International Journal of
Disaster Management
ISSN: 2527-4341

Measuring Resilience of Urban Slum to Climate Induced Disasters: A Study on Barishal City Corporation, Bangladesh

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Abstract— Measuring urban resilience is one of the important processes toward understanding the potential current and future risks of cities. Moreover, it also useful for assessing urbanization challenges guiding the development of urban areas. The research was conducted in a slum area named Bangabandhu Colony under Barishal City Corporation (BCC). The aim of the study was to measure the urban disaster resilience and to discover best approach of future urban disaster resilience in this area. Climate Disaster Resilience Index (CDRI) was utilised to measure climate-related disaster resilience by considering five dimensions: physical, social, institutional, economic and natural as resilience level ranging from 1-5, where 1 representing very poor to 5 considered as best. A semi-structured questionnaire was used for collecting primary and secondary data. Results revealed that the resilience level of physical, social, institutional, economic, and natural dimensions was 2.76, 2.79, 2.29, 2.53, 2.59 respectively, which indicates a medium resilience level of all dimensions. Finally, the study revealed the region level of resilience will increase through collaborative work between the community, government and non-government officials, in conducting public awareness programs, campaigns, seminars and discussions. The research finding enable to inform the researchers and development workers to improve disaster resilience in other areas under the Barishal City Corporation as well as other urban areas in Bangladesh.

Keywords— *Awareness, Resilience, Risk, Urbanization, Disasters*

INTRODUCTION

Disasters caused by the climate change have an impact on urban cities and their entire connected system. In recent years, climate-related extreme events have increased as a result of changing climate, unplanned urbanization, demographic pressures, land-use, and land-cover change, biodiversity loss, and ecosystem degradation. A recent episode of extreme climatic events in urban areas have highlighted that cities are not prepared to face the climate-induced disasters (Wan Mohd Rani et al., 2018). Developing countries are experiencing urbanization at such a rapid pace that it exceeds their economic growth and finance. Like other Least Developed Countries (LDCs), South Asian countries in general, and Bangladesh in particular, have been undergoing a rapid growth in urbanization (Helal et al., 2010). Urbanization has been so rapid in these countries that it makes it difficult for the government to maintain social and economic integration and provide for all the impoverished newcomers to the cities. Bangladesh is one of the most densely populated countries in the world and has experienced rapid population growth over the past century, although the rate of population growth has declined to moderate levels in recent times. (Panday, 2020b). Evidence revealed the country is going to witness a rapid spread of urbanization over the next decade (Helal et al., 2010).

Bangladesh is the 7th most populous country in the world with highest density population (Ahmed & Ahmed, 2017). Since its independence, the population of Bangladesh has been increased at an average rate of growth

Received 25 August 2020; Received in revised form 17 November 2020; Accepted 29 November 2020
DOI: https://doi.org/10.24815/ijdm.v3i2.17815

above 2 percent up to 1991. Annual exponential growth rate of urban population is much higher than population growth rate. From 1974 to 1981 urban population growth rate was recorder as the highest in Bangladesh (10.66%) (Milanovic, 1999). In 2011, urban population stands at 42.11 million with annual exponential growth rate of 4.12% which means 28.4% of the population of the country lives in urban areas (BBS, 2013). Since 1974 to 2011 urban population increased 7 times, which the number of additional urban population is 35.84 million (Parvin et al., 2013).

Currently, urbanization is regarded as an engine of growth and development of a country. However, the increasing number of slums, informal settlements, and increasing rate of migration is leading to more urban-centered disasters and put the cities into the high-risk zone (Sanderson et al., 2016). It creates various problems which hamper basic rights of the citizens. Utility services like electricity, water and gas fall short of demand, roads and transport facilities become severely inadequate. In low-and middle-income countries like Bangladesh, the threat of increased loss of life and livelihoods, floods, earthquakes, storms and conflict are becoming more of a reality due to urbanization. Underprivileged urban residents are usually among the most vulnerable, and endure more of the burden of disasters (Parvin et al., 2013).

