Evaluation of Disaster Risks, Vulnerabilities and Response Strategies of High Rise Buildings in Lagos Municipality

Isa Hassan-Enua Mshelgaru and Kabir Bala

Department of Building, Ahmadu Bello University, Zaria 8100001, Nigeria

Abstract: Although disasters can occur anywhere, certain types of disasters are more likely to have more effects on some buildings than others, especially on those in urban areas. Buildings in Lagos have had nasty experiences from both natural and artificial disasters, claiming lives and properties in the past. This study aims at evaluating the disaster risks, vulnerabilities and response strategies in the high rise buildings in Lagos municipality. Structured questionnaire was administered to building owners, estate managers and disaster managers who manage the high rise buildings. The information obtained was supplemented by personal interviews conducted with tenants and rescue organizations. The study identified collapse of building, fire outbreak, and communication and power failure as the most likely potential disasters, power failure and collapse had the highest severity of impact, and the degree of preparedness achieved to confront the disasters was below satisfaction. However, the specific status of the response strategies was as expected, but there was room for improvements. The potential disasters were natural, human and environmental and the most vulnerable sectors were other properties rather than the high rise buildings themselves. The magnitude of risk levels could be contained with the level of response strategies already achieved if coordinated.

Key words: High rise building, disaster preparedness, risk, vulnerabilities and response strategies.

1. Introduction

The International Federation of Red Cross and Red Crescent Societies [1] described disaster as an extreme disruption of function of a society—human life, livelihoods and property, which cause widespread human, materials or environmental losses, usually exceeding the ability of the affected society to cope with using its own resources. Disaster is also regarded as an impending situation caused by forces of nature, accident and intentional act or otherwise that constitutes danger to life or property [2]. Buildings located in urban areas are more likely to face disasters that are less likely to occur in rural areas [3] and the effects are usually devastating and worse in high rise buildings (10 floors and above) than in low rise buildings in the same locality. This is because high rise buildings, because of height require more special preparedness strategies and more sophisticated equipment to ward away or minimize severity of the impact of disasters [4, 5].

The broader concept of disaster describes set of measures that minimizes effects of disaster as disaster preparedness [6]. Preparedness for disaster is partially achieved by putting in place readiness measures that will expedite emergency response, rehabilitation and recovery [1, 5]. It may entail rapid, timely and targeted assistance to the affected areas. Comprehensive disaster analysis, assessment, preparedness and response plans form vital activities of pre-disaster preparedness [7] and the International Federation of Red Cross and Red Crescent Societies [1]. The Hartford Loss Control Department [8] outlined scopes of assessment that cover identification of disaster characteristics, and potential severity, areas
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and communities that are likely to be vulnerable and the ability of the sectors to withstand and cope with the effects of disasters. Preparedness for disaster is of paramount importance because waiting for events to occur is no longer a viable option to deal with disaster incidences [9, 10]. And in many instances, it is usually not enough to just return disaster-hit communities to frequently impoverished and vulnerable pre-disaster state [6]. Moreover, it is quite necessary to be prepared rather than to adapt buildings after disaster events. The International Federation of Red Cross and Red Crescent Societies [1] and Eun et al. [9] highlighted the objectives of disaster preparedness as to increase the efficiency, enhance effectiveness and impact of disaster emergency response mechanisms, strengthen community-based disaster preparedness and develop activities that are useful in addressing everyday risks and responding to disaster situations. This research, however, investigates potentials and likelihood of disasters occurrences, severity, vulnerability, risk level and the preparedness of the high rise buildings in Lagos municipality to deal with the disasters if occurred.

2. Methods

A structured questionnaire was used to collect information from the departments of disaster management, estate managers, facility managers and the owners of the high rise building. In addition to the disaster assessment factors identified in literatures, a pilot study was undertaken in a form of independent interviews with prototype high rise buildings in different locations to supplement and rectify the questionnaire. The final structure of the questionnaire contained 106 factors that were regarded by literatures and the pilot study to have potential influence on disaster risk preparedness plans and response strategies.

