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Capacity And Utilisation Of Multipurpose Cyclone Shelter As A Disaster Resilient Infrastructure In West Bengal

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Abstract : *Cyclones are among the most common catastrophic events witnessed along the coastal belts of West Bengal, India. Multipurpose Cyclone Shelters (MPCS) are government funded community buildings built to safeguard the local inhabitants and their livestock during natural calamities. Construction of MPCS is an important measure taken by the government to deal with cyclone disasters. There are 41 existing cyclone shelters across five cyclone prone coastal blocks of Purba Medinipur district, West Bengal, India. This study sets forth the findings of a primary survey that enumerates, the sustainable utilization of the MPCS during fair weather periods and evaluates their present condition based on a weighted scoring model. 46% (n=19) of the MPCS had amenities that required improvement while 54% (n=22) met and/or surpassed the basic requirements. The locations of the existing cyclone shelters have been analysed based on their mean centre of spatial distribution of population, indicating a non-equitable distribution of the MPCS. The available space per person in the MPCS has been calculated. None of the MPCS is humanely sufficient for the adjacent vulnerable population seeking refuge. There is requirement for more shelters. The capacity of the existing MPCS may be increased by providing multi-layered vertical bunk beds.*

Keywords : Cyclone; Cyclone Shelter; Coastal Community; Resilient Infrastructure; Vulnerability.

INTRODUCTION:

Cyclones are frequent natural calamity faced by the people living in the coastal areas of India. Tropical cyclones often lead to reshaping sand dunes, near coastal areas causing extensive coastal erosion (Datta, 2015). Cyclonic situations set up in the Bay of Bengal almost every year during the months of April-May and September-December. The high velocity cyclonic winds are accompanied by tidal waves, storm surges and torrential rainfall. People who reside within a distance of 10 km from the sea coast are generally the worst affected by inundation that vary between 2.5 to 5 meters approximately and last for about 5-6 days. Recent studies show an intensification of tropical cyclones in terms of wind speed and cyclone size over the Bay of Bengal in the past few decades (Murty, et al., 2016). Climate Change and subsequent Sea Level Rise (SLR) has increased the vulnerability of the coastal population significantly (NDMA, 2009). Multipurpose Cyclone Shelters (MPCS) are one of the most important structural measures taken by the government to deal with the devastating cyclones and subsequent storm surges in reducing the loss of lives (OSDMA, 2009). Construction of cyclone shelters has been a well proven measure of preparedness throughout the world.

LITERATURE REVIEW:

The need of 'Multi-Purpose Cyclone Shelter' surfaced in India after a severe cyclone in Andhra Pradesh in 1977 (Mishra, & Prakash, 1982). A cyclone shelter is a community building built on an elevated land to ensure safety of the local people from the cyclones and associated storm surge inundation (Rahman, & Islam, 2009). Cyclone shelters serve as immediate and temporary refuge to the local people and their livestock during any natural calamity (Haider, & Ahmed, 2014). Under the Prime Minister's National Relief Fund (PMNRF) scheme and National Cyclone Risk Mitigation Project- II (NCRMP-II) and the Integrated Coastal Zone Management (ICZM) Project assisted by the World Bank, several Multipurpose Cyclone Shelters (MPCS) have been constructed in Purba Medinipur district, while few are still under construction. The MPCSs in Purba Medinipur have distinct designs based on its construction under the respective schemes and projects. Each scheme/project has their own specification for the construction of the cyclone shelters; however, they follow the major design and structural recommendations provided by the GOI-UNDP Disaster Risk Mitigation programme (UNDP 2006) (Fig 1). West Bengal has been identified as Category I among 13 cyclone prone States and Union Territories (UTs)

in India, based on the frequency of occurrence of cyclones, its vulnerability and size of vulnerable population (Govt of West Bengal 2020). The area of interest of this study includes the coast-adjacent community development blocks of Ramnagar-I, Ramnagar –II, Contai-I, Deshapran and Khejuri-II (Fig 2). This coastal stretch has important fishing harbours like Shankarpur, Jyamra-shyampur, Dadanpatrabar, Tajpur and Junput which are inhabited by small scale farmers and local fishermen residing within 200m of the high tide line. On the other hand, it has one of India's most popular beach tourist spots, Digha-Mandarmani. The highly populous coastal belt is vulnerable to tropical cyclones and associated storm surges, which poses potential threat to the people living in this area.

