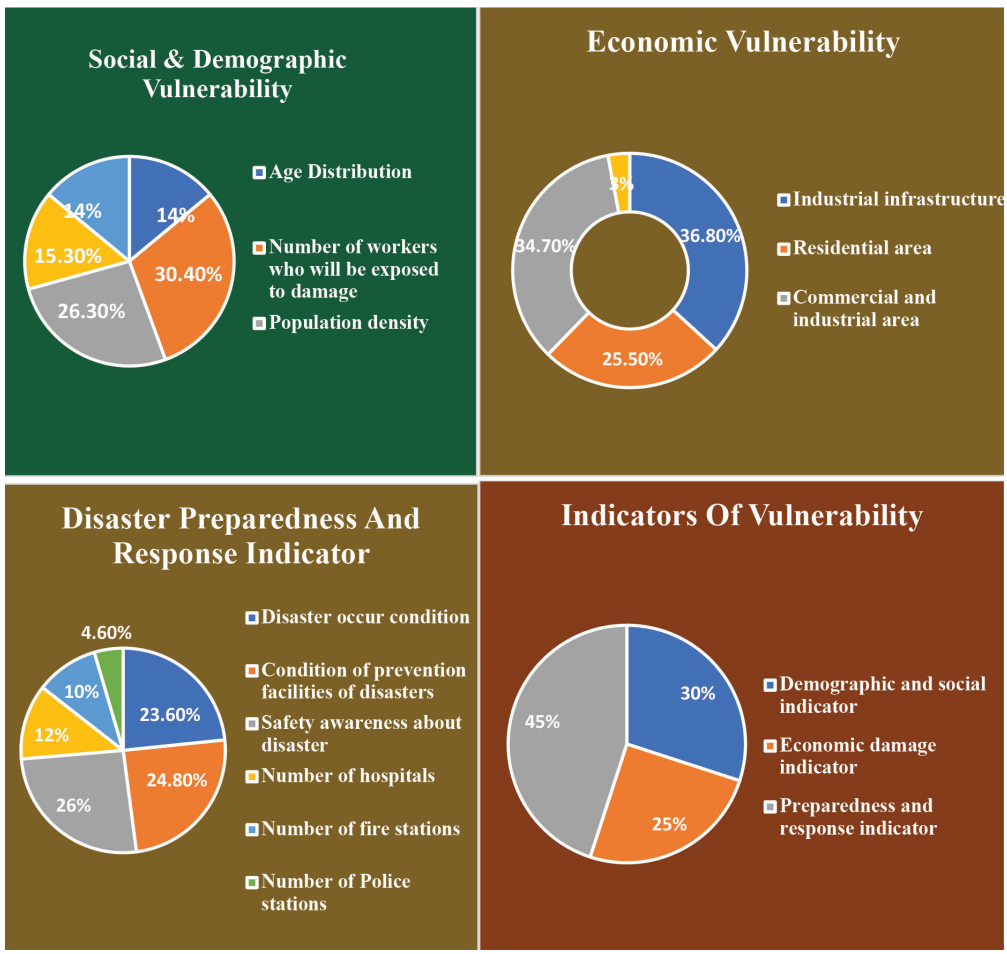

Figure 10: Socio-Economic Indicators of Vulnerability

Source: Based on Primary Data, 2020-2021

As per respondents, 23.60 percent agreed that there is a very high probability of disaster while 24.80 percent of respondents said that the condition of prevention facilities of disasters was available like hospitals, fire stations and police stations.

8.0 Capacity Building and Facilities Available to Reduce the Risk of Hazard for Disaster Risk Reduction (DRR)

In the Hazard and vulnerability assessment it was found out that the hazard could be due to a minor spark in electrical circuits to improper working of machines and equipments. The intensity of hazard is not high though but proper precautionary actions could even reduce or in sometimes eliminate the risk of hazard. Unsafe acts like working in industries and consuming drugs or alcohols in working hours increases the risk of mishap. This could be reduced with proper managerial inspections. Respondents had awareness about safety measures but according to them those facilities were not available and if they were available, it was in very bad condition. Most of the respondents agreed that facilities of emergency alarm are not present in their industry. According to most of the respondents, first aid facilities were not available but authorities paid the medical expenses if an emergency occurred. it was found out that respondents are not aware of government policies and programmes. According to the respondents if a mishap occurs it depends upon "thekedar or contractor" whether he wishes to compensate for the losses or not.

