EMSE 6315

Final Project

Risk Assessment Proposal - Dharavi

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1.0 Introduction

At the heart of the bustling city of Mumbai – India's financial capital – filled with high rises and glass buildings, lies Dharavi, one of the largest and oldest slums of Asia. Housing up to 1 million people over approximately 2.39 square kilometers (590 acres), gives rise to its hazardous living conditions and high levels of poverty [Ref 1]. This report is a proposal from Resilient City Builders (RCB) for a Risk Management Plan for Dharavi. If approved by the Municipal Corporation of Greater Mumbai (MCGM) – the governing civic body of Mumbai, the framework this plan provides can be executed in a timeframe of 1 year, 4 months. The plan is framed so that RCB and the Dharavi Constituency Assembly – the main government branch directly overlooking Dharavi, can execute it easily under the MCGM.

Although home to up to a million people, residences are not all that make up Dharavi. Made famous by the movie Slumdog Millionaire, Dharavi has a thriving tourism industry. It is also home to various micro – industries such as leather, steel, and textile industries. The largest of these is it's recycling industry, where up to 60% of Mumbai's plastic waste is recycled [Ref 1]. Dharavi's unique blend of industry and tourism necessitates a robust risk assessment plan. The activities of its industries contribute to environmental hazards like air and water pollution, and soil contamination. Tourists, drawn by Dharavi's history and resilience, bring an influx of income but also expose themselves to these risks. To mitigate these challenges and ensure the well-being of both residents and visitors, a thorough assessment is crucial. This would not only identify and prioritize the most

pressing environmental and safety concerns but also give way to informed solutions. By pinpointing the most vulnerable areas and industries, targeted interventions can be implemented, minimizing risks while allowing Dharavi's entrepreneurial spirit to flourish. Ultimately, a risk assessment becomes an investment in Dharavi's future, safeguarding its residents and industries.

1.1 Establishing Scope

Under the MCGM, Mumbai is divided into 7 zones, each zone containing 3 – 5 wards. The entirety of Dharavi is marked as the **Zone 3, Ward H East**. It is situated between the intersection of two of Mumbai's railway lines – the Western and Central Railway lines. In Figure 1, Dharavi – which is the scope of the risk assessment is market in red.

Figure 1: Dharavi – The scope of this Risk Assessment

Figure 2: Borders of Dharavi

To its north, lies the Mithi River, and the affluent Bandra – Kurla Complex. One of the borders to the scope is marked by the Mahim – Sion Link Road – which stretches from the SL Raheja Multispecialty Hospital to the Mithi River along the Maharashtra Nature Park. The second border is made up by the Central Railway Line. The scope's south borders are made up by the Western Railway Line, Shahu Nagar Road, and Jasmine Mill Road [Fig. 2].

The location of Dharavi, and its poor drainage systems makes it especially vulnerable to natural disasters such as floods and landslides. These disasters can cause widespread damage to property and infrastructure, and quite often in the past they have also led to loss of life [Ref. 2].

2.0 Risk Management Process

The Risk Management Process employed for this framework is based on the DHS Risk Management Framework [Ref. 3], and the NIST Risk Management Framework [Ref. 3]. Changes were made to suit the context of Dharavi better. There are 6 stages of this framework as can be seen in Figure 3:

1. Unveil Scope
2. Identify Potential Risks
3. Analyze Risks
4. Rank Risks
5. Risk Management Strategies
6. Implement and Monitor

Figure 3: Risk Management Process

2.1 Scope Unveiling

Unveiling the scope of this risk assessment would involve a series of kick off meetings that would set the course for the first section of the risk assessment. These meetings would inform key stakeholders – the Dharavi MLA (Member of Legislative Assembly, who heads the Dharavi Constituency Assembly) and MCGM officials. The scope unveiling would be done in 2 parts:

- Kick Off Meeting
- Community Outreach

Kick Off Meeting

This is the meeting where the strategy for the risk assessment is discussed. The scope and early requirements are explained to stakeholders – Dharavi Constituency assembly, and workers involved in the early stages.

The framework is a form of participatory risk assessment [Ref. 5]. Although Dharavi is a high-risk area, there haven't been any extensive risk assessment done for it that considers all types of major risks. This framework involves the community directly and hears from them about risks they've faced, and the consequences they have had. Interviewing community members would be the principal form of input from the community.

