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IARCO 2025

Algorithmic DR Shelter Planning in Public Open Spaces for Urban Disaster Victims of Old Dhaka

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Research Title: Algorithmic DR Shelter Planning in Public Open Spaces for Urban Disaster Victims of Old Dhaka

Introduction

Dhaka is vulnerable to earthquakes and fatal fires due to rapid, unplanned urbanization and non-compliance with building codes [1], [2]. Generally, a major earthquake hits this region almost every century [3]. Poor infrastructure, narrow roads, and limited open spaces define Old Dhaka, which is one of the most socially and physically exposed communities to such catastrophes [4],[5]. Following large-scale catastrophes, numerous structures in the area may become uninhabitable, necessitating urgent disaster-relief (DR) sheltering for affected families [6].

DR shelters provide secured and dignified accommodation for people while their homes undergo repair or reconstruction. Initially, emergency mass sheltering occurs under undamaged government structures or through temporary, short-term solutions like tents [7]. However, these options offer minimal privacy, security, and protection from noise and weather. On the contrary, the reconstruction or relevant authority-led permanent housing solution may span several years [8]. Transitional shelters may bridge the gap between the first phase of DR sheltering (emergency sheltering) and the final phase of finding a permanent solution, facilitating proper recovery [9].

DAP 2022-2035 has suggested post-disaster temporary sheltering on government parks or playgrounds for the victims of urban disasters [10], but there is a lack of specific guidelines for transitional sheltering in Dhaka city. Due to a crisis of open spaces in Old Dhaka [11], effective and optimized planning of sheltering sites is required before a massive disaster strikes [12]. In addition, Old Dhaka communities are well-known for their unique socio-cultural practices and intangible heritages [13], which need to be considered during shelter planning and design for their swift recovery [14].

Research Questions and Objectives

Stemming from the question "How will the families who may lose their homes to such disasters recover and lead a normal life again?", this research aims to design a system of transitional sheltering on any public playgrounds or parks of Old Dhaka with post-disaster essential facilities for at least two years. The objectives of this research are:

1. Study and find potential sites that can be converted into sheltering sites during an emergency and can be converted back to their original function as soon as the sheltering period ends.
2. Study the intangible heritage elements and socio-cultural layers of people's lives in Old Dhaka and include those considerations in the design process for faster recovery.
3. Exploring effective site planning and algorithmic design approaches that will ensure efficient use of available land while maintaining proper health, sanitation, WASH facilities, and other sheltering standards by the SPHERE and UNHCR, so that it can be an example of resilience. The clustering system will be optimized through the consideration of climatic factors such as daylight and ventilation for comfortable living.
4. Ensure that the design strategies are replicable to any site of similar context.

Literature Review

Emergency shelter is the most basic form of shelter support and provides life-saving assistance for short periods. It is often not conducive to long-term medical care or substantial food preparation [7]. Temporary shelters are also for short-term use. They can be as basic as a tent or a public mass shelter used for a few weeks after a disaster. On the other hand, temporary housing and transitional shelters are typically for extended periods, ranging from six months to three years [6], [9]. Such options, such as leased homes and prefabricated units, enable disaster victims to resume their daily routines. Relocation of transitional shelters from a temporary site to a permanent one, renovation into a portion of a permanent house, resale to raise funds for rehabilitation, recycling for reconstruction, and other uses are all commonplace [15]. The design life of such shelters should be more than two years [16].

International shelter handbooks and guidelines emphasize that the planning of the camp should be able to offer proper land per capita and sufficient culturally relevant services to ensure displaced families can live dignified and safe lives throughout this transitional phase. UNHCR recommends that the planned settlements should have an average camp area of 45 m^2 per person; 15 m^2 is allocated to household gardens. Overall, the planned settlement area on the site should not cross a 1:2 ratio, which means at least 50% of the site should be left as open space when installing shelters, although a ratio of 1:3 or 1:4 is recommended. Around 20-25% area of the site will be planned as roads and walkways, while 15-20% of the site will be allocated for open spaces and public facilities, such as play spaces, seating spaces, and so on. Minimum covered living area must not be less than 3.5 m^2 per capita, if communal services (shared kitchen and toilet) are used [17], [18]. For example, a shelter accommodating four adults must be at least 14 m^2 in area to meet humanitarian standards.