Proper training to workers reduces the risk of an awareness gap that could otherwise become a lethal source of a major disaster. It was found out that although the dense residential areas are about 2 to 5 km away from the industrial pockets but cases of release of any toxic element in the environment slowly and continuously deteriorate the health of the general public. Regular health check-ups should be provided to industrial workers in order to keep a check of their potential and weaknesses.

Although the infrastructural facilities are available but essential facilities which were not there in some cases which points out to a huge gap between the internal facilities and external facilities of industry and its surrounding area.

Listing the location of all the industries would help us to know about the vulnerability of the region and it will help in capacity development. Onsite and off-site emergency plans should be prepared so that the evacuation during an emergency can be conducted smoothly. Awareness campaigns should be conducted and proper installation of safety measures such as first-aid, warning systems like alarms can be installed to avoid or reduce impacts of the emergency.

8.1 Suggestions Related to Techniques/Approaches in Disaster Risk Reduction

A team of students, teachers and experts of this field along with regional planners should be made and a government-authorized survey should be conducted wherein the team must have a permit from the government to ask critical questions from the factory owners and authorities about the factories.

A list of all the authorized and unauthorized factories along with its coordinate location, industry type, raw materials used, storage and handling capacity, final product/s manufactured, machines and equipments and its health system, where is waste product send and what happens to it, map of through which roadways the material related to the industry is transported should be prepared, on – site and off site emergency plan should be prepared for all the factories. Benefits of :-

Listing of location of all the industries would help us to know about the vulnerability of the region and it will help in capacity development. Listing of raw material and final products will help us to know what are the major resources that are utilized and in what quantity they are utilized . This will help in sustainable planning of resources and experiments for alternative resources which can be used to produce the same material. Listing of machines and equipments and there health system will also help us to know about the risk posed by these factories. This will also help us to remove the defective equipments and machines so that risk of threat can be reduced. Not only this, it will give a brief idea about the procedure used in making the products which will help to experiment alternative and less risky methods for production of material. This will also help installing safety equipments according to the need of the hazard prone areas. It will also help in preparing uniforms and safety apparels accordingly as most of the hazard occurs when cloth is stuck in machines. Storage and handling capacity of material will help us to know regions where the storage tanks are placed which will help to put warning system and regular checks for maintenance purpose. Destination of waste produce would help to recycle the waste if possible and plan a proper waste management system of hazardous material. Map of through which roadways the material related to the industry is transported should be prepared so that material should not be transported in peak hours and safety measures can be made for passing roadways if an emergency occurs. On site and off-site emergency plan should be prepared so that the evacuation during emergency can be conducted smoothly.

Awareness campaign should be conducted and proper installation of safety measures such as first aid, warning systems like alarm can be installed to avoid or reduce impacts of emergency.

Conclusion

The study is based on an industrial area in the Ghaziabad district of Uttar Pradesh. From the study, it was found that the moderate scale industries do not have adequate safety measures. The major accident hazard units do have some safety measures but the level of safety is very less as it should be. A major study by the government should be done in this area as there are many loopholes and neglect related to not only the safety measures but manufacturing, storage and transportation of the products that are created in the industry. A suggested measure could be that a team of students, teachers and parents and experts of this field along with regional planners should be made and a government authorized survey should be conducted wherein the team must have a permit from the government to ask critical questions related to surveys from the factory owners and authorities about the factories. A list of all the authorized and unauthorized factories along with its coordinate location, industry type, raw material/s used, storage and handling capacity, final products manufactured, machines and equipment and its health system, type of waste produced and are environment-friendly measures are taken before it is dumped, map of which roadways and railway and airways the material is transported should be prepared, on-site and off-site emergency planning and it's proper implementation should be done. Taking such steps would help to develop the industrial sector in the study area more sustainably.

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