Given that Dharavi is a huge settlement, it is impossible and impractical to interview every household or business. Thus, the strategy would be to divide Dharavi up into sectors and to conduct group discussions with its members. This is a part of participatory risk

assessment that has already previously been carried out in areas of Dharavi and proven successful [Ref. 5]. A risk analyst and a social worker would be paired up to carry out this stage of the outreach. A risk analyst that understands the data that is actually required from the outreach and ensures that the outreach gathers the data. A social worker is skilled at understanding the community and getting through to people.

Community Outreach

The next stage is implementing the outreach. Dharavi would be divided into 30 sectors of about 20 acres each. Two teams of 1 risk analyst, and 1 social worker would have a week to cover each sector. Accounting for slack, this ensures that in 4 months time (or 16 weeks time), 2 teams can cover upto 12 sectors. Thus community outreach would require about 6 teams, each containing a risk analyst and a social worker.

The main questions, that are needed to be answered by the outreach are outlined below.

Questions
What are some disasters that affected you?
How were people affected?
How did it affect your household?
How did this affect the resources around you?
How were your daily activities affected?

2.2 Identify Potential Risk

In this stage, building upon the insights gathered from the previous outreach initiative, comprehensive reports, historical data, and leveraging the expertise of RCB's in-house risk analysts, potential risks to Dharavi are to be identified. Each identified risk is systematically categorized into one of three distinct categories:

1. **Natural Hazards:**
    - Natural or environmental disasters - this category includes risks arising from forces of nature, such as floods, earthquakes, or other environmental phenomena.
2. **Other Hazards:**
    - Covering risks stemming from man-made structures, machinery and processes that are not inherently environmental. This category spans a range of non-natural hazards associated with human activities and technological systems.
3. **Threats:**
    - Risks driven by malicious intent - this category encompasses deliberate threats posed by individuals or groups with harmful motives, often requiring a nefarious human element for their realization.

The following is an example of the output that would be produced at this stage of the framework:

Table 1: Output of Identifying Potential Risks

Natural Hazards	Other Hazards	Threats
Floods	Structural Failures	Terrorism
Cyclones	Industrial Accidents	Violence
Landslides	Electrical Hazards	
Earthquakes	Plague	
Heatwaves	Fires	
Droughts	Chemical Spills	
	Explosions	

2.3 Analyze Potential Risk

This section of the assessment aimsto qualitatively comprehend and articulate the consequences associated with each previously identified potential risk. The focus is on delineating the impacts across four crucial dimensions:

1. **People:**
    - Encompassing injuries, displacement, and potential loss of lives, this dimension examines the human toll and welfare implications resulting from the identified risks.
2. **Property:**
    - Addressing the potential damage inflicted upon buildings and structures, this dimension evaluates the impact on the physical infrastructure and spatial landscape of the community.
3. **Resources:**
    - Considering the harm to essential survival resources such as food, water, and medicinal supplies, this dimension explores the potential disruption to the fundamental elements necessary for community well-being.
4. **Operations:**
    - Examining the interruptions to daily routines, whether in terms of individual schedules, business operations, or industrial activities, this dimension assesses the broader societal and economic ramifications stemming from the identified risks.

Most of the consequences have been reported on from the initial section of the

assessment, specifically in the "Unveiling Scope – Community Outreach." This phase serves to consolidate the findings from the outreach efforts with the subsequent risk categorization. The following table exemplifies an output format for the analysis of potential risks. This forms a robust foundation for the forthcoming steps in the risk assessment process.

Table 2: Output for Risk Analysis

Hazards / Impact	**People**	**Property**	**Resources**	**Operations**
Floods, Cyclones, Earthquakes, Landslides	Deaths, Injuries, Displacement	Buildings (Houses, Workplaces, Schools, Religious Places) Destroyed	Water Contamination, Goods Destroyed, Power Outages	Roads blocked, Industries Closed, Tourism paused, Schools / Clinics Closed
Heatwaves	Deaths, Illness	Minimal Damage	Water Scarcity	Outdoor Activities Disrupted, Healthcare operations strained

Violence	Deaths, Injuries, Displacement, Violence against minorities	Religious Places, Workplaces, Housing Damaged	Community Services Disrupted	Curfews Enforced, Disruption of Affected Workplaces, Religious places, Tourism Falls
Structural Failures	Deaths, Injuries, Displacement	Buildings Damaged, Collapsed	Goods destroyed	Strain in operations
Industrial Accidents	Deaths, Injuries, Illnesses	Factories Damaged	Air and Water Contamination	Affected Factories Strained, Tourism Strained
Electrical Hazards	Deaths, Injuries	Buildings, Houses Damaged	Power Outages	Affected Places Strained
Plague	Deaths, Illnesses	Minimal Damage	Shortages – Panic Buying	Healthcare Strained, Schools /

				Workplaces Closed, Tourism Falls
Fires	Deaths, Injuries, Displacement	Buildings, Houses Damaged	Goods Destroyed, Air Polluted	Affected Places Strained
Train Derailment	Deaths, Injuries	Buildings, Houses, Train Damaged	Goods Destroyed	Affected Places Strained

2.4 Rank Risks

The next step in the framework is to rank the risk from most hazardous to least. This step involves taking the qualitative data gathered up till now and quantifying it. To make sure risks are being correctly ranked, expert elicitation is done.