METHODS:

MPCS are an immediate and short-term refuge to the local inhabitants during cyclones, as well as few days after the calamity in some cases. The use and maintenance of cyclone shelters during rest of the year or fair-weather periods is equally important as huge investments are involved in erecting these shelters (NDMA, 2009). The main focus of this study is to enumerate the sustainable utilization during fair-weather periods and evaluate their present condition. The population bearing capacity of each MPCS during a cyclone has been calculated and suitable recommendations attempted.

Figure - 1 *View of the MPCS constructed under PMNRF and NCRMP-II respectively, photographs taken by the author, May 2019 (Jadavpur University, 2019)*

The MPCS of the five blocks of Purba Medinipur District have been visited physically, and the locations have been collected through a handheld GPS receiver.

The shelters have been categorised based on several criteria with the help of weighted scoring model. The factors have been assigned a weight depending on its relevance to the functioning of the MPCS as obtained from the inputs of the surveyed respondents belonging to the vulnerable population. The factors were scored on pertinent criteria into 3 classes:

0- unsatisfactory; 1- average; 2- highly satisfactory. A score of 1 or average was marked when the individual factor fulfilled at least one of the criteria but not all.

Weighted score of each factor was attained by multiplying the individual score of the factor (as obtained above) with the assigned weight. The weighted score of each MPCS was achieved by summation of the weighted scores of each factor thus achieved. (Table 1) The achieved weighted scores of MPCS were then arranged in ascending order and classified into quartile classes: Good, Above average, Scope for improvement and Unsatisfactory.

Both primary and secondary data have been used in the study. Primary data has been collected through household survey, detailed questionnaire survey and focused group

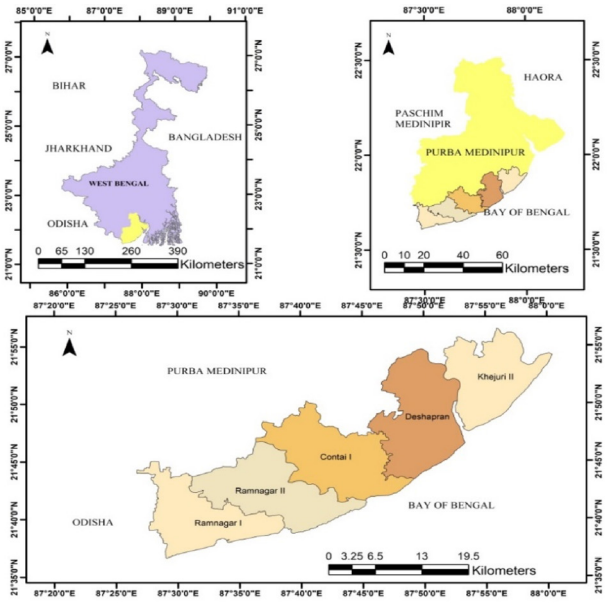

Figure 2 *Study Area of Five Community Development Blocks*

discussions with different stakeholders. Simple random sampling method has been used for the selection of the respondents of the questionnaire survey.

341 respondents belonging to 118 households were surveyed at doorstep through direct interview. Inputs from the local administrative offices were also taken into consideration. For even representation of household surveys, the study area of 5 blocks were divided into grids of 4 sq km each. At least one household was surveyed randomly from each grid.

Locational suitability of the MPCS with spatial distribution of population has been analysed by mean centre of population. Information about the problems faced by the local people during their stay at the MPCS has also emerged through these surveys.

Government reports and plans, published journals and the census of India are the major secondary sources of data. The local administrative offices have provided data about the different constructional specification of the cyclone shelters. The road networks to understand the connectivity and accessibility of the cyclone shelters have also been collected from the official website of Institutional Strengthening of Gram Panchayats (ISGP) Programme-II, Panchayats and Rural Development, Government of West Bengal.

RESULTS:

Location and Number of the Cyclone Shelters: A total of 41 existing MPCS have been surveyed in 5 blocks in the district of Purba Medinipur. The MPCS were constructed using government funding under 2 schemes- PMNRF and NCRMP-II. Fig 3 depicts their locations in the five community blocks of Purba Medinipur district.