The sampling frame contained 94 high rise buildings among which some were in clusters, some were single, isolated and scattered over the municipality. In the questionnaire, the respondents were asked to rank each factor in achieving preparedness in pre-disaster state on a five-point Likert’s scale from one to five, preparedness plan and respond strategies were graded and vulnerabilities and severities were rated as low, medium and high. The respondents were also requested to introduce and accordingly rate any other potential factors and rate them accordingly. The questionnaire was sent to the respondent by the researchers in field trips to 60 randomly selected sites of high rise buildings and 41 valid responses amounting to 68% of the total number sent out were returned.

In addition, interviews were conducted with tenants, rescue officers and owners of the buildings, some of whom were also among the respondents of the questionnaire. During the interview session, qualitative datum were collected about the tenancy mix of the high rise buildings and how they influence disaster risk and preparedness, the history of disaster and past impacts in each zone. The age of the building and changes in use over time were also discussed. The interviews were voice recorded, transcribed and coded. Quotes and comments from the interviews were confirmed and approved by the interviewees and a couple of citations were presented in the paper as representative in respect to specific subjects to illustrate points.

Certain portions of the regions were found to be more prone to certain disaster types, particularly those relating to natural disasters [7]. The municipality was divided into four zones according to geographical and demographical formations: Lagos Island—“A”, Victoria Island—“B”, Ikoyi—“C” and the remaining parts of the municipality—“D”. The Zone “D” comprises Lagos Mainland, Ikeja and Isolo. 86% of the high rise buildings are located on the densely populated islands of zones “A” and “B”. The 14% located in the less dense areas. 53% of the high rise buildings were covered in this study and 79% of them were between 10 years and 40 years of existence and
the numbers of storeys were 10-28. The assessment and the analysis were carried out in accordance with the outlined standard methods of the International Federation of Red Cross and Red Crescent Societies [1] and National Institute for Standard and Technology [11] and the outputs were expressed in percentages, figures and charts.

3. Results

3.1 Tenancy Mix and Use of the High Rise Buildings

Although disasters can happen anywhere, certain types of disasters are more likely to occur in some buildings than in others and one of the factors that can influence the vulnerability of buildings to certain disaster is tenancy mix or residential profile [12]. For instance, buildings occupied by politically sensitive organizations and incompatible tenant mix, such as commercial and industrial tenancy or business and mercantile will increase vulnerabilities to different types of disasters. Fig. 1 shows the use of the high rise buildings. 68% of the respondents believed the tenancy mix may contribute to disaster risks of the buildings even though 73% of them were satisfied with the disaster preparedness behaviors of the tenants.

3.2 Past Disaster Events

The difference and peculiarity of disasters in low rise and high rise buildings is the levels of risks involved [12]. For this reason, buildings in the same locality may be vulnerable to different disaster risks demanding different intensity of efforts to manage [10]. Disasters may be foreseen and anticipated on account of past disaster experiences and information from analysis of current disaster patterns. Investigating the past disaster events in the municipality, 64.3% of the respondents in zone “B” and 100% of zone “D” did not experienced disasters in the past and 57.1% and 100%, respectively, were confident of improvement in disaster situations in the recent years. The respondents in zone “A” had mixed opinions regarding past disasters but 85.7% admitted improved situation over the years. In zone “C”, the respondents admitted occurrence of disaster events in the past but 100% were convinced of improvement. On the average, only 24% of the entire respondents experienced disaster in the past and 88% believed that there had been improvements. The past disasters
impacted significantly on buildings, lives and livelihood in similar manners.

3.3 Potential Disaster Risks

The likelihood that a disaster will occur illustrates the probability of potential vulnerabilities to exercise within a zone and consequent implementations of disaster response plans are considered [7]. This is to say, if vulnerability is not likely to be exercised or the likelihood is low or there is low level of threat-source or capability or there are effective response strategies that can eliminate or reduce the magnitude of the risks. Table 1 shows the risk levels of disaster threats in the zones.

3.4 Likelihood of Occurrences of Potential Disasters

Some zones were more vulnerable to certain types of disasters, particularly those relating to natural and environmental disasters than others. Fig. 2 shows potential disasters and corresponding likelihood of occurrences in zone “A”.

Zone “A” is a commercial centre and is a highly populated island. It houses 42% of the high rise buildings.

The likelihood of occurrences of the potential disasters of zone “B” is presented in Fig. 3. 37% of the high rise buildings are located on this Island. The island is a commercial centre and is moderately populated.