The structure for the process is based on the IDEA protocol for expert elicitation [Ref 6]. Expert elicitation would measure the likelihood and impact of risks. Specialists from the fields of urban planning, environmental engineering, epidemiology, disaster management, and social science would be considered for this step. Experts would first be sent the reports of Risk Analysis so they have a comprehensive base on each risk and its consequences. Then over a week, experts would be gathered and introduced the risk analysis reports. They would then be asked to rank 5 parameters for each risk on a scale of 1 to 5 (1 being least and 5 being most) with their justification:

1. Historical – Rating of the historical occurrences of the hazard.
2. Probability – Rating of the probability of hazard occurring in the future, without regarding history.
3. Vulnerability – Rating of the amount of people and property that would be affected.
4. Spatial Extent – Rating of the geographical area that might be impacted.
5. Magnitude – Rating of the severity of losses of people and property

Once, they have done this, a select few random answers are revealed to all experts. Once again, the experts would have a chance to rank each of the risks on the 5 parameters.

Measuring Likelihood of risks

The final risk rankings of all substantive experts would be aggregated to measure the likelihood of each risk on a scale of 1 -10.

The following table is an example of the output of likelihood measurement of risks.

Table 3: Measuring Likelihood of Risks

Hazard / Threat	Historical	Probability	Likelihood
Floods	4	4	8
Fires	4	4	8
Violence	3	3	6
Cyclones	3	3	6
Structural Failures	2	2	4
Drought	3	2	5
Landslides	2	2	4
Plagues	2	1	3
Earthquakes	1	1	2

Similarly, the final risk rankings of all substantive experts would be aggregated to measure the impact of each risk on a scale of 1 -15.

Next, the risk formula will be used to measure the risk level – or hazard level of each risk.

Risk = Likelihood x Impact

The following table is an example of the final output of expert elicitation and risk Ranking.

Table 4: Output of Expert Elicitation and Risk Ranking

Risk	Likelihood	Vulnerability	Spatial Extent	Magnitude	Impact	Risk Level	Rank
Floods	8	5	4	5	14	112	1
Fires	8	5	4	5	14	112	2
Violence	6	5	4	5	14	84	3
Cyclones	6	5	3	4	12	72	4
Structural Failures	4	5	2	3	10	40	5
Drought	5	4	3	4	11	55	6
Landslides	4	3	2	3	8	32	7
Plagues	3	3	2	3	8	24	8
Earthquakes	2	3	2	3	8	16	9

2.5 Risk Management Strategies

Once all risks have been ranked, the next step is to assign a risk management strategy for each risk. The four risk management strategies that would be used to deal with each risk are:

1. **Risk Acceptance**: These are the risks that are too low in likelihood or would have too low of a consequence. In such cases, an implicit or explicit decision is taken to not take any steps that would affect the risk, or in other words, the risk, it's probability of occurrence and its consequences are accepted.
2. **Risk Avoidance**: The risks that have too high of a likelihood or consequence are completely avoided. Measures will be taken to effectively remove Dharavi and its communities from exposure to these types of risks.
3. **Risk Control**: These are deliberate actions taken to reduce the potential of harm of a risk or maintaining it at an acceptable level.
4. **Risk Transfer**: This is process of shifting some or all the risk to another entity, asset, or system.

The strategies and the cases in which they would be implemented are summarized in the table below:

Level		**Risk**	**Strategy**
Low Likelihood	Low Consequence	Low Risk	Accept
High Likelihood	High Consequence	High Risk	Avoid
All other combinations		Medium Risk	Transfer / Control

To further elaborate on the risk management strategies, the table below gives an example of how each of these strategies can be implemented. By the end of this stage of the assessment, a report, like the table below, is to be made for all the identified risks.

