FIRE DYNAMICS : KOLKATA, AN OVERVIEW

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AMRI fire: Court axes plea to discharge 13 accused

STATESMAN NEWS SERVICE

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UNIVERSITY OF CALCUTTA

B.Sc. Semester VI (Honours) Examination 2021
(Under CBCS)

SUBJECT: Geography (Honours), Project Report

PAPER: Hazard Management
[GEO-A-CC-6-14-P]

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This is to certify that the candidate bearing Roll No. 213047-11-0015 and Registration No. 047-1211-0246-21 has prepared this Project Report on "***Fire Dynamics: Kolkata, an Overview***" under my guidance and is submitting the same as part fulfilment of the syllabus (Paper-CC-14) of B.A./B.Sc. Sem-VI (CBCS), Examination -2024.

Date: 27/06/2024

Place: Kolkata

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Dept. of Geography

Examined

22.07.2024

ADY BRABOURNE COLLEGE KOLKATA

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I also Acknowledge the co-workers as well as my friends and my family members for their support.

CONTENT

CONTENT FOR MAPS AND DIAGRAMS

FIRE DYNAMICS: KOLKATA AND OVERVIEW

1.0 Preamble:-

Fire symbolizes the dawn of human civilization. It acts as friend as well as foe to the mankind. Fire is a chemical reaction between whatever material is on fire and oxygen. The air around fire supplies the oxygen needed for the reaction, if you manage to block new air from reaching the fire, the fire will quit. Fire could be a man made, natural and quasi natural disaster that resulted in the loss of property and lives. It has been categorised into few types like A, B, C, D and K (ANNEXURE I). various models have also been prepared by social scientist to understand the genesis of fire.

Fire is a common hazard or disaster throughout the globe both in urban as well as in villages, but urban fires become more disastrous events causing huge loss of life and property It also adressly affect environment, it occurs primarily in cities or towns with the potential to rapidly spread to adjoining structures. These fires damage and destroy homes, schools, commercial buildings and vehicles.

The bustling city of Kolkata, India's oldest metropolitan city, has

Fire Models

There are three models that explain the nature and ingredients necessary for a fire to occur, including the fire triangle, the fire tetrahedron, and the fire pentagon.

The fire triangle is the basic model explaining the components of a fire. The first side of the triangle is heat. A fire can't ignite unless it has enough heat. The second side is fuel. A flammable fuel source like paper, rubber, or oil is needed for a fire to burn. If there is no fuel, there is no fire. The third element is oxygen. Oxygen is required to continue the chemical reaction of a fire. Some hering a fire removes the oxygen and puts out the fire.

experienced fire a number of times due to a number of reasons from cigarette smoking to storage of Kerosene to faulty wiring and lack of proper disaster management system (ANNEXURE II). Since Kolkata was the capital of British colony, CBD area, some portion of central Kolkata and in South up to Park Street area were developed in a very planned manner. Afterwords with huge population growth, the metropolitan city expanded in unplanned happazard manner. subsequently with huge refugee immigration, created both notified slums and illegal 'Bustees' were sprung up with least amenities and safety. Narrow lanes and by lanes, old buildings in a dilapidated condition and illegal unplanned new construction without taking proper safety measures made Kolkata highly suseptible to fires at various levels in different parts of the city. In this backdrop we have attempted to make study on fire incident characters of Kolkata Municipal Corporation area, henceforth would be referred as Kolkata.

2.0 OBJECTIVES :-

- To make a register of fire in Kolkata for the last decade from 2011 - 2021.
- To find the areas where fire incidents occur frequently.
- To understand the pattern of fire cases.
- To unearth the causes behind major fires.
- To assess the vulnerability of people and areas.
- To assess the hazard perception of people, media and areas policy makers about 'FIRE'.
- To suggest few remedial measures

LOCATION MAP OF THE STUDY AREA

figure no. → 1

02.7.24

to be helpful for preparedness, mitigation and management strategies for the policy makers.

3.0 LOCATION OF THE STUDY AREA:-

Kolkata is located in the eastern part of India at 22°28'N to 22°58'N and 88°10' to 88°27'E. Spread roughly north south along the east bank of the Hooghly River. Kolkata sits within the lower Ganges Deltas of eastern India (Figure 1). It covenes an area of 205 sq. km. Kolkata has a total population of 4,486,679 persons, of which 2,362,662 are males and 2,124,017 are females. Among the total population, 1457,273 are slum inhabitants which accounts for 32.48% of total population [census of India 2011]. Considering density Kolkata is the 7th most crowded city of India. The city has all-together 141 wards.

4.0 METHODOLOGY:-

The entire project report has been prepared on the basis of secondary data sources. Both quantitative and qualitative data have been collected from different sources and these data have been processed with the help of different statistical techniques. Through simple diagrams these data have been represented and analysed. In such cases, it involves compiling existing data sourced from a variety of channels. This includes external sources (such as government statistics, organisational bodies, and the internet).

(2011 – 2021)
DECADAL VARIATION OF FIRE INCIDENTS IN KOLKATA

YEAR WISE TOTAL NO OF FIRE INCIDENTS

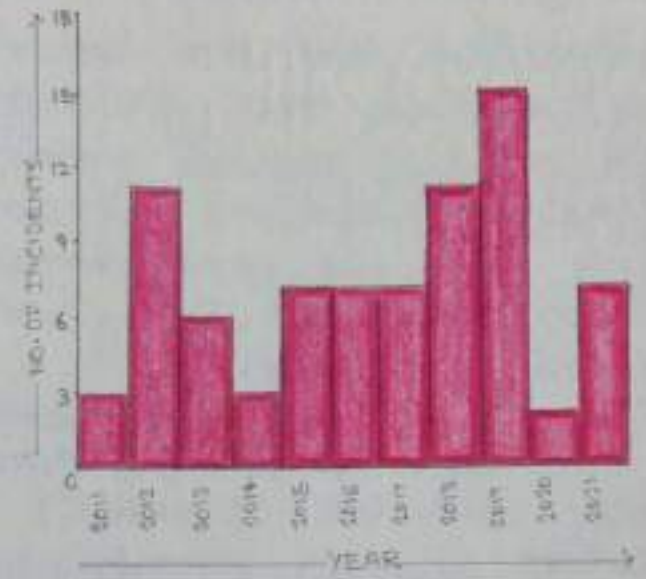

Figure: 2

DECADAL GROWTH OF FIRE INCIDENTS

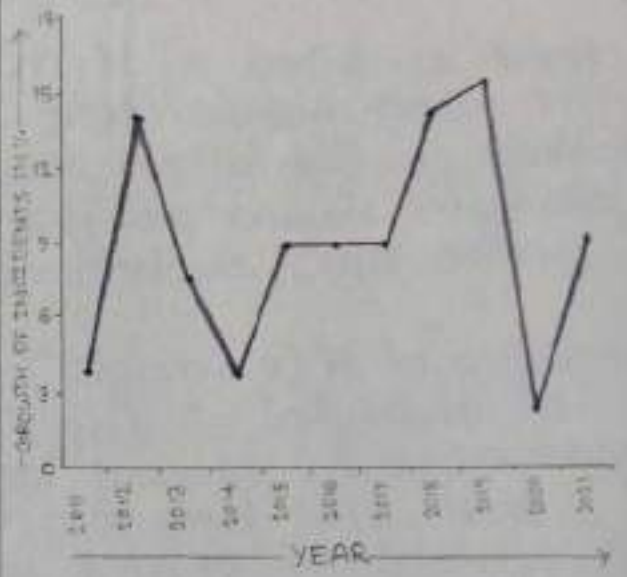

Figure: 3

ZONE WISE DISTRIBUTION OF FIRE INCIDENTS

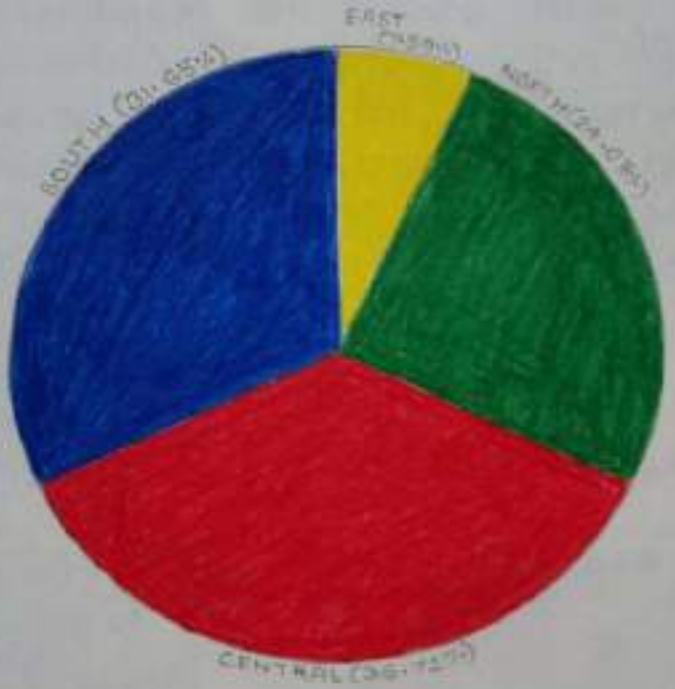

Figure: 4

MONTH-WISE DECADAL VARIATION OF FIRE INCIDENTS FOR THE LAST 10 YEARS

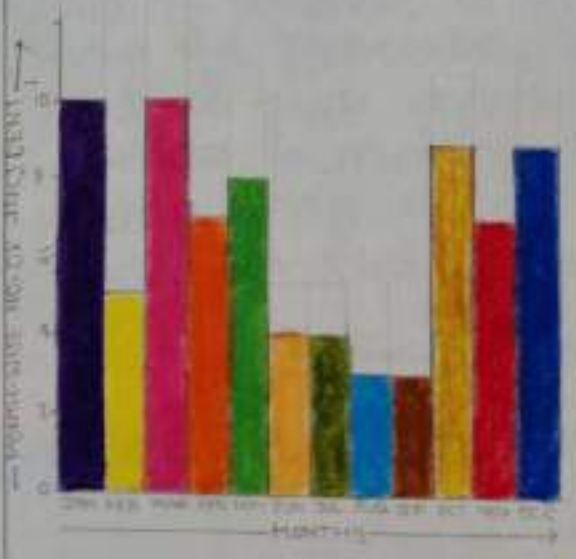

Figure: 5

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5.0. FIRE IN KOLKATA :-

5.1. Data Analysis

5.1.1. Decadal Variations in Fire incidents in Kolkata during 2011-2021:

Based on the information it is evident that during last decade (2011 – 2021) altogether 79 fires brooke out in Kolkata as found in print media online. Number may be much higher, some may be not so hazardous and some may not be reported.

From the diagram (Figure 2) it is evident that number of fire incident is highest in 2019 i.e. 15 in number and lowest in 2020 only 2 (Table 1). In the year 2012 and 2018, the incidents range between 8 to 12 incidents. A cursory look onto figure 3, explains no pattern of incidents. 2012 and 2019 attained high note incidents. If we consider the spatial spread of fire incidents we find that most of the fire incidents occured in (Table 2) Central Kolkata (36.71%) followed by southern (31.65%) and Northern part of Kolkata (24.05%). Least number of fires took place in East Kolkata (7.59%) (Figure 4). In figure 5 an attempt has been made to understand if there is any seasonal character of fire in Kolkata. But no such trend emerged out of our analysis. Highest number of cases were found in January and March during the 10 years under study followed by October and December months (Table 1)

Table 1: Year and Season wise variation in Fire incidents in Kolkata

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Total No of Fire incidents	3	11	6	3	7	7	7	11	15	2	7	79
Trend in %	3.79	13.92	7.59	3.79	8.86	8.86	8.86	13.92	18.98	2.53	8.86	100%

NO. OF INCIDENTS	10	5	10	7	8	4	4	3	3	9	7	9
MONTHS	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec

Table 2: Area-wise distribution of fires in Kolkata (2011 – 2021)

East Kolkata	North Kolkata	Central Kolkata	South Kolkata	Total
6	19	29	25	79
7.59%	24.05%	36.71%	31.65%	100%

5.1.2. Category-wise characteristics of Fire Incidents:-

Basically the fires which we have b seen in this decade maybe classified under few categories. These are residential as well office buildings, markets, Go-down of factories, hospitals, hotels, slums etc. According to the map of Kolkata taken from Kolkata Municipal Corporation site, we have been able to show the areas where the fires have occured in Kolkata. For example, figure 6, shows that godown fires have been seen in almost every part of Kolkata. The most important hospital fires broke out in SSKM and AMRI hospital in South Kolkata where as in calcutta Medical College in central Kolkata there are quite a roumbers of building fires both in Central as well as in north Kolkata (Table 3). In the case of Market fire, market fire are more prevalent in the central and North Kolkata. We also see some factory fires mainly in east and southKolkata. We also see some factory fires mainly in east and south Kolkata. There were also fires in some slum areas mainly in central Kolkata and some hotel fires in north and Central Kolkata.

So from this observation we know that the northern and central regions of Kolkata had the highest of fires in the last 10 years.