The analysis of the central tendency in a spatial distribution of point patterns yields an idea of the centre involving the average of a given data set. Mean centre of distribution is the simplest measure of central tendency which allows locating the mean centre of a spatial distribution.

Key factors	Detailed criteria for scoring	Assigned weights
Site selection	• Elevated land • Nearness to coast	10
Accessibility	• Road network connectivity • Metalled road connectivity	15
PwD friendly	• Ramp for movement of wheelchair • Special toilets	12
Ventilation	• High ceiling for good air circulation	6
Sanitation	• Separate toilets for males and females • Area for hand washing	15
Inner design	• Shelves for storing belongings of the MPCS users • Usable kitchen area • Operational fans and lights	12
Indoor construction	• Proper Doors and Windows as per the government guidelines • Area for shelter of domestic animals • Staircase	6
Fire detection	• Fire safety measures	6
Emergency power	• Availability of emergency power generators	6
Signage	• Sign boards • Knowledge of the existing nearby cyclone shelter among locals	7
Maintenance of Infrastructure	• Present condition • Sustainable use • Maintenance of the building	5

Table.1 Key factors and criteria for assigning weighted scores to each MPCS (Faruk, Ashraf, & Ferdaus, (2018)

Cyclone shelters are more required in areas having higher population in the concerned Community Development Block. So, the locations of the centroid of the administrative units have been weighted by population. Fig 4 depicts the weighted mean centre of population in correspondence to the locations of the existing MPCS.

The MPCS were categorised into quartile classes. Relevant factors were considered and they were assigned weights. The MPCS was scored in each of these factors as 0, 1 and 2. (Table 1). The weighted score of each MPCS is calculated and the ascending order of their arrangement is depicted in the form of a box and whisker diagram with quartile classes. The study finds that 29.2% (n=12)

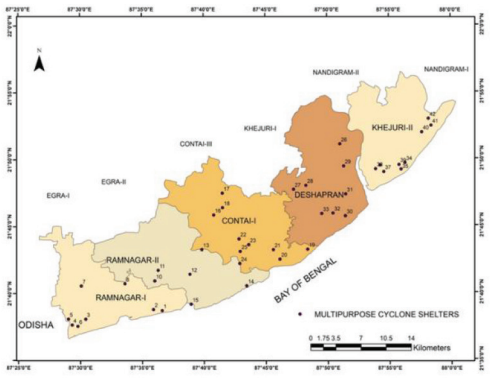

Figure 3 Location of cyclone shelters

of the 41 MPCS in the 5 blocks to be unsatisfactory in terms of maintenance and available amenities, while 26.8% (n=11) fared good in the selected criteria.

$$\bar{x}_{w}=\frac{\sum(x_i w_i)}{\sum w_i} \qquad \bar{Y}_{w}=\frac{\sum(y_i w_i)}{\sum w_i}$$

Where, $(\bar{x}_w \bar{y}_w)$ = the coordinates of the weighted mean centre; W_i = the weight (i.e., population) (Burt, et.al, 2009).

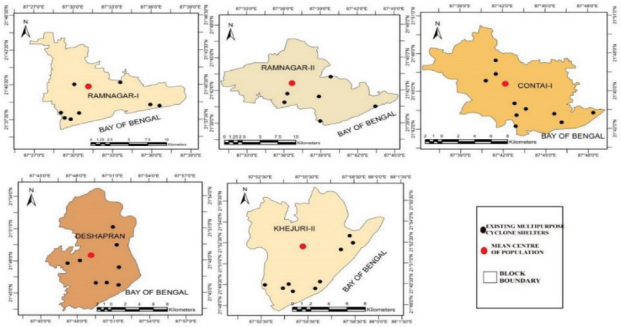

Figure 4 Mean Centre of Population and Location of Existing MPCS

Sustainable use of the MPCS: The use of this shelter during non-disaster periods leads to its better maintenance and can be used more effectively during emergencies. Regular use also provides economic justification for the investment. The primary use of the cyclone shelter is to provide refuge to the local population in times of the natural calamities such as flood, cyclone, tsunami and other disasters. The Cyclone shelters are often used as training camps, election booths, health camps, community gatherings and meetings, but use as schools or offices are not recommended as the shelters are to be evacuated immediately in case of cyclone warning. In Ramnagar I block one of the cyclone shelters is being used to assemble and store bicycles (Fig 6) for a local government scheme which is violating the basic norms as relocating huge amount of goods and parts of a bicycle is not a very easy task considering disaster situations. Another MPCS in Contai 1 is being used as a computer training centre. Some are even used as local primary schools.