The likelihood of occurrence of the disasters at zone “C” is presented in Fig. 4. There were few high rise buildings in this moderately populated area.

Fig. 5 shows the likelihood of disaster occurrence for zone “D”. This zone is thinly populated and it houses

| Table 1 - Disaster risk levels of the high rise buildings in Lagos municipality. |
|-----------------------------|----------------|-------------|-------------|-------------|
| Disaster type               | Disaster       | Zone A      | Zone B      | Zone C      | Zone D      |
| Natural                     | Inclement weather| M           | M           | L           | L           |
|                             | Earthquake/tremor  | L           | L           | L           | L           |
|                             | Lightening       | H           | L           | L           | L           |
|                             | Cyclone          | L           | L           | L           | L           |
|                             | Tornadoes        | M           | L           | L           | L           |
|                             | Hurricane        | L           | L           | L           | L           |
| Environmental               | Tidal wave       | M           | M           | L           | L           |
|                             | Mud flow         | M           | L           | L           | L           |
|                             | Landslide        | M           | M           | L           | L           |
|                             | Flood            | M           | H           | L           | L           |
|                             | Erosion          | L           | L           | L           | L           |
|                             | Environmental degradation | H           | L           | H           | L           |
|                             | Excessive settlement | H           | M           | L           | L           |
| Man-made                    | Arson or act of terrorism | H           | M           | M           | L           |
|                             | Radiological accident | M           | L           | L           | L           |
|                             | Civil disturbance | H           | H           | L           | H           |
|                             | Biological/chemical hazard | L           | H           | L           | L           |
|                             | Road traffic accident | H           | H           | M           | L           |
|                             | Environmental pollution | H           | H           | L           | L           |
|                             | Chemical explosion | L           | M           | L           | L           |
|                             | Plane crash      | H           | H           | L           | L           |
|                             | Criminal activities | H           | H           | L           | L           |
|                             | Fire outbreaks    | H           | H           | H           | L           |
|                             | Collapse of building | H           | H           | L           | M           |
|                             | Power failure     | H           | H           | H           | H           |
|                             | Communication failure | H           | H           | L           | L           |

H = High; M = Medium; L = Low (On risk scale of the National Institute of Standard and Technology, 2008).
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Fig. 2  Likelihood of occurrence of disasters in zone “A”.

Fig. 3  Likelihood of occurrence of disasters in zone “B”.

Fig. 4  Likelihood of occurrence of disasters in zone “C”.
only 8.5% of the high rise buildings.

3.5 Severity of Potential Disasters

The anticipated severities of impact of the potential disasters for zone “A” are presented in Fig. 6. 13 potential disasters were found to have significant severities if allowed to occur.

Fig. 7 shows the severity of impacts the potential disaster in zone “B”. 16 potential disaster sources peculiar to this zone were identified.

The severities of impacts of the potential disasters of zone “C” are presented in Fig. 8. Severities of eight potential disasters sources were identified.

The severities of five potential disasters peculiar to zone “D” are shown in Fig. 9. Fewer disaster sources were prone to this vast area of the municipality.

The likelihood of occurrences and the severity of disasters that are anticipated to set on in Lagos municipality are presented in Fig. 10.

3.6 Disaster Vulnerable Areas

A potential threat-source can successfully exercise a particular vulnerability if there exists a weakness that can accidentally be triggered or intentionally exploited. A threat-source does not present a risk when there is no vulnerability that can be exercised [1]. The structural vulnerability of the high rise buildings, other properties and neighborhood present likely of damage or disruption while human vulnerability indicate relative lack of capacity of a person or community to cope with or resist the impact of the disaster hazard.

3.7 Response Mechanisms and Strategic Preparedness

One of the factors that increase vulnerability to disaster is lack of knowledge of how to effectively resist the effects of disasters [6] as well as preparedness mechanisms and the strategies that will enhance and increase effectiveness of responses [2] to disaster. Table 2 presents availability of elements of preparedness plan and to which they were achieved.

Various degrees of readiness in terms of administrative provisions of preparedness plan items are presented in Table 2. 34% of the responses suggested non available or insufficient availability of preparedness plan efforts while 66% made significant efforts.

The relevant strategies include developing of issues required to response to the disasters. The degrees of attainment or perfections (in percentage) in developing of each of the issues are summarized in Table 3.