CATEGORY-WISE CHARACTERISTICS OF FIRE INCIDENT

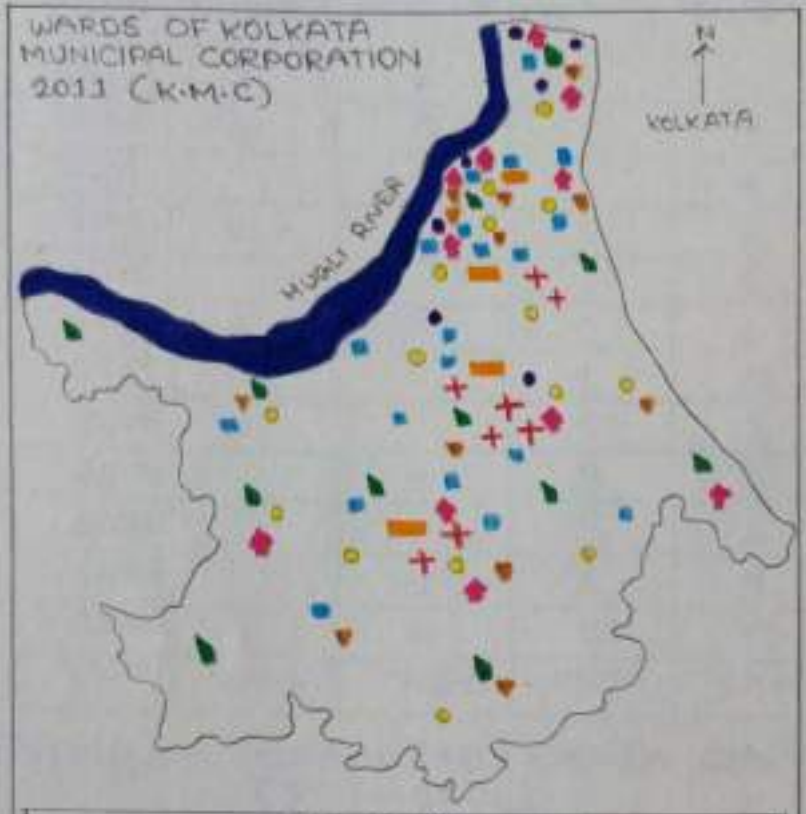

FIGURE:6

SPATIAL DISTRIBUTION OF CATEGORY-WISE FIRE ACCIDENTS

CATEGORY-WISE FIRE ACCIDENTS DURING THE YEAR 2011 TO 2021

FIGURE:7

NO. OF INCIDENTS IN PERCENTAGE

CATEGORY-WISE NO. OF FIRE INCIDENTS

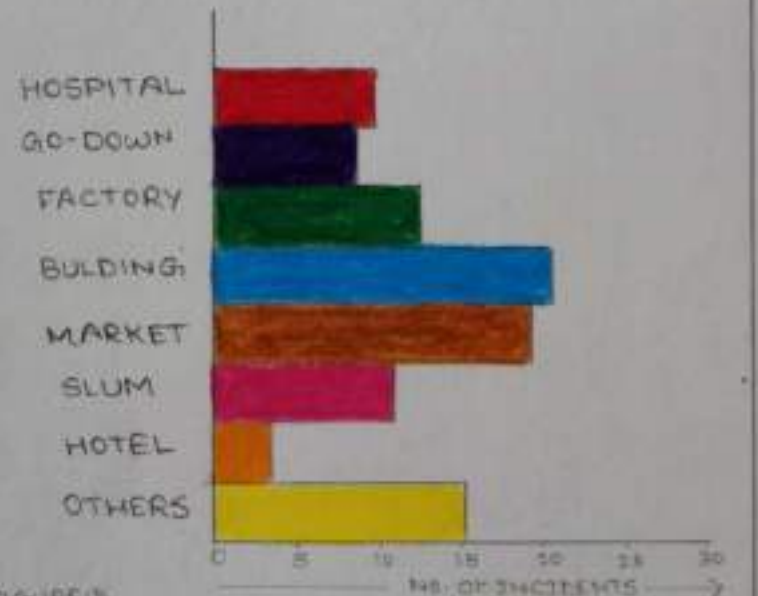

FIGURE:8

TOTAL NO. OF DEATH AND INJURY IN FIRE INCIDENT DURING YEAR (2011-2021)

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FIGURE:9

Table 3: Characteristics of fire incidents:

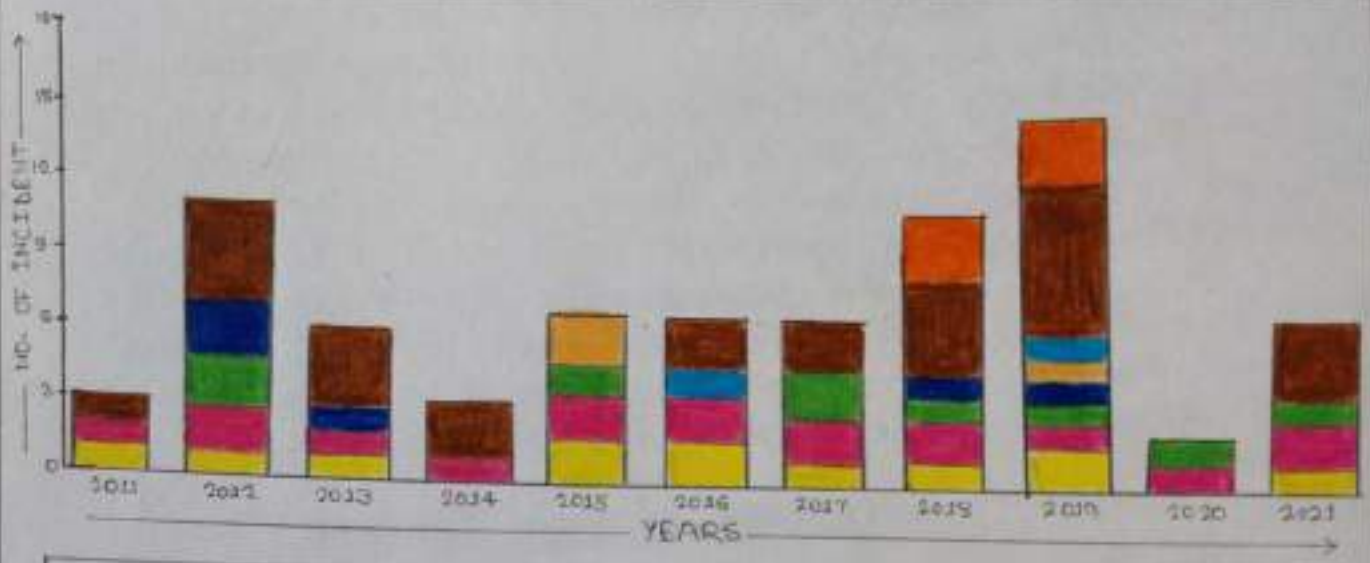
Years	Hospital	Go-down	Factory	Building	Market	Slum	Hotel	Others
2011	1	1	1					
2012	2	1	1	4	2	1		
2013		1		1	1	1		2
2014	1			1		1		
2015			1	1	3	1		1
2016	1		1	1	1	1		2
2017			1	2	2		2	
2018	2		1	2	2	1	1	2
2019		2	3	3	4			3
2020				1		1		
2021		1	1	1		2		2
TOTAL	7	6	10	17	15	9	3	12
IN %	8.9%	7.6%	12.7%	21.5%	19%	11.4%	3.8%	15.2%

Table4: Year-wise Death and Injury of a Decade [2011-2021]

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Death	93	6	19	-	1	-	22	2	-	2	9
Injury	-	5	58	2	1	5	19	40	-	-	-

YEAR WISE IDENTIFIED CAUSE OF FIRE

FIGURE 10: YEARWISE IDENTIFIED CAUSE IN GENERAL



INDEX FOR CAUSES

- INFLAMMABLE SUBSTANCE
- SHORT CIRCUIT
- BURST OF GAS CYLINDER
- A.C. BURST
- FAULTY WIRING
- GENERATOR & TRANSFORMER
- UNKNOWN
- OTHERS

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FIGURE:12 YEAR-WISE NO OF FIRE TENDER IN RELATION TO OCCURENCE OF FIRE

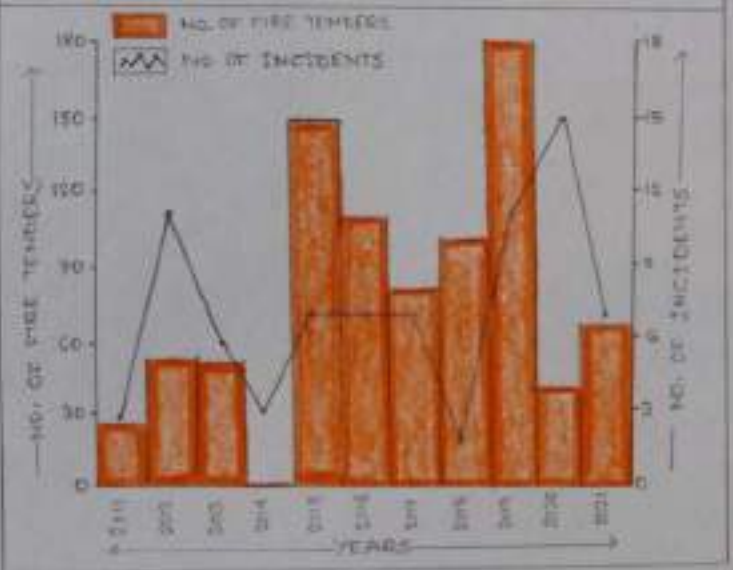
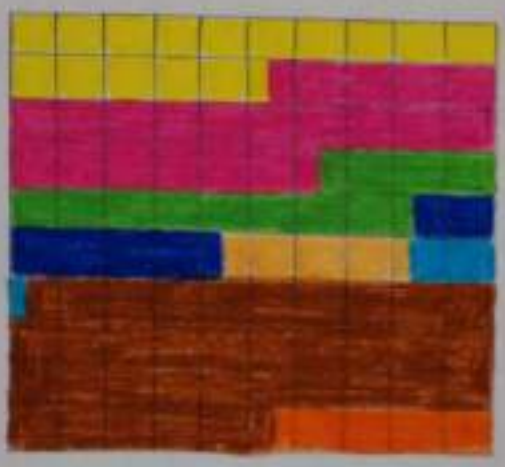


FIGURE:11 PERCENTAGE-WISE DISTRIBUTION OF CAUSE OF FIRE



5.1.3. Causes of fire:-

From figure 9 it is clear that in most of the cases the causes are not identified by the disaster management team. Second in importance is short circuit. Other important causes remain gas and air condition burst. Faulty wiring system has been responsible for fire mostly in 2015 and 2019. In figure 9, the percentage share of various causes responsible for fire in Kolkata during last decade. The most important feature that figure 11 represents is lack of fire tenders needed, especially in the year 2012, 2013, 2014 and 2018. The situation for 2011 was also not satisfactory.

Table 5. Causes of Fire in Kolkata.

Year / Causes	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Inflammable substance	1	1	1	-	2	2	1	1	2	-	1
Short Circuit	1	2	1	1	2	2	2	2	1	1	2
Burst of gas cylinders	-	2	-	-	1	-	2	1	1	1	1
AcBurst	-	2	1	-	-	-	-	1	1	-	-
Faulty wiring	-	-	-	-	2	-	-	-	1	-	-
generation and Transformers	-	-	-	-	-	1	-	-	1	-	-
unknown	1	4	3	2	-	2	2	4	6	-	3
others	-	-	-	-	-	-	-	2	2	-	-
Total	3	11	6	3	7	7	7	11	15	2	7

Table 6 : No. of fire tenders used:-

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total NO. of incident	3	11	6	3	7	7	7	2	11	15	7
Total NO of fire tenders used	25	50	49	4	148	107	81	99	180	40	66

6.0.0 CASE STUDY:

6.1.0 AMRI FIRECASE

On December 9, 2011, building of Advanced Medicare and Research Institute (AMRI) Hospital, Dhakuria, in south Kolkata, witnessed a massive fire at early in the morning. The fire started in the basement of the hospital around 2.30 am in the morning where a pharmacy and a go-down were located. The basement and the floors of the hospital were allagedly stored with highly inflammable material like disel, motor oil and wooden furniture cause spread of the fire quickly. As soon as the fire started, due to combustible materials, in all floors thick density of dark coloured smoke, fumes and toxic substances produced. It started from basement to the upper floors along with the fire flame. What worsened the situation were the air conditioning duct that sucked the poisonous smoke and carried it all through the floors of the building causing suffocation to the patients and staff.

WHAT WENT WRONG?

- The fire broke out at around 02:00 am. The hospital staff started fire fighting operations on their own without initiating a fire alarm or informing the fire brigade immediately. This resulted in loss of initial crucial time.
- The hospital security staff did not allow local residents to enter for rescue work after the fire was detected. Few local youths of neighbouring slums scaled the hospital's rear boundary wall and jumped into rescue work.
- The hospital staff informed fire brigade and police only when fire was out of control.
- Fire brigade help also turned up very late and were found entering smoke areas without BA sets. Also had no search lights/ ladders to initiate any effective rescue operation at initial stage.

- The fire alarm system for the building was found switched off to avoid false alarms. Emergency lightning too did not work / was adequately available. resulting in total darkness inside the building hampering rescue / firefighting.
- The fire brigade vehicles couldn't reach closer to the building since the approach route was halved due to DG set installation and gas Bank and emergency vehicles could not turn through the narrow passage.