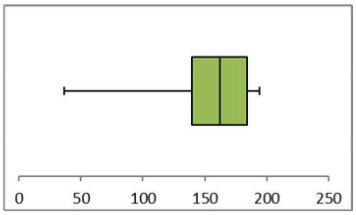

Figure - 5 *Box and whisker diagram of the MPCS as per their assigned weighted score*

Figure : 6 a) Computer Training Centre; b) Cycle Assembling/ Storing; c) Primary school

Population bearing Capacity of MPCS: On an average, about 50-60% of total population of vulnerable locations use the cyclone shelters during emergencies (UNDP 2006). Cyclone shelters provide shelter to both the villagers and their livestock. It caters to the basic needs of the people by providing electricity, drinking water and sanitation during cyclones and storm surge. According to the UNDP guidelines, the recommended floor space in the MPCS per person is 2 sq. feet (UNDP 2006). However, even in times of emergency and considering the duration of stay in the MPCS to be not too brief due to the flood situation, dignity of the vulnerable population should be respected. It will be too optimistic to expect that people will stand or squat throughout the difficult times, because the allocated 2 sq. feet of floor area may be too little for any other postural change. The 41 studied MPCS erected under the government schemes are constructed in lines with a uniform design where there are two halls in two floors that cater to the shelter of the vulnerable population- "the small hall" in the first floor having a dimension of 24.8 ft X 24.6 ft and "the large hall" in the second floor having dimension of 38.5 ft X 24.6 ft. The total floor area of the two living halls is 1557 sq. ft.

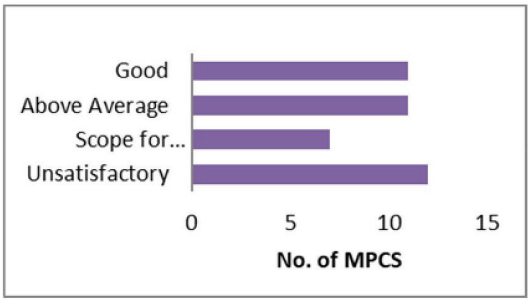

Figure 7 *Classification of MPCS according to their weighted score*

As per this guideline, the MPCS will be able to bear 778 persons from the vulnerable population (1557 sq. feet total floor area of the two halls / 2 sq. feet per person allocated floor area). However, such a distribution will be catastrophic given the number of communicable diseases it may spring up in the aftermath of the pandemic due to lack of proper living conditions, not to mention the abysmally poor hygienic situations and the huge toll on mental health of the occupants.

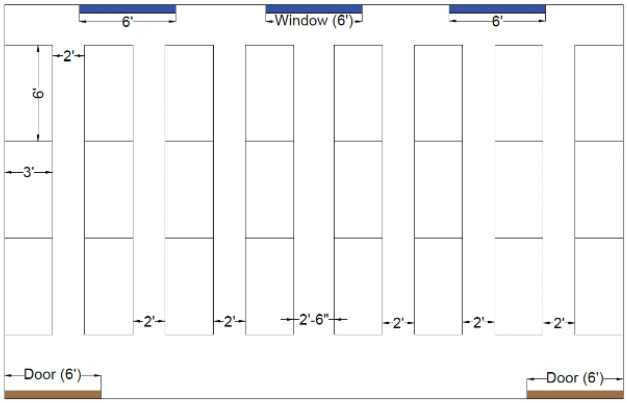

Figure 8 Line diagram of the arrangement of the multi-layered vertical bunk beds in the large hall of the second floor of a standard MPCS of the study area