Snowstorm	Low Risk	Accept – Mumbai's location close to the equator makes it so that it never snows there
Train Derailment	High Risk	Avoid - Construct a sturdy wall between train lines and communities
Floods	Medium - High Risk	Control - Improve drainage, or alternatively relocate communities in low lying areas

Each of the proposed strategies must be evaluated on the following criteria:

- **Implementation effectiveness** - This criterion assesses how well each strategy addresses the identified risks, ensuring that it provides robust and comprehensive risk mitigation rather than superficial or limited control measures.
- **Cost effectiveness** - Evaluating the financial investment required in comparison to the anticipated benefits, this criterion ensures that the chosen strategy optimizes resources to achieve effective risk management without unnecessary expenditure.
- **Adaptiveness** - Focusing on the dynamic nature of risks, this criterion emphasizes the necessity for strategies to be adaptive and flexible, capable of responding to evolving threats rather than providing a one-time or minimal risk control.

- **Community acceptance** - Acknowledging the importance of local perspectives, this criterion gauges how well the community embraces and supports the proposed risk management strategies, recognizing that successful implementation relies on community understanding and cooperation.
- **Long term effectiveness** - Assessing the sustainability of each strategy, this criterion ensures that the selected measures contribute to lasting risk reduction rather than offering short-term fixes, promoting resilience against future challenges and uncertainties.

Implement and Monitor

The final step in the risk assessment framework would be to evaluate and monitor each of the risk management strategies. Although, in the previous stage a qualitative evaluation for each of the strategies would have already been implemented, it is important that any feasible options should be tested on small scales as drills. This is so that there is definite proof that the strategies employed are accepted by the community and they would be willing to partake in the methods if they are implemented.

Figure 4: Process to Implement and Monitor Strategies

- Pilot Implementations
    - Communicate strategy to people
    - Implement preliminary strategies
    - Evaluate effectiveness
    - Identify disruption to communities
    - Identify possible failures of strategy
- Feedback Loop
- Final Report on Risks and Strategies
- Large Scale Implementation

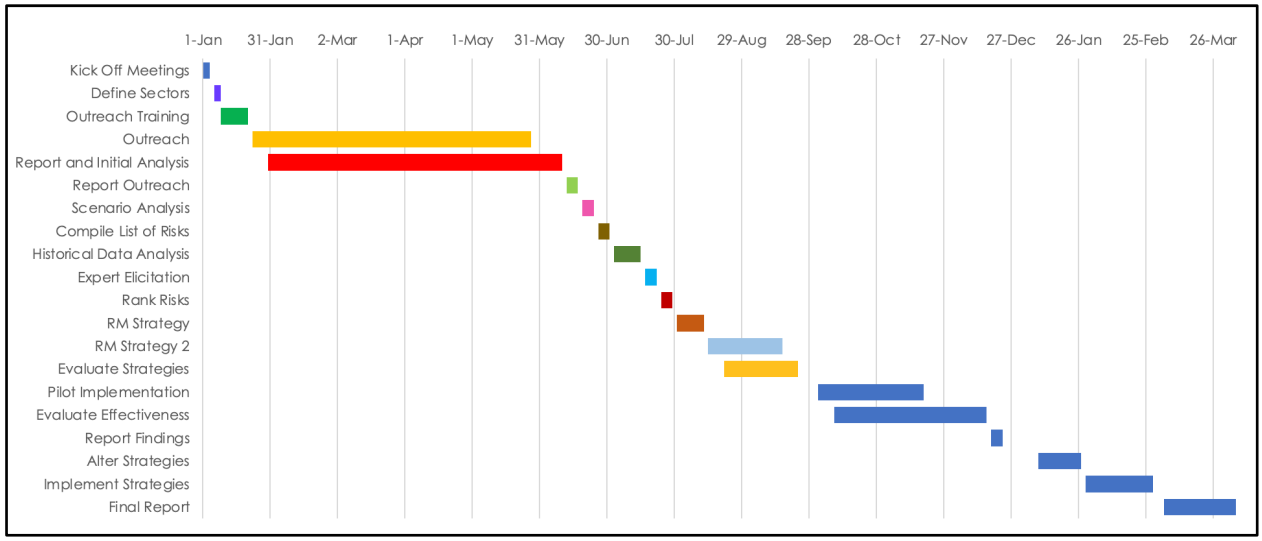
3.0 Qualifications of the Team

The team for the framework would be made up of inhouse RCB risk analysts and data analysts, social workers employed by the Dharavi Constituency Assembly, and experts. Experts from the following fields would be consulted for a week:

- Disaster Experts
- Social Scientists Experts
- Chemical Engineers
- Civil Engineers

4.0 Time Requirements

The following is the time schedule of the entire project. It would take just under a year and 4 months.



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