IMPACT/LOSS -

According to a hospital spokesperson there were around 150 patients in the hospital including 40-50 of them in the intensive care. Since the event had occurred in the early hours of the morning, most of the inmates were asleep, immobile on on life support. 93 deaths were reported.

► Government Grant :-

The government announced exgatia pay of Rupees 2 lakh each in death cases. It also included a provision of employment in cases where the earning member lost his/her life. Rupees 50,000 were granted to each of the injured persons.

7.0.0. RISK ASSESSMENT AND VULNERABILITY:-

With a meange data we have attempted to assess the risk and vulnerability of people for fire incidents. Central and North Kolkata share major part of old Kolkata consisting a very old buildings, narrow lanes and by lanes. Source of available water needed for fire fighting scanty. High drains are chocked due to ill maintanance. It is very common to find a building with so many tenants where old wiring is hardly repaired and remaind as it is. Safety measures are not taken because entire building has become no one's baby and turned into very high risk zone. Narrow lanes restrict the movement of fire brigade Acute congestion of buildings cause to rescue operation as well as extinguishing the fire.

Kolkata slums mainly the 'Bustees' are illegally made either along the rail lines both is north and south section and along the canals in north and east Kolkata. Major characteristics of these 'bustees' starting from materials like nylon sheets for the shelter to cooking oil use for lighting the room to hooking from the electric lines make the slum dwellers highly vulnerable. Monetary valuation wise the loss of these kinds of slum dwelles can't be compared with high rise building because they are the most marginalised people who are forced to live for their live-lihood with little resource. They are least resilient thus the impact of loss is very high and thus need quite long time to cope up with the loss.

Since mid 1980s in South Kolkata sky scrapers and multistoried building were constructed indiscriminately. Some of them are legal but most of them were illegally constructed. But still there are places left behind which may help in rescue, rehabilitation

and reconstruction. Again it is to remember that this part is the fastest growing area South Kolkata gradually it may attain the same faith like north and central Kolkata.

8.0.0 DISASTER MANAGEMENT:

In case of disaster management of fire in Kolkata, following issues are to be given priority chronologically:

8.1.0. Preparedness and Adaptive Strategies- modify human vulnerability:

Considering very high density of population and tremendous congestion of buildings there is always possibility of voluntary and involuntarily made hazards like fire in Kolkata. This kind of response promotes changes in human behaviour towards hazards. The community of high and moderate risk zone, the residents of old buildings and slum dwellers must be prepared for the event. They should know their places in details. They are to be trained in such a manner so that during any fire they know few facts such as which switches are to be made off, immediately inform fire brigades, the room where old people reside and the shortest route of rescue. Youth volunteers to be identified and trained.

8.2.0 Protection- modify the event:-

These are ways to reduce the hazard by exerting some control over the processes involved. Regular monitoring the fire sources of old buildings, hospitals, markets, godowns and slums by the experts

of disaster management department, Gov. of West Bengal. Organization of mock trial of rescue, rehabilitation and reconstruction procedure is must especially in high risk zone.

8.3.0 Mitigation – modify the loss burden:

The most limited responses spread the financial burden as possible beyond the immediate victims through disaster aids. Here generally concerned government make arrangements for 5 lakhs for death and 50,000/- for the injured ones.

CONCLUSION

The above mentioned details may suffice following few suggesions which may help the policy makers:

- Kolkata contains more than 4.5 million residents and floating population of 60,00,000 per day. A substantial number of floating people are engaged in different sectors. With such a huge density, anybody can apprehend the state of vulnerability. 36 water supply installations are insufficient for combating the fire incidents i.e. average 7.9 per year.
- High risk zones must be categorized micro zones so that mitigation can be properly made.
- Regular mock training of both the fire man as well as the community. Fire tenders must be regularly checked. More fire tenders are needed. for 141 wards under 15 borough.

02.7.24

ANNEXURE-I

TYPES OF FIRE

CLASS OF FIRE	TYPES OF FIRE RISK MATERIAL	EXAMPLE
CLASS 'A'	Class A fires involves ordinary combustible materials which is effectively quenched by water.	wood, Fabrics, papers, plastics. and rubber.
CLASS 'B'	Class B fires mostly involve flamable liquids and flamable gases. Dry chemicals and carbon di oxide are used to Extinguish these fires.	Gasoline, paint, petroleum oil, propane, Butane solvents, oils and Alcohols.
CLASS 'C'	class c fire involves live electrical equipments like motors, generators and other appliance. Non conducting extinguishing agents such as dry chemicals or CO_2 are usually used to put of these fire.	Computers, Motors, transformers and appliances.
CLASS 'D'	Class D fire involves combustable metals, sodium carbonate, graphite, bicarbonate, sodium and salt based chemical are used to extinguish these.	Magnesium, Titanium, Sodium, Alluminium, Lithium, and Potassium.
CLASS 'K'	class K fires are fires in cooking appliance that involves combustible cooking medium.	Oils, animal and vegetable fats.

ANNEXURE-II

SOURCE OF FIRE

SOURCE OF FIRE	DESCRIPTION
cooking equipments	when a pan or a pot overheats or splatters greabes, there is a possibility of fire to take place within seconds.
Heating equipments	Heading equipments is one of the significant causes of fire in a building. Home space heaters and baseboard heaters can cause fire when fabrics like cloths, rugs etc. and other combustibles are left too close to them. So, ensure that to keep them away from the heating equipments.
Smoking in a building	Smoking in a building can prone to be a significant cause for the fire in your house if there is any sort of carelessness from the family members who smoke.
Candles/ lamps (i.e. Diyas)	Candles if kept nearer to fire catching things like curtains, clothes. or some flammable liquides, it can catch fire rapidly.
Faulty wiring	If here is any fault in the wiring of the house chance of sparks are acute as a result fire can catch on fire.
Dried leaves	Dried leaves or wood can easily catch and spread the fire.
Electrical Equipments	Electrical appliances like microwave, oven, toasters etc. can bad to fire if there is a fault in the

SOURCE OF FIRE	DESCRIPTION
	instrument on it the cord of appliance is faulty.
Flammable Liquids	Flammable liquids like petrol, diesel, kerosene, solvents, cleaning agents, paints etc are combustible. They can turn explosive if mishandle and rapidly catch and spread fire.
Curious Children	Sometimes kids play with the matchbox or some lighten, unaware about the adversities of fire.
Gas Leak	Gas leakage is one of the main reasons that can lead to a major fire mishap. LPG Cylinders are usually stored in the houses and can be dangerous if there is any leakage or minor leak in the gas pipeline. If it is ignored can catch and spread the fire very rapidly too.

02.7.24

ANNEXURE-III

Year	Incident Location	Death	Injured	No. of Fire tenders used	cause
2011	AMRI hospital Dhakuria	93 death	Many injured	25 fire tenders	Inflammable substances present in basement
	A Timber go-down in north	No loss of life	No one injured		Not mentioned
	Rubber shoe factory in SE Kolkata Tiljala				Short circuit
2012	Apeejay House in Kolkata Park street			12 fire tenders	
	A garments store near Sealdah Railway				
	A shoe shop in Thakurpukur			6 fire tenders	
	Kalikapur Region	1 death	5 injured		Burst of Gas Cylinder
	Hospital in Kolkata				Ac Burst
	A multi-storied building Chowringhee			10 fire tenders	Short circuit

Year	Incident Location	Death	Injured	No. of fire tenders used	cause
2012	Regent park area	5 death		Fire service was alerted by neighbours	Cylinder blast
	Three storied building on Egrastseel			4	Short circuit
	Oil godown at Dankuni in Hooghly district			18	Spark from the welding fell on an oil barrel and caught fire.
	Paint factory in N. Kolkata				
	Hub of Kolkata in Hospital				AC Burst
2013	Hub of Kolkata				AC condition-er
	Surya Sen Market complex	19 death	50 others injured	26	Under investiga-tion Kolkata joint commissio-ner of police
	Shantoshpur mahestala area				

Year	Incident Location	Death	Injured	No. of fire tenders used	cause
2013	Fire in Kolkata Auditorium Alipore			6	
	Fire in N. Kolkata a guilding ultadanga area			3	The cause of fire was not cleared
	Two Go-downs in N Kolkata's cossipore area		8 person injured	14	Flammable substances
2014	Slum near 45 no. Tiljala Topsia		2 injured		Short circuit
	24 floor iconic chaterjee internadio-nal building				
	Libreary section of a private hospital in parkstreet area			4	yet to be assertain-ed
2015	Bank of India, Raja Rammohan Sarani			31 pumps	Meter box
	Building of Suren Sankar roy road			24 pumps	Common hazard material

Year	Incident Location	Death	Injured	No. of fire tenders used	cause
2015	City mart New market			26 pumps	Electric wains
	482 madan daha EM Bypass Kalikapur			15 pumps	Flammable chemical reaction
	SS Hog market Fish Bazar			22	Improper electrical fittings
	Dum Dum park	1(70 years old died)	1 injured		Burst of cylinder
	New market Neli Sengupta Sarani			15	Substandard electrical materials
2016	Brace Bridge premises		5	13	Short circuit
	Princep street, CESC receiving and distribution center			14 pumps	power fluctuations from power outage
	Ballygunje science college		11 person rescued	13 pumps	
	56, Sayed Amir ali avenue			11	
	Krishna metallic pvt. Ltd. New market			25 pumps	Flammable materials

Years	Incident Location	Death	Injured	No. of fire tenders used	cause
2016	Top floors of Ronald ross building SSKM hospital			19 pumps	
	South City Mall			23 pumps	Defective generator
2017	Jawaharlal Nehenu Road			10 fire engines	Short circuit
	Surya sen market	20 death	12 injured	25	
	Bagri market			more than 25	Inflammable materials
	Golden park hotel near Hochiminh sarani	2	7	10	Short circuit
	Aminia resturant new market			3	Gas cylinder
	Rubber factory, Chowbaga area			7	Inflammable material
2018	KolKata office building				
	Tangra area in Kolkata		No injury reported	10	Chemical Explosion
	Dum Dum bound metro		Atleast 40 people injured, 7 people were admitted in SSKM		A spark in the TRCS third rail that supplies power to the trains might have caught in fire

Year	Incident Location	Death	Injured	No. of fire tenders used	cause
2018	City's central business area of Chowringhee			21	Fire spread through nylon nets
	Building Housing offices in Kolkata's Park Street			10	Air conditioner
	Priya Cinema in Rashbihari Avenue		4		
	Hotel in Bowbazar			5	From kitchen of the Roy and Roy Hotel.
	Barabazar in Kolkata			25	Gas cylinder exploded
	Armenian ghat			21	
	Calcutta medical college & Hospital			3	Electrical short circuit
	Gorabazar in DumDum cantonment	2		24	Electrical short circuit
	Calcutta medical college and Hospital		More than 200 people were evacuated		From pharmacy department

Year	Incident Location	Death	Injured	No. of fire tenders used	cause
	Chemical go-down near howrah bridge				
	at the basement of a shopping mall in saltlake				
	161B Rash Bihari Avenue			24 pumps 4 jets	
	Golam Md. Shah Road			10	
2019	Jawharlal Nehenu Road			12	
	5 storied building garia hat southern Kolkata		Some people have breathing problem		Blast of transformer
	Top floor of a 40 storied building, Exidemore south Kolkata				unknown
	39840 Rifle Range Road P.S- Konya			18 pumps 43 jets	Inflammable modernials
	Eastyard under circular Railway station			10 pumps 4 jets	

Year	Incident Location	Death	Injured	No. of the fire tenders used	cause
	Kapuria's Hotel Lenin Sarani			10	
	48A park street P.S parkstreet			11	
	Jagannath ghat road			25	
	TCI tenright vivekananda Road			22	Inflammable materials
2020	Kolkata ganesh ch Avenue N. part of the city	2		25	Electrical short circuit
	Slum area near Eastern metro politan Bypass in E Kolkata near Bengal chemical			15	Suspected that fire was aggravated by LPG cylinders & other combustable materials
2021	Kolkata Bagbazar area			25	Several continious Cylinder explosions.
	Eastern Railway headquaters new Koilyahad building on Stand Road	9		20 fire tenders 2 hydraulic ladders	The cause of fire is yet to be ascertained

Years	Incident Location	Death	Injured	No. of the fire tenders used	cause
2021	Salt lake city's central park area				
	Nationalized Bank in Stand Road area in Kolkata				Electrical short circuit
	High rise building at central Kolkata's lenin Sarani				cause is unknown
	113 park street, 3rd floor go-down			10	Short circuit
	New Barrackpur Bilkanda area			11	Inflammable materials

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02.7.24

A STUDY OF LANDSLIDES AND THEIR IMPACT ON DARJEELING DISTRICT WEST BENGAL

UNIVERSITY OF CALCUTTA

B.Sc HONOURS SEMESTER-VI

PRACTICAL EXAMINATION - 2024

UNDER CBCS

HAZARD FIELDBOOK - CC14

PAPER - CC14

REGISTRATION NO : 047-1211-0232-21

ROLL NO : 213047-11-0006

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TO WHOM IT MAY CONCERN

This is to certify that the candidate bearing the Roll Number ...21 3047-11-0006..... and Registration Number 047-1211-0232-21..... has completed all the assignments of GEOA CC14 **(Hazard Management Project Lab)** as per University of Calcutta practical syllabus and regulations under the supervision of the undersigned teacher.