Table 2 Summary of proposed bed allocation and accommodation strength

Item	Small Hall	Large Hall
Location	First Floor	Second Floor
Floor dimensions	24.8 ft X 24.6 ft	38.5 ft X 24.6 ft
Total floor area (a_1,a_2)	610 sq ft	947 sq ft
No of columns of series of vertical bunk beds (b)	5	8
No of vertical bunk beds in each series (c)	3	3
Total no of bunk beds (d) [d=b*c]	15	24
Total no. of sleeping surface (each bunk bed has 3 storeys) (e) [e=d*3]	15 X 3= 45	24 X 3= 72
Accommodation strength (f_1,f_2) [f=e*2]	90	144
Cumulative floor area (g) [g=a_1+a_2]	1557 sq ft	
Total persons accommodated in the two halls (f= $f_{1+}f_2$)	234	
Effective floor area per person (g/f)	6.65 sq ft	

The average Indian man measures 5'8" in height and weighs 65 kg. The average Indian woman measures 5'3" in height and weighs 55 kg. With a gender distribution of 950 females to 1000 males in the affected population (Sarkar, Chakrabarti and Dutta 2021), the author advocates 8.25 sq. feet of area per person (5.5 ft X 1.5 ft) to each individual and hence vertical bunk beds each measuring 6' X 3', each bed having 3 storeys that can carry 2 persons in each tier with reasonable living conditions are recommended (Table 2, Figure 8).

DISCUSSION

According to the UNDP guidelines, coastal states are advised to carry out a survey within 10 km from the coast (UNDP 2006). Studies have shown that unless a cyclone shelter is within 1.5 km of the house, it may be too distant to reach the shelters at the crisis moment. The local people, afraid of theft sometimes defer their withdrawal to the shelter (Rahman & Islam,2009.) The shelters are a community asset for sustainable and regular utilization of the structure and it is best to be constructed inside or near villages (UNDP 2006).

However, we found an unequitable distribution of the MPCS with respect to the mean centre of population. The cyclone shelters in Ramnagar-I are located near the coast, about 6 kilometres from the mean centre of population; the shelter nearest to the mean centre is at a distance of about 2 kilometres. There is unavailability of shelters towards the northern parts of the block. In Ramnagar-II block, the shelter nearest to the mean centre of population is 1.8 kilometres away while the farthest is 12 kilometres away. Maximum number of MPCS is located in Contai-I block. However, there is scope for construction in the northern parts and around the mean centre of population for providing shelter to more vulnerable population.

In Deshapran block, the farthest MPCS from the mean centre of population is 7 kilometres away. The MPCS are dispersed almost throughout the block. However, there is need for more in the northern part of the block as well as the western section. All the MPCS are away from the mean centre of population in Khejuri-II block. They are concentrated near the coast line, almost 7 kilometres away.

In the present scheme of arrangement in the MPCS, the height of the halls is not being utilised resulting in under-utilisation of the total available volume and hence, reduced floor area per person that in many a situation may lead to unfavourable living conditions, even considering the emergency situation. Since the postulated design intends to use triple storey bunk beds, the effective usable area is enhanced by 3 times the actual floor area as the height of the halls is being utilised. Hence, with the same architectural infrastructure of the MPCS, interior modifications lead to optimal utilisation of space resulting in ability to accommodate more from the vulnerable population. This design also intends to provide better and more hygienic living conditions for the relocated population, thus preventing or minimising food and water borne diseases that are rampant in the aftermath of a cyclone disaster, generally further aggravated by overcrowding.

This design apart from utilising the height of the rooms and accommodating sizable number of affected persons in reasonable living conditions, also provides for sufficiently wide corridors and empty spaces in front of doors and windows in the rooms. This provides for movement of the people with reasonable ease and assures smooth evacuation if any emergency arises. It also ensures adequate sunlight in the room maintaining the hygienic conditions and catering to the mental health of the occupants of the MPCS even in the difficult times

CONCLUSION

The study set in the 5-cyclone prone community development blocks of Purba Medinipur, India concludes that majority of the 41 MPCS are unsuitably located with respect to the mean centre of population and unsatisfactory in terms of maintenance and available amenities. Few MPCS, though are being sustainably used with regular revenue generation that in turn assists in funding the maintenance of the structures.

We recommend a three-storeyed vertical bunk bedded system, thus utilising the height of the room and with well thought out interior modifications, the effective usable space may be increased resulting in enhanced carrying capacity in decent living conditions.

Therefore, proper planning, interventions for timely upkeeping and funding are the need of the hour for the optimal maintenance and utilisation of the MPCS in the vulnerable population in times of need.

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