Barishal is one of the major cities in Bangladesh which Stands 95 Km North of the Bay of Bengal with 0.3 million people in 58 Sq. Km area (Rahman, 2014). Migration is a great force behind rapid urbanization in this city and it generates different unplanned slums within the city area. Drought, salinity intrusion, cyclone, and storm surge are still relatively low in this city but flash flood, heavy rain, water logging, fire, accident, unemployment, terrorism, drainage congestion, and building collapse are the main problems faced by the urban dwellers specially slum dwellers of this city (Rahman et al., 2017). Living conditions in this slum are awful and damage the environment. Common descriptions of slums include lack of water supply, unhygienic sanitation facilities, congested and ramshackle habitation, perilous location and anxiety over tenure, among other kinds of social and economic deprivation (Panday, 2020a)

Urban disaster resilience has been defined as the capability to be prepared, respond to, and recover from multi-hazard threats with minimum damage to public safety and health, the economy, and security of a given area (Leichenko, 2011). Proper awareness, preparedness measures, public safety measures, education, health awareness, social capital, institutional collaboration, economic safety, and good governance can increase the resilience against the problems of Barishal city. There was a knowledge gap between the service provider and the service recipient in the Slum area on urban resilience issues. In this paper, the researchers try to address those gaps. The purpose of the research was to measure the urban disaster resilience and to discover better way of future urban disaster resilience in this area.

METHODOLOGY

Overview of study area

Bangabadhu Calony under Ward no 11 of Barishal City Corporation is adjacent to the river Kirtankhola and is a low developed area with latitude $22^0$41'30" and longitude $90^0$23'0" (Figure 1). Total population of the area is 14611 with 7879 men and 6732 women. It covers 0.9 sq. km area and total holdings of this area are 1546 (M. M. Rahman, 2014).