18/07/24

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22.07.2024

LADY BRABOURNE COLLEGE • KOLKATA •

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CONTENTS

1. INTRODUCTION

The term 'landslide' refers to a variety of processes that result in the downward and outward movement of slope-forming materials, including rock, soil, artificial fill, or a combination of these. The materials may move by falling, toppling, sliding, spreading or flowing. A landslide is a mass movement of material such as rock, earth or debris, down a slope. They can happen suddenly or more slowly over long periods of time. When the force of gravity acting on a slope exceeds the resisting forces of a slope, the slope will fail and a landslide occurs.

A landslide occurs when part of a natural slope is unable to support its own weight. For example, soil material on a slope with slippery surface underneath, can become heavy with rain water and slide down due to its increased weight. A landslide is a downward or outward movement of soil, rock or vegetation, under the influence of gravity. This movement can occur in many ways. It can be a fall, topple, slide, spread or flow. The speed of the movement may range from very slow to rapid. The mass of moving material can destroy property along its path of movement and cause death to people and livestock. Although landslides usually occur at steep slopes, they may also occur in areas with low relief or slope gradient.

Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients, from mountain ranges to coastal cliffs or even underwater, in which case they are called submarine landslides. Gravity is the primary driving force for a landslide to occur but there are other factors affecting slope stability that produce specific conditions that make a slope prone to failure. In many cases, the landslide is triggered by a specific event (such as a heavy rainfall, an earthquake, a slope

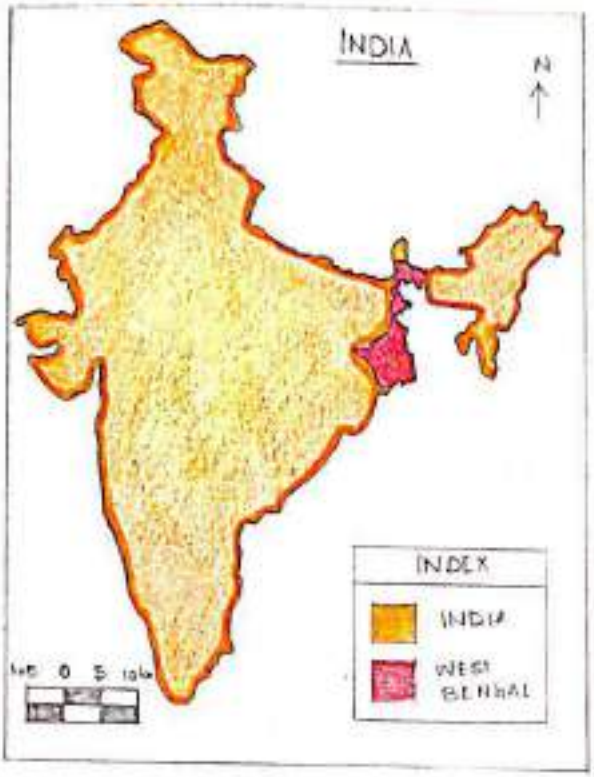
cut to build a road, and many others), although this is not always identifiable. Landslides are frequently made worse by human development (such as urban sprawl) and resource exploitation (such as mining and deforestation). Land degradation frequently leads to less stabilization of soil by vegetation. Additionally, global warming caused by climate change and other human impact on the environment, can increase the frequency of natural events (such as extreme weather) which trigger landslides. Landslide mitigation describes the policy and practices for reducing the risk of human impacts of landslides, reducing the risk of natural disasters.

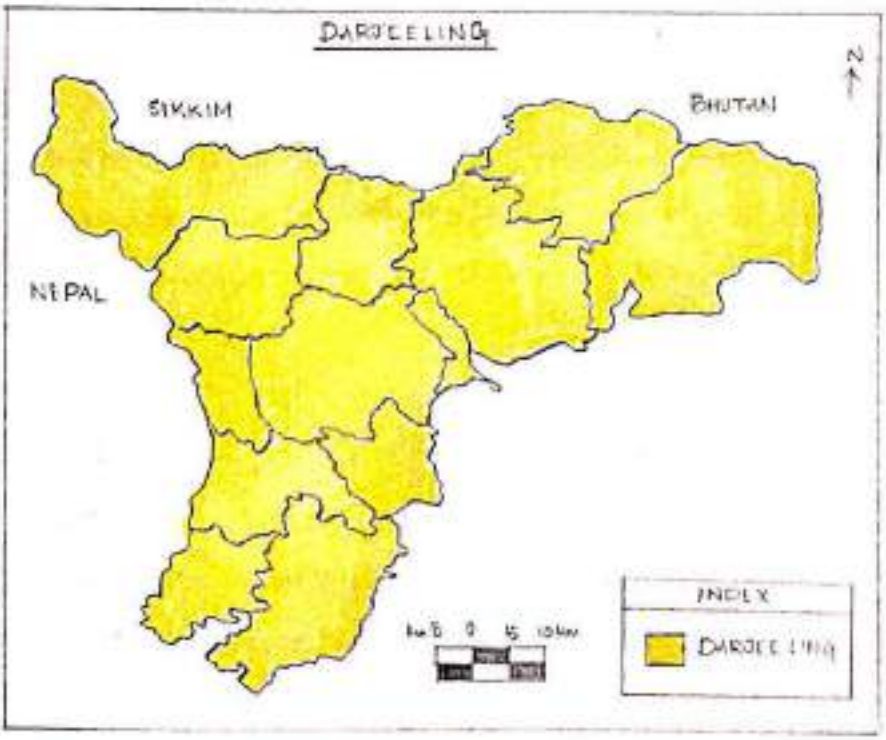
2. LOCATION OF THE STUDY AREA

Darjeeling district is the northernmost district of the state of West Bengal in eastern India in the foothills of the Himalayas. The district is famous for its hill station and Darjeeling tea. Darjeeling is the district headquarters. Kurseong, Siliguri and Kalimpong, three major towns in the district, are the subdivisional headquarters of the district. Kalimpong was one of the subdivision but on 14 February, 2017, it officially became a separate Kalimpong district.

The district is bounded on the north by Sikkim, on the south by Uttar Dinajpur district of West Bengal, southwest by Kishanganj district of Bihar state, on the southeast by Panchagarh district of Bangladesh, on the east by Kalimpong and Jalpaiguri districts, and on the west by easternmost Province No. 1 of Nepal. Darjeeling district has a length from north to south of 18 miles (29 km) and a broad breadth from east to west of 16 miles (26 km). As of 2011, it was the second least populous district of West Bengal (out of 19), after Dakshin Dinajpur.

LOCATION MAP: DARJEELING





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SOURCE : SURVEY OF INDIA

3. LITERATURE REVIEW

I. In his study, "Landslide along the Highways : A Case Study of Darjeeling Hill, West Bengal", Chiranjib Nad highlights the severe impacts of landslides on Darjeeling, particularly along highways NH31A, NH55 and SH12A. He states, "The black memories of previous marine landslide hazard took large impression on the inhabited society. Sometimes, the district remain isolated island due to breakdown of transportation for a stretch of days in the time of marine landslide along study route". Nad underscores the importance of understanding landslide characteristics and management to mitigate their significant disruption to local communities and infrastructure.

II. Hanuprasad Vairagya and Vishan Chandra Jha's study, "Landslide and seismic activities of Darjeeling district : related problems and sustainable management", addresses the threats of landslides and seismic activities to Darjeeling's tourism industry. They identify causes like slope instability and unplanned development. Their recommendations include better road construction, improved settlement patterns, and landslide warnings to protect the region and enhance its economic development. This approach aims to secure Darjeeling's status as a major tourist destination and support local livelihoods.

III. R.K. Bhandari's 2014 paper examines the geological conditions causing landslides in Darjeeling, emphasizing the area's complex geology, including rock types and structural features. He notes the significant impact of these geological formations on slope stability and landslide frequency. Bhandari

identifies specific formations prone to landslides and stresses the importance of understanding these factors for effective mitigation. The study includes detailed geological surveys and risk assessments to improve landuse planning and disaster management strategies.

IV. Basu S.R. and De S.K.'s 2003 paper, "Rainfall Threshold for Landslide Occurrences in Darjeeling", investigates the relationship between rainfall patterns and landslide incidents in the Darjeeling region. The abstract highlights their analysis of historical rainfall data and landslide records to establish critical rainfall thresholds that trigger landslides. They identify specific precipitation levels and durations that significantly increase landslide risks. The study emphasizes the importance of these thresholds in early warning systems and landslide prediction, aiming to improve disaster preparedness and reduce the impact of landslides on the local population.

4. DEMOGRAPHIC PATTERN

In 2011, Darjeeling had a population of 1,846,823 of which male and females were 837,259 and 909,561 respectively. In 2001 census, Darjeeling had a population of 1,609,172 of which males were 830,644 and remaining 778,528 were females. It is noticed that the population of Darjeeling had been rapidly increasing from 1991 to 2001 at the rate of almost 23.78% which influences the settlement pattern, landuse pattern and the pressure in the subsurface zone. Darjeeling area is of 3149 sq km. Back in 2001, the density of Darjeeling used to be 511 person / sq km. whereas from 2011 census, it was declared as 586 persons / sq km. The average literacy of Darjeeling as per 2011 census is 79.56%.

5. TYPES OF LANDSLIDES

Based on the type of movement involved, there are mainly four types of landslides :-

a. FALLS : They refer to the type of landslide that involves the collapse of material from a cliff or steep slope, which then falls down the slope and collects near the base.

b. TOPPLE : Under this type of landslide, the falling mass undergoes forward rotation and movement around an axis or point at or near the base.

c. SLIDES : Under this type of landslide, there is a distinct zone of weakness that separates the moving material from a more stable underlying material. There are two major types of slides:

i) ROTATIONAL - In this type of slide, the surface of rupture is curved concavely upward and the slide movement of the falling mass is rotational about an axis that is parallel to the ground surface and traverse across the slide.

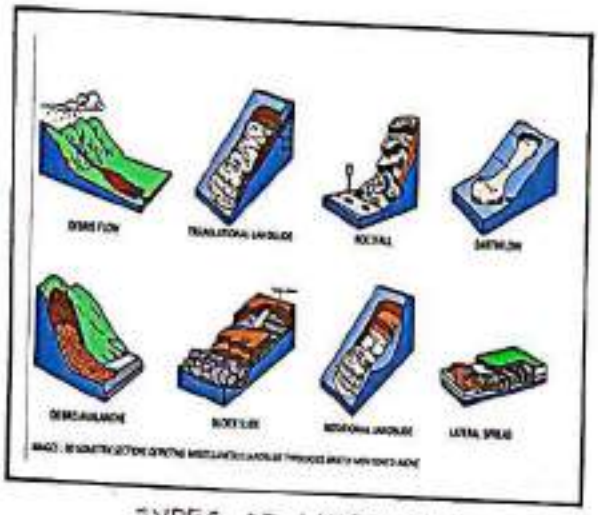
ii) TRANSLATIONAL - In this type of slide, the landslide mass moves along a roughly planar surface with little rotation or backward tilting.

d. FLOWS : This type of landslide involves the movement of material down a slope in the form of a fluid. There are three different types of flows :

i) MUDFLOW - It involves the movement of wet material of which which a majority portion is compromised of sand, silt and clay-sized particles.

ii) DEBRIS FLOW - Masses such as loose soils, rocks and organic matter combine with water to form a slurry. It, then, flows down a slope.

iii) ROCKFLOW - This is a specific type of landslide or mass movement involving the flow of rock material downslope.



TYPES OF LANDSLIDES

6. LANDSLIDE ZONES

For a better understanding of the geographical distribution of landslide-prone areas in Darjeeling town, the following 5 categories of susceptibility zones have been identified :—

CLASS I : EXTREMELY HIGH SLIP PRONE ZONE —
Almost after every torrential rain, these tracts experience slips. They are mostly found on eastern slope of Jalapahar-Katapahar ridge mainly covering areas like Alubari, Hanspoti bustee, Toongsong, Pandam tea garden.

CLASS II : VERY HIGH SLIP PRONE ZONE —
These are the areas where slips occur for more than 5 times in 10 years. They are found along the eastern as well as the western slopes of the edge, i.e, upper Alubari, upper Toongsong, along Tensing Norge road, C.R. Das Road, eastern slope of Hall, below Raj Bhavan

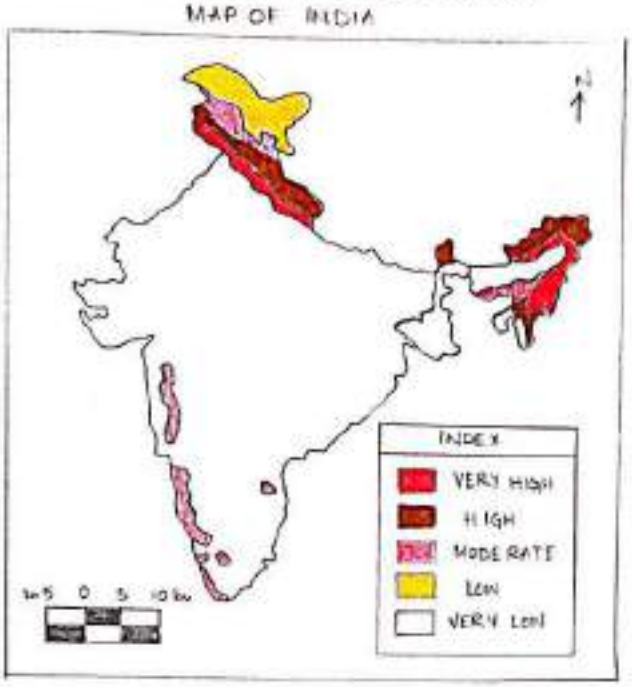
CLASS III : HIGH SLIP PRONE ZONE —
It covers the western spur of the town along the Hill cart road, Gandhi Road, Nimbidara, Police line, Happy Villa, Kaypuri, Upper Kagjhora. Here, landslides occur 2-5 times in 10 years.