Similarly, at a minimum, one latrine or water closet (WC) will be required per 20 people, while a minimum of one universally accessible toilet is required per 250 people. The maximum distance from the shelter to any shared toilet would be 50m, while it should be at least 6m away from any household and kitchen [18]. UNHCR suggests that planning should start at a family scale and slowly increase up to community, block, sector, and settlement levels [17], hinting at a bottom-up approach of design. Layout planning or clustering should be informed by social structures, community relationships, and traditional settlement patterns to develop a sense of ownership, which will help recover faster from trauma [17], [19]. These principles especially apply to Old Dhaka, where there is minimal space and high vulnerability, and the communities exhibit unique sociocultural values and intangible heritages such as deep-bonding between neighbours, senior citizens telling stories to children, and many others, which can be termed as ‘intangible heritage.’ [13], [20]. A study showed that managing the shelters with no connection to the intangible cultural heritages did not show a good result [21]. Therefore, the system of shelter clustering should address the local cultural norms and intangible heritages of such unique communities. The shelters should be arranged in such a way that adequate and quality daylight and cross ventilation can be ensured. These parameters play a vital role in improving mental state, reducing depression, and enhancing the overall recovery rate of the affected [22], [23].

Parametric design (PD) is a process of design on algorithmic thinking that uses parameters and rules to constrain them [24], [25]. Generative design (GD) is defined as systems based on algorithms that generate designs and search a design space. Since it can embed several constraints and quickly produce alternatives, the parametric design is appealing to humanitarian shelter design

or planning due to its flexibility. A typical parametric workflow may include physical parameters such as floor area, contextual parameters like family size and cultural practice and climatic parameters (eg., sunpath, wind) [26]. When adjusting these variables in software like Grasshopper/Rhino [27], designers can automatically create shelter geometries that meet humanitarian requirements and rapidly modify layouts to suit various family sizes or weather conditions.

Proposed Methodology

1. **Background Study:** First, different wards of Old Dhaka will be visited and observed to find ward-based vulnerability with the help of relevant secondary sources on Old Dhaka's disaster vulnerability mapping and its assessment, evacuation plan [28], and existing open spaces. Simultaneously, based on Google Earth imagery, the potential open spaces will be surveyed to evaluate their suitability for transforming into a sheltering site. After that, at least one vulnerable area or community will be identified based on population density, observation, and literature.

   A questionnaire will be prepared to interview the residents of the chosen area (50 persons from different families). The questions will help to find out the percentage of land/ house owners, the percentage of tenants in the area, the primary income source of the households, the location of the shops or godowns of the business persons in the area, the percentage of the number of building storeys, etc. The questions will also include whether the building owners followed building codes properly if the residents have any alternative place to stay for one or two years till they find a permanent solution, whether they want to stay there even after a disaster, or whether they are open to the notion of moving away from their area or community, etc further to identify the target groups or user-groups of the project.

   The perspectives and needs of vulnerable communities in Old Dhaka regarding disaster-relief sheltering will be documented through questionnaire surveys or interviews, with a specific emphasis on expectations, challenges, and preferences.

   In addition, the socio-cultural layers and intangible heritages will be investigated through area mapping and empirical research methods. A focus group discussion related to the intangible heritages of Old Dhaka will be conducted with relevant stakeholders. All the findings are to be presented with sketches and infographics so that these can properly be used during the design process. **Analysis of Site and Surrounding Context:** After collecting data from secondary sources, two case sites will be chosen from a shortlist of possible government fields or parks to temporarily accommodate the previously identified vulnerable community for the determined duration. Studying the history, size, stakeholders, overview of the site surroundings, road connectivity, feasibility study of installing shelters and relief-distribution zones, etc, will help select the site. A detailed site survey will be carried out to sketch the existing site plans with relevant measurements and later drawn using AutoCAD software for future use.