The marked data portions represent areas where significant efforts on individual response strategy items were achieved. An average response strategy status of “good” was scored.
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Fig. 6  Severity of impact of disasters in zone “A”.

Fig. 7  Severity of impact of anticipated disasters in zone “B”.

Fig. 8  Severity of impact of anticipated disasters in zone “C”.
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Fig. 9 Severity of impact of anticipated disasters in zone “D”.

Fig. 10 Likelihood of occurrence and severity of disasters in the municipality.

Table 2 Preparedness through development of preparedness plans.

| Preparedness plan                                      | Not available (%) | Insufficiently sufficient (%) | Moderately sufficient (%) | Sufficient (%) | Highly sufficient (%) | Preparedness achieved (%) |
|--------------------------------------------------------|-------------------|-------------------------------|----------------------------|----------------|-----------------------|---------------------------|
| Disaster preparedness policy statement                 | 13                | 22                            | 25                         | 28             | 13                    | 67                        |
| Developed policies and procedures                     | 10                | 26                            | 35                         | 16             | 13                    | 59                        |
| Identified organizational resources for disaster       | 9                 | 30                            | 33                         | 15             | 12                    | 58                        |
| Outlined response activities                           | 9                 | 30                            | 36                         | 15             | 9                     | 57                        |
| Allocation of roles and specific responsibilities to personnel | 9                 | 16                            | 41                         | 13             | 22                    | 64                        |
| Identified emergency shelter sites to be used during disaster | 18                | 24                            | 36                         | 12             | 9                     | 54                        |
| Publicized evacuation routes                           | 3                 | 21                            | 33                         | 39             | 3                     | 64                        |
| Identified sources of emergency life-line-services (e.g., water) | 3                 | 24                            | 39                         | 24             | 9                     | 62                        |
| Functional stopcocks                                   | 14                | 32                            | 25                         | 21             | 7                     | 55                        |
| Set budgets, resource lists, supplies, relief stocks and equipments | 14                | 21                            | 46                         | 14             | 4                     | 54                        |
| Determined chains of command and communication procedures | 3                 | 19                            | 59                         | 6              | 13                    | 61                        |
| Trained response personnel and people on what to do during disaster | 3                 | 9                             | 59                         | 19             | 9                     | 64                        |
| Described how relief supplies will be procured, stored and distributed | 23                | 38                            | 31                         | 8              | 0                     | 45                        |
Table 3  Preparedness in response strategies to disaster risks.

| Response strategies                                      | Poor | Fair | Good | Very good | Excellent | Percentage preparedness |
|----------------------------------------------------------|------|------|------|-----------|-----------|-------------------------|
| Developed evacuation procedures                         | 3.2  | 25.0 | 40.6 | 15.6      | 15.6      | 63                      |
| Trained search and rescue teams                         | 18.8 | 21.9 | 28.1 | 31.2      | 0         | 54                      |
| Disaster assessment teams                                | 6.7  | 26.7 | 30.0 | 23.3      | 13.3      | 62                      |
| Assessment process and information priorities           | 6.5  | 29.0 | 29.0 | 25.8      | 9.7       | 61                      |
| Measures to activate special installations              | 22.6 | 38.7 | 19.3 | 9.7       | 9.7       | 49                      |
| Procedures for activating distribution systems           | 22.5 | 32.3 | 32.3 | 9.7       | 3.2       | 48                      |
| Preparations for emergency reception centers             | 21.9 | 18.8 | 40.6 | 15.6      | 3.1       | 52                      |
| Procedures for activating emergency programs            | 22.6 | 12.9 | 51.6 | 6.5       | 6.4       | 52                      |
| Prepared storage and rapid acquisition of facilities    | 9.4  | 40.6 | 31.3 | 12.5      | 6.2       | 53                      |
| Developed emergency preparedness plans                   | 3.2  | 29.0 | 45.2 | 16.1      | 6.5       | 59                      |

* represents areas where significant efforts on individual response strategy items were achieved.

**Fig. 11**  Sector vulnerable to disasters.

**4. Discussions**

The major use and tenancy mix of the high rise buildings in Lagos is shown in Fig. 1. 23% of the buildings were used for office purpose followed by corporate headquarters, banking and finance and commercial tenancy with 17% and 14%, respectively. Each of the buildings had multiple tenancy and uses.