CLASS IV : MODERATE TO LOW SLIP PRONE ZONE —
In this zone, landslides occur once or twice in last 10 years. It is found mostly along the ridges of Katapahar-Jalapahar upto the mall including the Bazaar area.

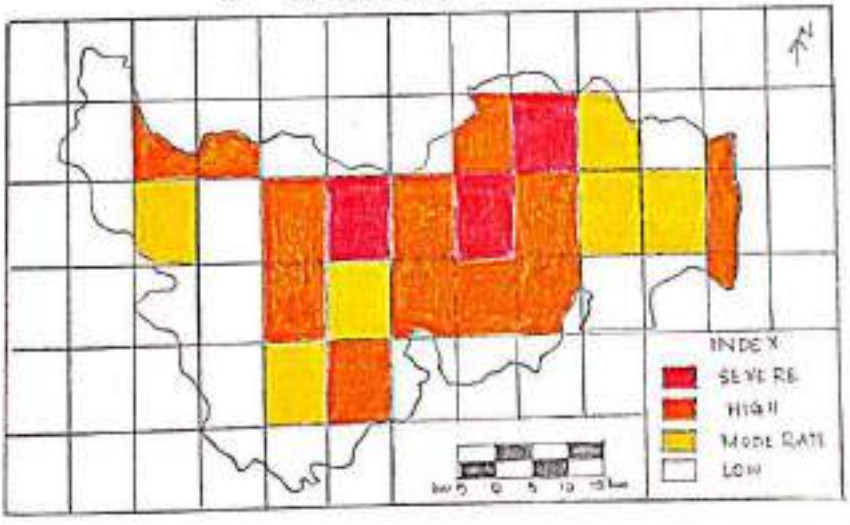
CLASS V : NONE TO NEGLIGIBLE —
It is found in pockets on the ridge tops of the Jalapahar-Katapahar ridge, the Lebong ridge (Military Cantonment) and the Observatory Hill and on the top of the Birch Hill ridge where slips rarely occur.

ZONATION MAP : DARJEELING

LANDSLIDE HAZARD ZONATION MAP OF INDIA



LANDSLIDE HAZARD ZONATION MAP OF DARJEELING DISTRICT



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SOURCE : SURVEY OF INDIA

7. OBJECTIVES

1. To identify the main reasons of the landslides occurring in the Darjeeling district.

2. To assess the critical areas and how the landslides are affecting the people residing there.

3. To suggest necessary mitigation measures that can be put into use to reduce the impact of the landslides.

8. METHODOLOGY

The following research paper is structured one based on secon-
-dary data sources collected from different published research materials and maps over time, to determine the reasons, impacts and consequences of landslides in areas of Darjeeling and how the local government has taken necessary mitigation measures to reduce the effects of landslides on the physical and human environment. Secondary data has been collected about the major landslides that occurred mainly between 2015 and 2022, from different government and non-government websites, journals, newspaper cuttings and Wikipedia. All the secondary data done been collected and organised into tables and diagrams for better understanding of the impacts of landslides in Darjeeling.

9. RESULT AND DISCUSSIONS

9.1 MAJOR CONSEQUENCES

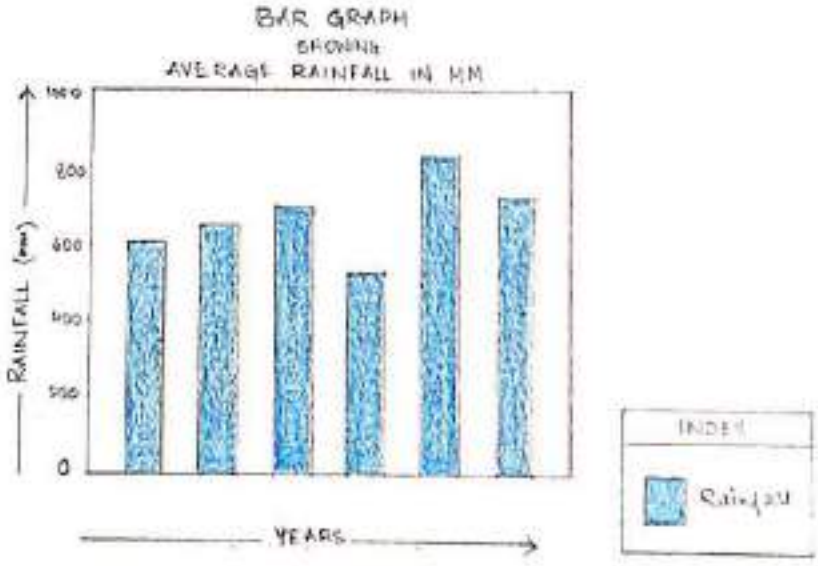
9.1.1 NATURAL CAUSES OF LANDSLIDES —

1. HEAVY RAINFALL AND PRECIPITATION :

Heavy rainfall or precipitation is a very common thing in Darjeeling. Rainfall is the most important factor of landslide. It decreases the matric suction, increases the pore water pressure and causes the groundwater table to rise. Heavy rainfall is the cause of landslides in all development due to its impact on slope stability and groundwater dynamics. The intensity of precipitation, along with the hydraulic & mechanical properties of soil, play a significant role in triggering landslides. Rainfall induced changes in surface & groundwater conditions reduce slope stability, making the slopes more susceptible to mass movements. Understanding the relationship between rainfall characteristics and landslide vulnerability is crucial for analysing and predicting landslide occurances.

TABLE : YEARWISE DATA OF ANNUAL AVERAGE RAINFALL OF DARJEELING

YEAR	AVERAGE RAINFALL (mm)
2010	600.25
2011	650.30
2012	700.50
2013	625.75
2014	830.00
2015	720.10



SOURCE: INDIA METEOROLOGICAL DEPARTMENT

SCALE —
VERTICAL : 1cm = 200mm

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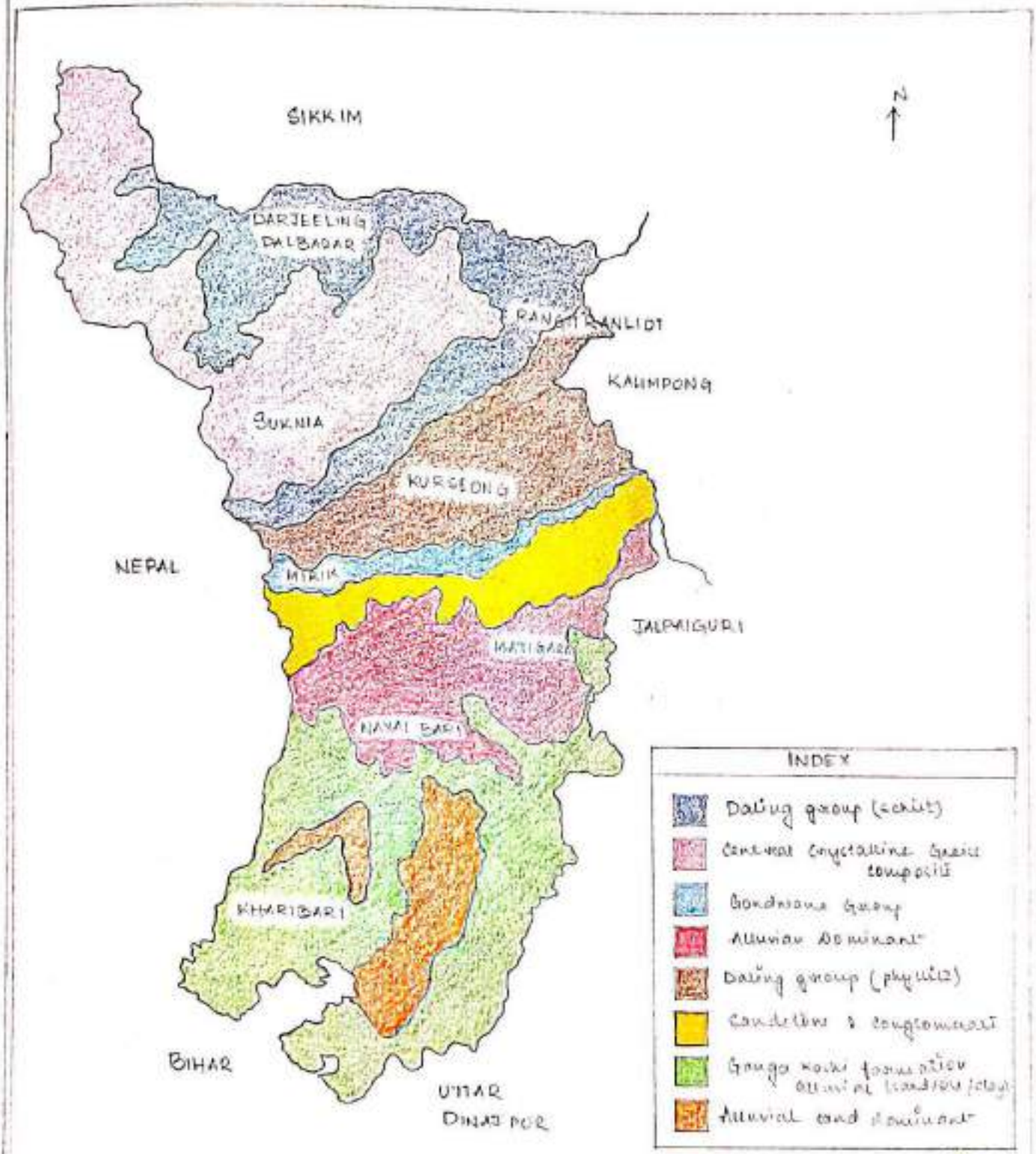
B. WEAK GEOLOGICAL SETUP –

The Darjeeling hill area is formed of comparatively recent rock structure that has a direct bearing on landslides. The geological formation consists of – Daling group of schist rocks, central crystalline gneiss, composite Gondwana group of rocks, Alluvial dominant, Daling group of phyllite rocks, sandstone, and conglomerate, Alluvial sand / silt / clay formation and alluvial sand dominant in the lower altitude. These geological structures owe their formation to tectonic activities and are influenced by fluvial morphology. Thus, the structure is mostly weak and unstable, becoming prone to landslides. The geological formations are loose, filled with cracks, unstable with faults and scarps.

The upper Darjeeling region which are most prone to landslides consists of low to high grade metamorphic rocks that have been subjected to constant fluvial weathering resulting in development of faults, a weak lithology and soil erosion. The schist and phyllite of the Daling group are easily weathered to become thin flakes, which promote landslides in crystalline schist and gneiss areas that surround the region at the altitude of 1000 - 1600 m (above sea level). Additionally, the Gondwana group of rocks indicate depositional characteristics which being fluvial in origin are weak & unstable. These geological attributes of Darjeeling pose risk of landslides in the region. The geological structure of Darjeeling is composed of weak foundation of rocks that are weathered and fragile. After studying the geophysical aspects of the district, it has been seen that the problem of landslides is basically related to the effects of threats, faults, avalanches, slope instability, subsurface rainfall, tampered vegetation cover, population pressure and anthropogenic influence.

GEOLOGICAL MAP OF DARJEELING



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SOURCE : GEOLOGICAL SURVEY OF INDIA

C NATURAL DISASTER :

Natural disaster like earthquake and volcanic eruptions often cause landslides. Violent shaking of the ground often trigger landslides, causing significant and even catastrophic damage to houses. If a house is in the path of an earthquake-induced landslide, it is at risk for damage from landslide debris, as well as sliding downhill itself. During volcanic eruptions, magma releases volcanic gases that partially dissolve in groundwater, resulting in a hot acidic hydrothermal system that weakens rock by altering minerals to clay and eventually causes land-slide.

ANTHROPOGENIC FACTORS OF LANDSLIDES —

Human activities can be a contributing factor in causing landslides. Many human-caused landslides can be avoided or mitigated.

A MINING :

Mining methods can be of different types ranging from open pit mines, underground mines or quarries. Excavation of slopes destabilises the soil and triggers landslides. Mining companies contribute to the vulnerability of a community in a rainfall-induced landslides in several ways. It is the key cause as because of its different operation that produce a huge number of vibrations, especially blasting techniques and its vibrations that can reach 100s of metres under the soil surface and pose threat to areas, that are at risk of sliding.

3 DEFORESTATION :

Agricultural expansion, wood extraction (eg, cutting down trees for domestic fuel), and infrastructure expansion such as road building and urbanisation, these human activities eventually cause landslide. Deforestation adds to landslides because the roots of trees and plants hold the soil. On clearing the vegetation, the mountain slope looses its protective layer due to which the rainwater flows at a very high speed on the slopes due the pull of gravity and as a result, the landslides occur.