2. **Case Study and Shelter Standards Study:** Relevant national and international cases of disaster relief shelters and refugee camps will be studied, focusing especially on the modularity, materials, construction techniques, assemblage, shelter clustering layouts, provided facilities, and amenities. There is already a lack of well-documented urban cases in

Bangladesh; therefore, several key informant interviews (KII) with humanitarian activists, designers, engineers, urban planners, and relevant scholars and industry experts will be required.

Relevant projects focusing on compact and adaptive living, and their spatial quality, will also be studied. The findings are to be documented with illustrations. National and international shelter design guidelines and standards from documents of UNHCR, Sphere Association, and Bangladesh Shelter Cluster will be reviewed.

3. **Design Process:** Different input parameters and constraints of this project will be determined based on case studies and existing standards. The sites will be redesigned to enhance disaster preparedness and recovery process so that they can function as a community field, but also can accommodate temporary and transitional shelters for at least two years when necessary. After that, schematic diagrams will be generated to determine the zoning of shelters, services, and facilities such as relief distribution and storage zones, water collection points, emergency health-care units, and other relevant facilities. Parallel to this, design strategies and principles will also be developed to help design shelter clusters with integrated services. As around 28% of the buildings in Old Dhaka may be damaged due to a large-scale disaster [29], any site area may not be enough to accommodate all the affected, unless the cluster design is optimized by an algorithm. Space optimization tools like 'Galapagos' and multi-object optimization plugin 'Octopus' will be used for this cause in the visual programming language plugin "Grasshopper" that runs within 'Rhinoceros 3D' computer-aided design software [30], [31].

   At first, the shelter spaces will be optimized. Multiple shelter units will be joined together to form a cluster so that a common living space can be designed and space can be utilized. The cluster's floor area will be optimized as the 'Fitness objective (dependent variable) with the Genomes (independent variables such as door-to-door distance, allocated area per person, number of openings of a shelter, etc). Several clusters will form a community, with essential services for around 80 people. After prioritizing social spaces and therapeutic spaces respecting Old Dhaka's intangible heritages, the layout will be planned and optimized using the Python programming language and Octopus tool within Grasshopper, as such, it achieves a minimal circulation from shelters to services (e.g., toilet, kitchen, water tank), and an introverted courtyard of minimal area, while adhering to the 20-25% of walkways and roads, a maximum of 50% shelter area out of the occupied space, minimum 6m gap between a shelter and a toilet and other relevant international standards. During this planning, several aspects of Old Dhaka's intangible heritages could be incorporated into the layout design and optimization. A small list of iterations with the least circulation from shelter to services will then go through environmental optimization, focusing only on daylight penetration and ventilation to make it healthy and energy efficient. 'Climate Studio' and "Autodesk CFD" software will be used for daylight simulation and wind flow simulation, respectively.

   Thus, a masterplanning Masterplan with multiple clustering options will be generated for the two case sites. In case of an open space surrounded by mixed-use buildings, the residents' commercial activities space allocation will also be considered in the master plan.

Expected Outcomes

The envisioned outcome of this project is the presentation of an efficiently designed transitional sheltering system with necessary drawings, such as master plans, detailed plans, and sections through which the design ideas can be communicated to different stakeholders.
Other expected outcomes are:

1) Spatially and climatically optimized modular shelter clustering options based on international shelter design standards that will help the user groups recover from their trauma quickly and get back to their usual living pattern.
2) Socially viable and physically acceptable sheltering solution that will reflect the cultural significance and some of the intangible heritages of Old Dhaka communities of different areas.
3) A replicable algorithm and shelter planning system that will both address the sociocultural characteristics of its target groups and will be environmentally viable and energy efficient.

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