To assess the disaster-source, the National Institute of Standards and Technology [11] recommended considering all sources of disasters including those whose likelihood of occurrence may be insignificant. The likelihood of disaster occurrences for each one of the zones is represented in Figs. 2-5 and the probability of potential vulnerability sectors. Potential disasters and likelihood of occurrence for zone “A” shown in Fig. 2 suggest that power failure had the highest source of disasters ahead of collapse of building structures and communication breakdown. Criminal activities and fire out break were also significantly high. Fig. 3 presents the disaster situation in zone “B”. Power failure, fire outbreak, collapse of buildings and communication breakdown were the major likely source of disasters. The subsequent likely significant sources were environmental pollutions, road traffic accident, flood and criminal activities. In Fig. 4, fire out break and power failure were more likely to occur in zone “C”. Plane crash, criminal activities and collapse of buildings had the least probabilities of occurrences. Fig. 5 shows the
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5. Conclusions

Similar to the historical even of occurrences of disasters in the municipality, the potential disasters and likelihood of occurrences remained few and slim. The few threatening disasters were in the categories of human and environmental whose vulnerability and impact were found to be more on other properties than the building structures themselves. The general likelihood of disaster occurrence for zone “D” of the municipality in which little or no disaster was identified, replicating the past experiences. All of the few disasters that could occur in this zone had slim chances of occurrences. The anticipated severities of impact of the potential disasters in zone “A” are reported in Fig. 6. Power failure had the highest probability of severity if it is exercised. In zone “B”, the disasters with highest point of severity were collapse of building structure, power failure and environmental pollutions while the least severe were road traffic accident and environmental degradation (Fig. 7). Fig. 8 shows severity of potential disasters at zone “C”. Disasters with most severe impacts in this zone were in the categories of environmental degradation, fire out break and power failure. Collapse of buildings, failure in communication, criminal activities and plane crash were having minimal severities. The severity of disasters likely to occur at zone “D” is shown in Fig. 9 in which collapse of building structures and breakdown in communication had the highest severities of impact while criminal activities had the lowest impact. In a summarized form, the entire municipality will face power failure, fire outbreak, communication failure and collapse of buildings as the most highly likely disasters that could occur and have significant impacts (Fig. 10). Road accidents, excessive settlement, biological or chemical attack, and terrorism could have weak impacts.

When disaster occurs, some sectors will show more tendencies of resisting and coping with the disaster better than others. Fig. 11 summarizes the vulnerability of different aspects of the sectors to the anticipated disasters. Fig. 11 suggested that other properties such as human lives, livelihood and neighborhood were safer in zone “B” than at zone “C”. The risk levels for the municipality are shown in Table 1. Risk levels are indications of likelihood of disaster source, magnitude of impact and adequacy of plan to reduce or eliminate risk. The two islands (zones “A” and “B”) held the majority of the potential disasters. About 86% of the high rise buildings were situated on these islands. The remaining 14% were located on the less dense areas of zone “C” and “D” of the metropolitan which faced fewer threats. High (H) and medium (M) disaster risk levels in Table 1 suggested that corrective action plans be put in place as soon as possible, whereas the low risk levels (L) affords options to either determine whether corrective actions were required or decided to accept the risk [11].

The percentage preparedness among the high rise buildings in Lagos municipality showed in Table 3. This table presents a wide range of degrees of readiness to combat the anticipated hazards tabulated in Table 1. Provisions of evacuation procedures in event of disaster onset were mostly attained as expected (63%) and even somewhat better than were expected to be in place while assessment of process and information priorities for response to disaster in the buildings was somewhat between worse than expected (61%). Efforts on development of emergency preparedness plans, processes and procedures was (59%) achieved whereas measure to activate special installations like mobile hospital facilities and procedures for activating distribution systems were somewhat worse than expected with 49% and 48% scores, respectively. The availability of disaster assessment department to identify disasters, their likelihood, vulnerability and impact was somewhat better than expected (62%). The degree of preparations for storing or making arrangements for rapid acquisition of facilities was 53%.
status of the response strategies were satisfactory but there were rooms for further improvements, and the level of preparedness achieved among the high rise buildings was quite sufficient to overcome the risk envisaged if it could be coordinated well.

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