Some of the most affected areas in Darjeeling due to landslides caused by deforestation are :—

1. MIRIK: known for its scenic beauty, Mirik has experienced numerous landslides due to deforestation causing damage to infrastructure and homes.

2. KURSEONG: This area has seen a significant increase in landslides, triggered by deforestation and soil erosion, disrupting transportation and daily life.

3. DARJEELING-SIKKIM-BORDER: The region has experienced several landslides caused by deforestation and heavy rainfall resulting in loss of life and property.

4. SENCHAL WILDLIFE SANCTUARY: Deforestation and landslides have affected the sanctuary, threatening the habitat of endangered species and disrupting ecosystem balance.

5. TANDHARIA : This area has experienced landslides and soil erosion due to deforestation, causing damage to infrastructure and affecting local livelihoods.

These areas highlight the urgent need for sustainable forest management and conservation practices to mitigate the risk of landslides and protect the environment and livelihoods in Darjeeling.

TABLE : LANDSLIDES CAUSED BY DEFORESTATION

YEAR	DEFORESTATION (IN KM)	NO. OF LANDSLIDES
2009	150	5
2011	200	8
2013	250	12
2015	300	15
2017	350	20
2019	400	25

C BUILDING ROADS AND CONSTRUCTION :

The construction of roads and buildings needs massive clearance of land. Removing vegetation and destabilizing soil layers can weaken the slope's stability, making it prone to sliding down because of heavy rains or earthquakes. Construction activities often involve heavy machinery and drilling, generating ground vibrations that can trigger landslides. These vibrations weaken the soil cohesion and reduce its ability to resist sliding. Also unauthorized construction around hill slopes without proper engineering and cheap materials causes landslide during heavy precipitation.

D POOR DRAINAGE SYSTEM :

A common problem with poor drainage is erosion - water over runs over land and down the slopes without catch basin or trench drain containment carries soil, mulch and debris with it and robs trees and plants of nutrients. Heavy rainfall can saturate the soil and cause it to become unstable leading to landslides. This is particularly common in areas with poor drainage systems.

9.2 MAJOR IMPACTS

Here are some common aftermath of landslides with reference to Darjeeling :-

A ECONOMIC DECLINE :

Loss of industrial, agricultural and forest productivity and tourist revenue as a result of damage to land or facilities of transportation systems. Reduced real estate values in areas threatened by landslides. Loss of tax revenues on properties devalued as the result of landslides. Thus, landslides eventually lead to economic loss. As per the Geological Survey of India, the economic loss due to landslides may amount to

as much as 1% or 2% of the Gross National Product in many developing countries. Around 15% of the country's landmass is susceptible to landmass hazards.

B. LOSS OF LIFE AND INJURY:

Landslides can result in fatalities and injuries, especially in densely populated areas or areas with inadequate infrastructure and emergency response capabilities.

For example: 40 people have been killed in landslides triggered by heavy rains in Darjeeling, Kalimpong and Kurseong sub-divisions of Darjeeling district on end July, 2015.

C. PROPERTY DAMAGE AND DESTRUCTION:

Landslides can damage or destroy homes, buildings, roads, bridges, utilities (like water, electricity supply) and other infrastructure.

For example: The landslide in 2015 have caused extensive damage to NH 10 and NH 55, cutting off road and telecommunication link to Darjeeling and Sikkim.

D. ENVIRONMENTAL IMPACT:

Landslides are the most widespread natural disaster in Darjeeling which increases its spatial extent day after day. The erosional debris left by the landslide leaves behind rugged landscapes that are unsightly. The pile of soil, rock and debris downhill can cover the lands utilized by the community for agricultural or social reasons.

E. INFRASTRUCTURE DISRUPTION:

Landslides can block roads, railways and transportation routes hindering access to affected areas and disrupting supply chains

For example: Heavy rain triggered a massive landslide in Kurseong in Darjeeling district of West Bengal. It took place in paglajhora which incidentally lies between National Highway 55. The National Highway was blocked which connects the plains with the Darjeeling hills and also the Himalayan railway services.

F IMPACT ON WATER RESOURCES:

Landslides can alter hydrological patterns affecting water availability, groundwater recharge, and flood risk. The soil, debris and rocks can slide downhill and block the river courses, killing off the marine population due to interference of the natural flow of water. Communities depending on the river water for household activities and irrigation will suffer if the water is blocked.

For example: In 1988 and 1993, landslides damaged water pipelines in different parts of Darjeeling. During tourist season when the population double itself, the water problem reaches maximum these months. (April - June and late September - November)

TABLE : CONSEQUENCES OF LANDSLIDES FOR 3 CONSECUTIVE YEARS

YEAR	DATE	NO. OF PEOPLE DIED			HOUSEHOLD DAMAGE	
		AFFECTED	DEATH	INJURED	FULLY	PARTLY
2018	MAY 14	3	1	1	-	-
	JUNE 12	12	5	1	-	5
	JUNE 14	10	-	-	-	3
	JUNE 21	14	-	10	-	5
	JUNE 26	8	-	-	1	-
	JUNE 26	32	10	2	-	13
	JUNE 30	45	6	-	3	8
	JULY 5	54	-	5	5	13
	JULY 8	7	-	-	2	-
TOTAL		185	22	19	11	48
2019	JUNE 26	3	-	-	-	1
	JUNE 27	6	-	-	2	-
	JUNE 28	-	-	-	-	-
	JUNE 29	4	2	20	-	-
	JULY 6	200	18	2	50	36
	JULY 7	9	-	-	2	-
	JULY 8	-	1	5	-	-
	JULY 9	42	-	2	7	1
	JULY 25	30	3	-	10	2
TOTAL		294	25	29	71	40
2020	APR 26	1	-	-	-	1
	AUG 06	8	-	-	-	2
	AUG 31	-	-	-	-	1
	SEP 23	1	-	-	-	-
	SEP 25	-	8	-	100	6
	OCT 2	18	4	-	3	2
TOTAL		27	12		103	12

SOURCE : DISTRICT DISASTER MANAGEMENT PMU, DARJEELING

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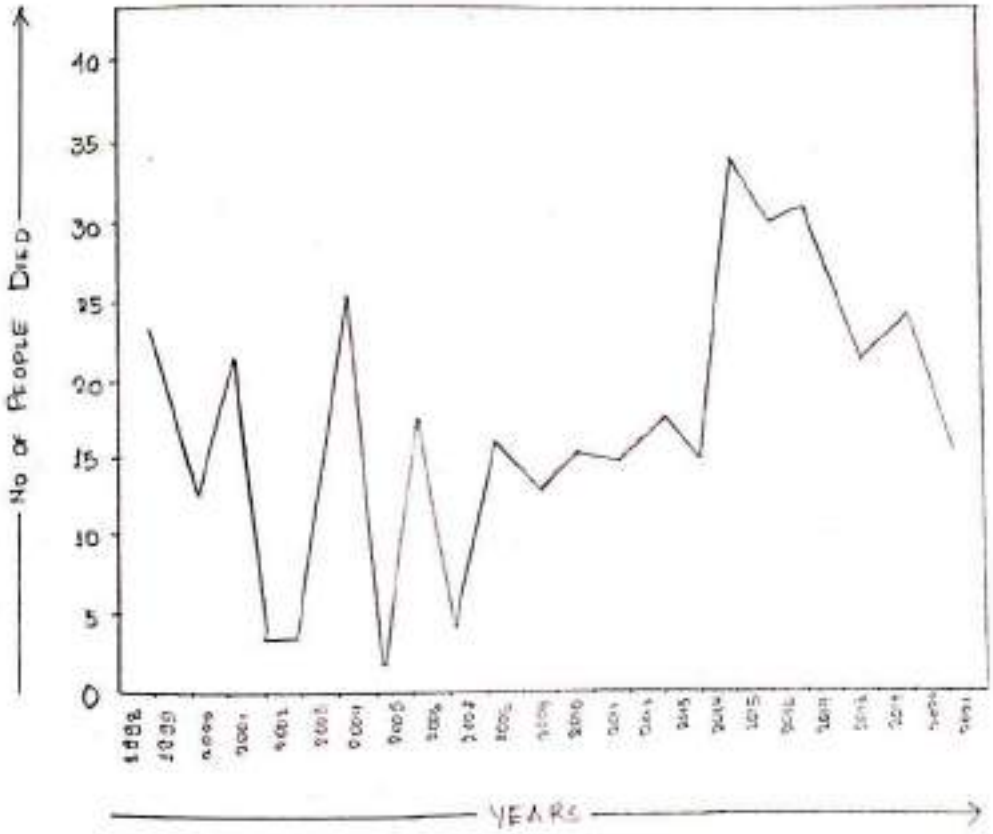
LINE GRAPH

SHOWING

NUMBER OF PEOPLE DIED IN LANDSLIDES (1998-2020)



SCALE :

HORIZONTAL : 0.5cm ≈ 1year

VERTICAL : 1cm ≈ 5persons

SOURCE : DISTRICT DISASTER MANAGEMENT PLAN, DARJEELING

19.07.24

10. LANDSLIDE MANAGEMENT

10.1 WHAT TO DO BEFORE LANDSLIDE ?

- The key to staying safe is to prepare and to have an emergency plan in place, and have your emergency kit ready.
- Find out if you live in an area where landslides could potentially happen. They may also be referred to as mudslides, debris flow, mudflows or debris avalanches.
- Listen to local news and weather reports for any potential landslide watches & warnings in your area.
- Talk with your family and neighbours about what you would do during a landslide. Identify a safe place to go together.
- Have practice drills with your family, so you know what to do and are prepared when the time comes.
- Become familiar with the land around your living place and your working place so that you understand your risk in different situations.
- Avoid actions that can increase instability. For example, do not undercut a steep bank, build near the top or base of steep slopes, drain swimming pools which can increase water flow down the slopes.
- Learn how to recognise the sign of potential imminent landslides, this could include slope cracks, slope bulges, an unusual seepage of water on the slope, sudden changes in streamflow, and small rocks falling.
- Watch the patterns of storm water drainage on slopes near your home, where runoff water converges.
- Watch patterns and know who to notify if you see these signs. Have municipal emergency contact numbers on hand.
- Make a personalized emergency kit. Families should be prepared to be self-sustaining for at least three days.

- Kit should include practical items such as drinking water, food, cash, and a portable radio. However, they should also include items that are unique to your own family's needs. This could include baby items, medical prescriptions, pet food etc.
- If you have already dipped into your emergency kit and food supply while staying at home, consider safely getting the supplies replenished following your local public health authorities' guidelines for leaving your residence.
- During the COVID-19 pandemic, also add items (hygienic) such as hand sanitiser and non-medical mask to keep your family safe during an evacuation.

10.2 WHAT TO DO DURING LANDSLIDE ?

- Be prepared to evacuate at a moment's notice.
- If you suspect imminent danger, evacuate immediately. Inform affected neighbours if you can, and contact your public works, fire or police department.
- Listen for unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together.

If Indoors :—

- Find cover in the part of the building that is the farthest from the approaching landslide.
- Take shelter under a strong table or a bench.
- Hold on firmly and stay put until all movement has stopped.

If outdoors :—

- Move quickly away from its likely path, keeping clear of embankments, trees, power lines and poles.
- Stay away from the landslide area. The slope may experience

additional failures you have to days afterwards.

- If you are in your car, watch out for collapsed pavement, and, fallen rocks and other indications of possible debris flow.

10.3 WHAT TO DO AFTER A LANDSLIDE ?

- Continue to take precautions and listen to and follow directions from local authorities.
- Listen to the radio, watch your local news channels, and/or follow your local news outlet and/or emergency officials on social media for further instructions from officials and local leaders.
- Stay away from the slide area until local officials say it is safe to enter.
- Look for and report broken utility lines to appropriate authorities. Reporting potential hazards will get the utilities turned off as quickly as possible, preventing further hazard and injury.
- Check your home's foundation, chimney and surrounding land for damage. Replant damaged ground as soon as possible because erosion caused by lack of ground cover can lead to flash flooding.
- If you suspect your home is unsafe, do not enter. Rely on the professionals to clear your home for re-entry, if you are unsure.
- Experiencing a disaster is challenging enough, during the COVID-19 pandemic, however, it can feel even more difficult. The Red Cross has many resources available to help you navigate these challenging times. You can also find mental & emotional well-being resources on the Public Health Agency of Canada, or any provincial/territorial health authority website.

11. MAJOR FINDINGS

On the basis of this hazard project report, it is clear that Darjeeling is a landslide prone area in West Bengal. Darjeeling is a district where heavy torrential rain is a common thing, and due to heavy rainfall, landslides are bound to happen. It is particularly common in areas with poor drainage system. Weak rock formation is also a factor of landslide in Darjeeling. Five geological units encountered in the district are Kanchenjungna gneiss, Darjeeling gneiss, Chungthang schists and gneiss, Lingtse granite gneiss and Daling group of rocks consisting of Phyllite, slates, Quartzites and schist of Pre-cambrian age. These sedimentary rock of young folded mountain promotes the active erosion in Darjeeling Himalaya. This region is highly vulnerable to landslides due to its unstable rock structure. Also landslides are more common on steep slopes due to erosion. Erosion happens on slope like mountains, when heavy rains move water down the slope. The movement of water down the slope means that the side of the slope is not absorbing very much water. This leads to reduced vegetation and a higher landslide rate. Last but not least, human activities such as construction, mining and deforestation can weaken the soil and cause landslides. It is also known that natural activities such as earthquake and volcano eruptions can cause landslides.

12. CONCLUSION

Landslides are a significant natural hazard that can have devastating effects on human lives, infrastructure and the environment. Understanding the causes and effects of landslides is crucial for developing effective strategies for prevention and mitigation. Governments and communities can work together to develop early warning systems, improve landuse planning, and reduce the impact of human activities on the environment. By taking proactive measures, we can reduce the risk of landslides and their devastating effects on society. Darjeeling is such a district which can be developed a lot on the basis of tourism industry. The other options for developing the economy of the district are not enough because of its unfertile and undulating topography. Usually, the tourists are interested to visit the areas having natural beauties, safety and security. If the mitigation measures which are recommended in the study can be made fruitful or effective in the near future, then the district may take an important role in West Bengal as well as India's economy. The slogan for the Hill-people of India may be encouraged to "Save Darjeeling to Save the Queen and Save the beauties".

19.07.24

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B.Sc. Semester-VI (Honours) Examination-2024
Under CBCS

Paper : GEO-A-CC14 Hazard Management Lab
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CU Roll No : 213047-11-0028
Department of Geography

Project Report : Issues Related to Arsenic Contamination in Groundwater : Study Area of C.D. Blocks Baruipur And Sonarpur, South Bengal.

SIVANATH SASTRI COLLEGE

(Formerly City College Com. Dept. South Kolkata (Morning)
[City College South Kolkata Women's Branch]
[Accredited by NAAC]

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Department of Geography

To Whom it may concern

This is to certify that ....ARUNIMA SINHA..... bearing Roll No.213047-11-0028..Registration No.047-1212-0123-21.....Year.2024... of Semester VI Geography (Honours) has prepared the group project under my supervision, entitled ***'Issues related to arsenic contamination in groundwater: Study of C.D. Blocks Baruipur and Sonarpur, South Bengal'.*** The report fulfills the requirement of the geography undergraduate syllabus of the University of Calcutta (GEO-A-CC-14- Hazard Management Lab) for the B.A./B.Sc. (CBCS) Examination, 2023.

Bhaswat Roy
25.6.24.
Signature & date
(Dr. Bhaswati Ray)
Associate Professor
Department of Geography

SIVANATH SASTRI COLLEGE * KOLKATA-29 *

Examined
22.07.2024

LADY BRABOURNE COLLEGE * KOLKATA *

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I also acknowledge my friends as well as my family members for their constant help and support.

CONTENT

Issues related to arsenic contamination in groundwater: Study of C.D. Blocks Baruipur and Sonarpur, South Bengal

Introduction:

Arsenic contamination in groundwater has been termed as 'the largest mass poisoning in history' because of its detrimental effects on human population (Mori et al 2018). Arsenic pollution in groundwater, used for drinking purposes has been envisaged as a problem of global concern and is reported from many countries like Taiwan, China, Argentina, Chile, Mexico, Cambodia, Thailand, Myanmar, Nepal, USA. But the severity of this contamination in India and Bangladesh is unprecedented.

The chronic toxicity developed by the consumption of arsenic contaminated water has been a widely documented global issue, the most affected region being South-East Asia. Prolonged consumption of arsenic-rich groundwater (As level > 0.01 mg/l) causes chronic arsenic toxicity in human beings resulting in major health issues.

Effects on human health include vomiting, abdominal pain, diarrhoea, muscle cramping, diabetes, hypertension, reproductive disorders. Chronic arsenic toxicity may ultimately turn fatal. Pigmentation changes and skin lesions is the main criteria to identify arsenic poisoning. The indications of arsenic poisoning start from the change of skin pigmentation, skin lesions and hyper keratosis which becomes visible after 1 year of arsenic exposure (Guha Majumder, 2000). Long term exposure to arsenic contaminated water causes hyperkeratosis (hard patches on palms and soles of feet), keratinized warts numbness and tingling of limbs. Arsenic poisoning may also result in the cancer of skin, bladder, kidney or lung. Skin carcinoma is the most common skin cancer that may be matured from keratinized warts (ASTRD, 2007). The early sign of skin cancer is observed as pigmentation changes, skin lesions and dark patches on skin (WHO 2018). The exposure of arsenic in children impacts the physiology and behavioural pattern. Children may develop stomach irritation, skin colour changes, blood vessel damage; reduction in nerve function and IQ scores (ATSDR, 2007) and may accelerate mortality rate among juvenile population.

Arsenic contamination also affects livelihood patterns. Accumulated arsenic in plants affect growing mechanisms and yield of crops. Health issues of the affected population results in economic instability due to loss of livelihood and employment as well as social stigma.

Arsenic contamination in ground water is a classic example of slow onset disaster and people identify the impacts of arsenic toxicity when the damage is already done. Hence it is important to understand and create awareness about arsenic toxicity and its impacts.

Study Area:

Recent epidemiological studies in West Bengal, sponsored by the Arsenic Task Force and supported by PHED/UNICEF, show that in South 24 Parganas district, out of the 7683 people examined in 57 arsenic affected villages, the prevalence of arsenical skin lesion was found in 4.6 percent. The arsenic affected C.D Blocks in West Bengal include Maldah, Murshidabad, Bardhhaman, Nadia, Howrah, Hooghly, North 24 Parganas, South 24 parganas.

The study area consists of Baruipur and Sonarpur C.D. Blocks located in South 24 Parganas district in southern part of West Bengal (Figure 1). The district is extended from Kolkata to the remote villages of Sundarbans near the Bay of Bengal. The district has 5 subdivisions and Sonarpur and Baruipur comes under Baruipur subdivision. In Baruipur there are 138 villages under 19 gram panchayats and in Sonarpur the number is 72 under 11 gram panchayats. According to the Census of India the total population of Sonarpur Block is 219863 while that of Baruipur Block is 433119, thus leaving more than 6.5 lakh people vulnerable to the health hazards associated with arsenic contamination.

Both the blocks under study have been categorised as highly arsenic affected. Amount of arsenic is as high as 2.6 mg/l in Sonarpur Block and 3.2 mg/l in Baruipur when the permissible acceptable limit is 0.05 mg/l according to WHO. BIS recommends the permissible limit to be 0.01 mg/l and in the absence of other alternate sources the amount may be increased to 0.05 mg/l.

Figure 1: Location of the study area

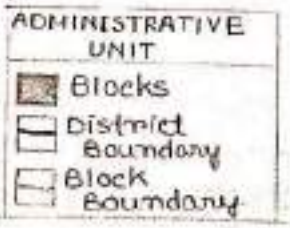
India

Map not to scale

West Bengal

Map not to scale

South 24 Parganas



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Objectives:

- To identify the causes of arsenic contamination in ground water.
- To assess the vulnerability of the CD Blocks under study to arsenic poisoning.
- To understand government intervention to combat arsenic contamination in the study area.

Methodology:

The study is based primarily on secondary data.

Literature regarding arsenic poisoning of ground water, causes and implications, and the geographical distribution was consulted to help understand the need of the study and also to identify the study area.

Thereafter literature on arsenic contamination of drinking water and ground water as well as the impact on human health and socio-economic condition was studied specific to the study area. For demographic data Census of India documents were consulted.

The literature was analysed and conclusions drawn.

Maps and diagrams were prepared as necessary.

Causes of arsenic contamination in ground water:

Drinking water beyond the permissible limit can initiate serious arsenic related health issues to human beings. Most importantly it is a slow onset disaster and symptoms develop only after 8-10 years of consumption of high level of arsenic, though with higher concentration levels it may take only 3 years to develop symptoms (Singh and Ghosh, 2012)

The distribution of arsenic in the groundwater in India tend to be defined by the hydrogeological provinces, with arsenic found principally in association with young alluvial deltaic aquifers.

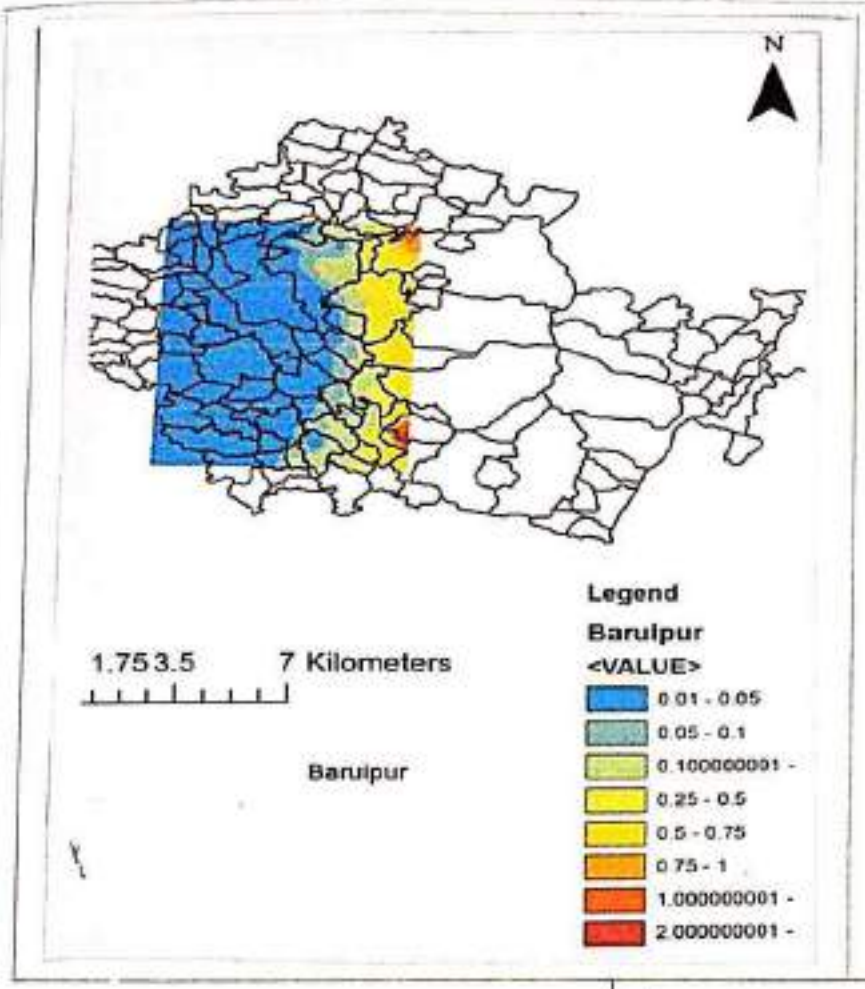
Arsenic contamination of groundwater is a form of groundwater pollution caused by naturally occurring high concentration of arsenic in deeper levels of groundwater. Arsenic is a metalloid existing in insoluble state in rocks and minerals (Routh and Hjelmquist, 2011). In natural

water bodies arsenic mostly found in two states trivalent arsenic (As^{3+}, Arsenite) and pentavalent arsenic (As^{5+}) both forms are highly toxic inorganic species (Fendorf et all., 2010). Generally, in groundwater, natural occurrences of high arsenic levels were reported in aquifers - especially unconsolidated sediment aquifers throughout the world (Smedley and Kinniburgh, 2013).

The factors responsible for the release of arsenic into the groundwater system are pH, presence of organic matter in sediments (like peat, lignite and plant debris), water table fluctuation, water saturation of sediments, limited supply of sulphur and microbial activities, groundwater flow direction, age of groundwater and topography. The mechanisms which cause the release of arsenic into ground water include:

1. Oxidation and dissolution of As and Fe bearing minerals.
2. Weathering and reductive dissolution of arsenic-bearing primary and secondary minerals in the presence of natural organic matter.
3. Combination of both oxidative and reductive dissolution of arsenic-bearing iron oxides and oxyhydroxides.
4. Competitive exchange of Arsenic by other compatible ions such as nitrate, phosphate and bicarbonate.

Arsenic rich minerals are linked with the Quaternary deposits of alluvial sediments belonging to the Holocene age. As contamination occurs due to the reductive dissolution of As-bearing minerals, the Arsenic-rich sediments are transported by rivers originating from the Himalayas and are deposited into downstream basins and deltaic areas. The reductive dissolution of arsenic bearing Fe-oxyhydroxides coupled with the microbial activities in the organic-matter-rich Holocene grey sands is believed to be the primary reason for releasing arsenic in groundwater. The microbial reduction of iron (Fe) from Fe^{3+} to Fe^{2+} due to the consumption of oxygen bound to As bearing ferro-hydroxides results in the subsequent release of Arsenic in water.



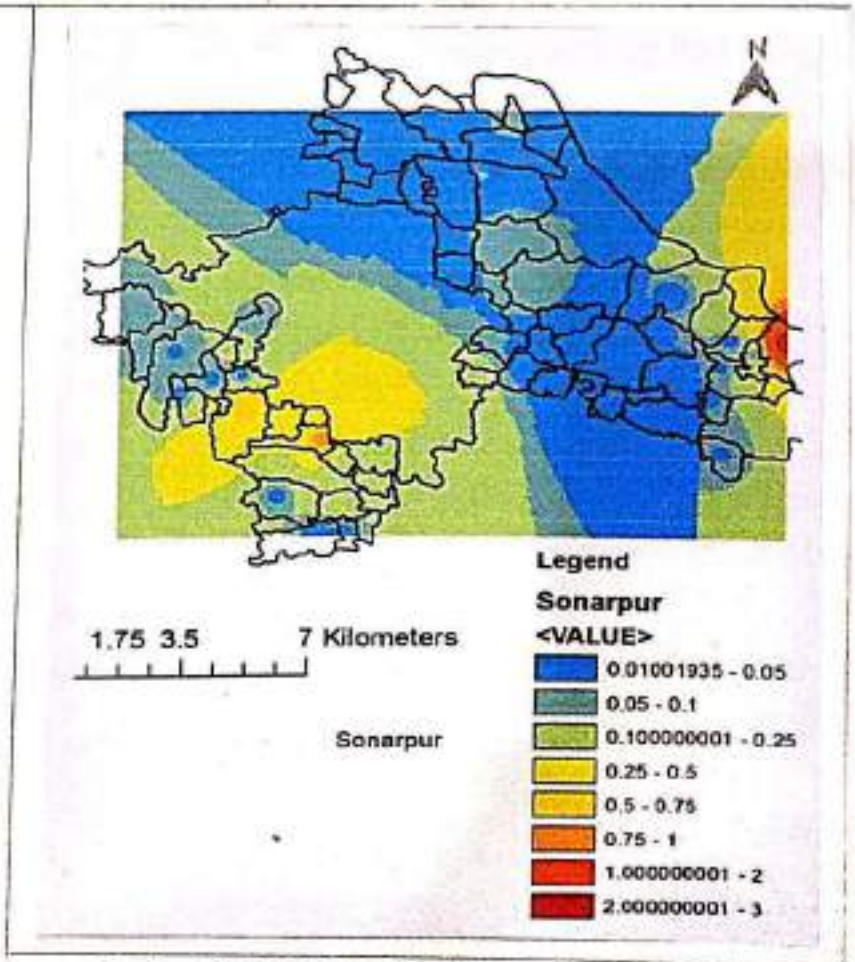


Figure 2: Distribution of arsenic in C.D. Blocks Barulpur and Sonarpur

Source: Chaudhuri, P. Ailch, P. and Dutta, A. (2019)

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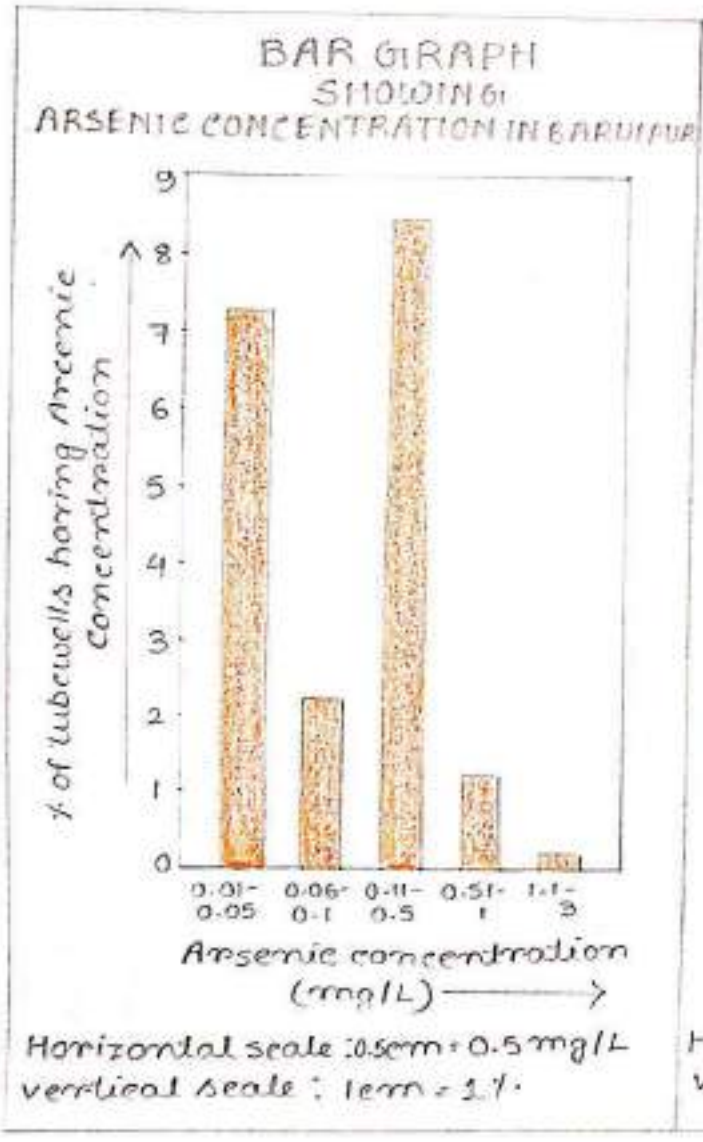
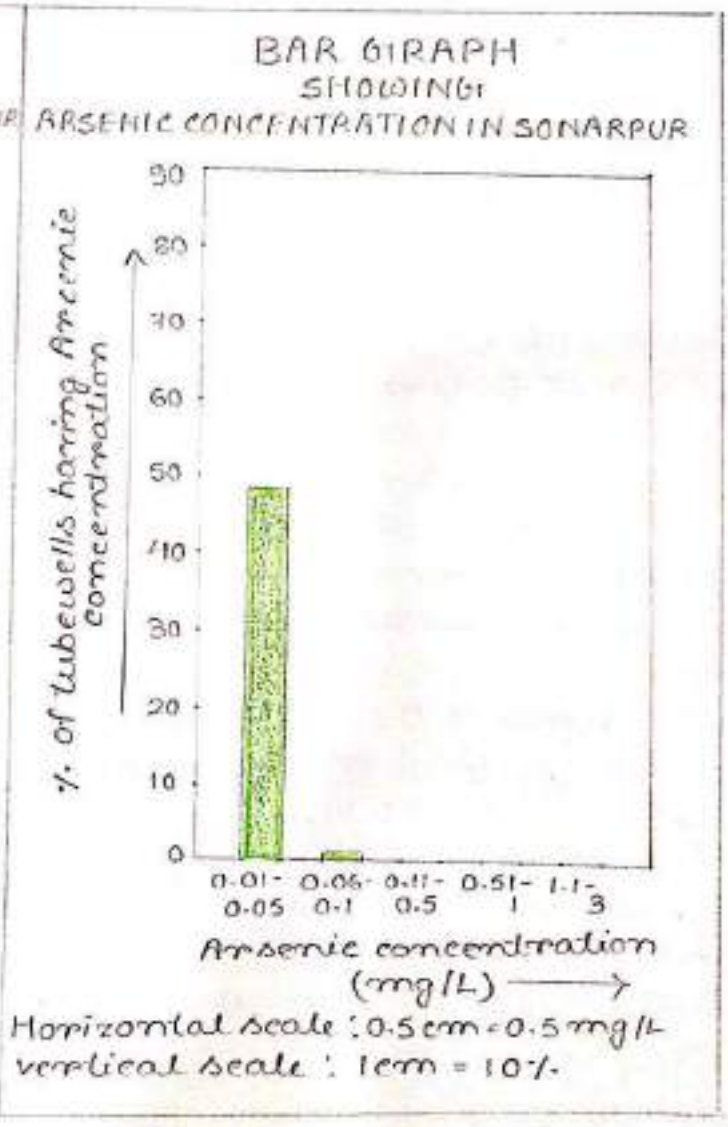
Distribution of Arsenic concentration in Barwipur and Sonarpur block :

Name of the Block	Arsenic concentration of tubewells (mg/L)	% of tubewells having arsenic concentration	Maximum Arsenic concentration
Barwipur	0.01 - 0.05	7.34	2.56
	0.06 - 0.1	2.18	
	0.11 - 0.5	8.35	
	0.51 - 1	1.17	
	1.1 - 3	0.15	
Sonarpur	0.01 - 0.05	47.73	2.72
	0.06 - 0.1	1.29	
	0.11 - 0.5	0.38	
	0.51 - 1	0.25	
	1.1 - 3	0.12	

Source : Chaudhuri, P. Aitch, P. and Dutta, A (2019)





Vulnerability of the CD Blocks Baruipur and Sonarpur to arsenic poisoning

The presence of arsenic in the groundwater of the densely-populated Bengal Basin evolved as a mass poisoning agent in Baruipur & Sonarpur. High level arsenic was detected in the shallow aquifers-tube wells in the late-20th century. The oxidation-reduction conditions and the biogeochemical activities in the shallow aquifers support the existence of arsenic.

Baruipur and Sonarpur are the most arsenic contaminated blocks and arsenic concentration levels are very high (Chaudhuri et.al, 2019). The distribution of arsenic concentration is not even and is found to occur in small patches (Figure 2).

In the study conducted by Chaudhuri et.al. it was seen that 88 percent tubewells in Baruipur C.D. Blocks and almost 97% of tubewells in Sonarpur C.D. Block contain water that are not harmful for human body according to WHO and BIS. However, in Baruipur the maximum concentration is 256 times and in Sonarpur it is 272 times greater than the WHO permissible limit (Chaudhutri, 2019).

In the map prepared by Chaudhutri et.al., 2019 villages in eastern and south eastern and western part of Baruipur are arsenic free. The western part has a concentration of 0.01 to 0.05 mg/l. The villages in central part has arsenic concentration amount of 0.1 - 0.25 mg/l. Beside that a large stretch is contaminated with 0.25-0.5 mg/l A small pocket with a concentration as high as 2.5-3 mg/l and 1.5 - 2 mg/l is also seen. In Sonarpur, most part has arsenic concentration level between 0.01 - 0.05 mg/l, considered to be within permissible limit. The north eastern and south western parts have arsenic concentration of 0.25 - 0.5 mg/l.

No dermal effects were reported up to 0.01 mg/l arsenic concentration. The prevalence of skin lesions was documented if a person consumes 0.023 mg/l arsenic daily. Skin lesions development is actually more obvious if a person consumes 0.1 mg/l arsenic contaminated water daily. (ATSDR, 2007). Hence, the entire population who live in the arsenic patches with arsenic concentration above 0.01 mg/l are susceptible to arsenic poisoning.

Government interrention to combat the arsenic contamination in West Bengal

West Bengal is in the process of implementing the Master Plan in consultation with Arsenic Task Force on arsenic mitigation and intends to coren all arsenic affected habitations identified under the Bharat Nirman Programme (India Planning Commission, 2007). President, Institude of Public Health Engineers, K D Nath is of the opinion that the most adranced and latest technologies hare been used in the arsenic removal units attached to 400 tubewells installed by the state gorernment as part of the masterplan (Business Standard, May 2024). He adrocates the need for effective mass awareness to sensitize the people.

Vission 2020 implementation in West Bengal encompasses the prorision of a permanent supply of drinking water to rural areas at 70 liters per capita per day (lpcd) through piped water supply schemes and household. connections. It aims to phase out water supply from hand pumped tube wells to surface water based sustainable sources.

Central Ground Water Board (CGWB) has come out with technology to construct Arsenic free wells tapping deeper aquifers. The specially designed wells with cement seal technique proride the solution to handle the situation of the interconnection between the lower and upper aquifers. The cement sealing is applied to a suitably thick interrening clay layer separating the arsenic contaminated aquifer from arsenic free aquifer. This cement seal prerents seeping of contaminated water through the annular space which is filled with gravel material.

Under the National Aquifer Mapping Programme (NAQUIM) of CGWB, special attension is girren to ground water quality including contamination by toxic substances such as arsenic. Further under NAQUIM, arsenic safe deeper aquifer zones hare been identified and wells hare been constructed tapping the arsenic safe deeper aquifers using innorative cement sealing technique. 513 exploratory wells tapping arsenic safe aquifers hare been constructed, including 188 in West Bengal.

The option of local rain water harresting and use of surface water is also being examined. rillage ponds that are promoted for multiple uses in West Bengal may be properly protected and used for drinking water supply after properly treatment. Such reserroirs need to be earmarked

as dedicated water source for drinking. The quality of water needs to be upgraded by using horizontal roughing filter/ slow sand filter. The local community to be involved for managing system.

Government of India in its Jal Jeevan Mission (JJM)- Har Ghar Jal, operational since August 2019, makes provision for potable tab water supply in adequate quantity, of prescribed quality and on regular and long-term basis to every rural household by 2024. Priority is given to quality-affected habitations. Since, planning, implementation and commissioning of potable piped water supply scheme takes time as an interim measure, States/UTs have been advised to install community water purification plant especially in arsenic and fluoride affected habitations to provide potable water at the rate of 8-10 lpcd to meet drinking and cooking requirements.

In many villages of Baruipur and Sonarpur C.D Blocks, water from the tubewells were tested by PHED to determined the level of arsenic and tube wells/hand pumps have been painted with different colours red for arsenic contaminated and green for not contaminated.

Conclusion:

The problem of arsenic contamination in ground water becomes complicated in the lower part of West Bengal delta because of hydraulic conditions, geological conditions, hydro-geochemical interactions and oxidation-reduction conditions arising from groundwater exploitation and other hydro-geological causes.

It is thus necessary to adopt a targeted and focussed approach involving all stakeholders including the local community, farmers, landowners, local government representatives and government officials, academicians, the scientific community and identify the remedial measures suited to local conditions. The remedial measures at community level may include installing arsenic removal systems and filters searching for alternative aquifers, substituting high arsenic sources, such as groundwater with low arsenic safe sources such as rain water and treated surface water dilution of contaminants by artificial recharge with low arsenic water to achieve acceptable concentration level.

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