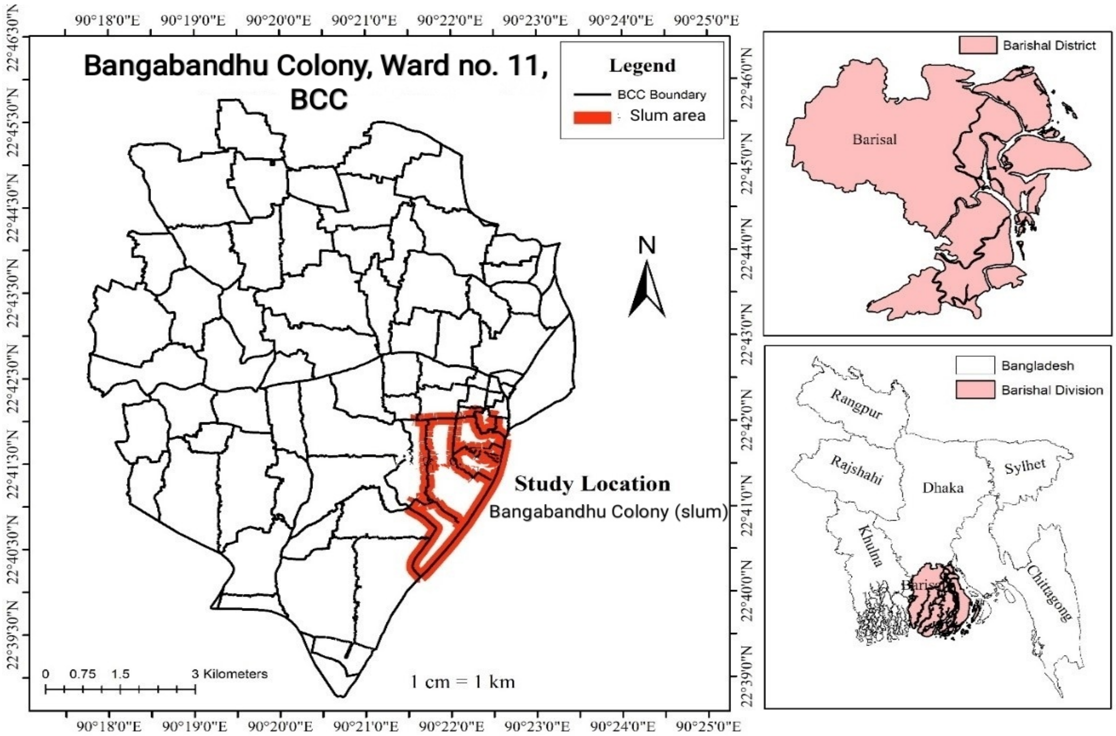

Figure 1. Study area (Source: Barishal city corporation)

Research method

Construction of CDRI

The Climate Disaster Resilience Index (CDRI) consist of five dimensions, 25 parameters (Table 1) (five in each dimension), and 125 variables (five in each parameter, 25 in each dimension) aim to cover key aspects of a community's resilience to urban disasters (Joerin & Shaw, 2011; Prashar et al., 2012). Following an extensive literature review, the different dimensions, parameters, and variables were carved out to define the resilience of communities in an urban system (city) to climate-related disasters. The principal aspect of these indicators inter-related to city services. In order to improve the resilience of a city, it is essential to enhance their capacity in managing the area (Steiner & Markantoni, 2014). There are several discussions on mainstreaming disaster risk reduction, but the accurate mainstreaming occurs when resilience is blended with the different city services (Bosher & Dainty, 2011) and the CDRI methodology attempts to do this.

As noted, various risk drivers, such as aspects of urbanization, declining ecosystems, urban poverty and unplanned urban city growth, characterize many cities in developing countries. To alleviate them, sustainable development is required, connecting different elements of a city. This explains why economic, natural, and social dimensions are part of the CDRI framework. The institutional and physical dimensions are added owing to the fact that communities are embedded in a built environment (physical dimension) and that, in the event of a disaster, local government has a crucial role to play (institutional dimension) in confronting and managing such an event (Prashar et al., 2012;Woolf et al., 2016).

The selection of the physical dimension (accessibility of roads, electricity, housing and land use, sanitation and solid waste disposal, and water), for example, is based on the premise that a well-functioning or disaster-resilient city can provide key services to its residents (communities). This not only reduced the probability of a shock occuring, but also it may enhance the capacity of the community to respond to them if they are properly cared for and equipped. (Joerin et al., 2012b; Wan Mohd Rani et al., 2018). This point is also particularly relevant to the social dimension where, for instance, decent social capital base among communities and the level of disaster preparedness (availability of emergency materials and voluntary support in relief activities) illustrate how well people are connected and how well they may support each other in the case of a disaster. Risk drivers such as urban poverty or urbanisation are reflected in various parameters, including employment, income (number of people below the poverty line), and population (number of informal settlers). Both of these risk drivers are connected to some degree, as high population growth rates are likely to increase the number of people affected by urban poverty in urban areas (Joerin et al., 2012b). The economic dimension reflects the ability of people to acquire income through employment, as well as to what extent they can transfer money into savings that can be used in a time of disaster. The availability of calamity funds from local government and funding for disaster risk reduction (DRR) activities reveal whether systems are in place to finance issues related to disaster risk management before and after an event (Joerin et al., 2012a). The institutional dimension measures the functionality of local government, including whether disaster drills are conducted and whether a disaster management plan or an early-warning system is in situ. Furthermore, it is essential to the overall functionality of the system that the local government at the zone level is able to perform during a disaster, both on its own and in communication with other stake- holders (non-governmental organisations (NGOs), private organisations, or other zones, for example). Also fundamental is the extent to which the crisis management framework is capable of responding to a potential disaster (Joerin & Shaw, 2011). The natural dimension includes the fragility of the various urban ecosystems, the loss of urban green space over past decades, the existence of urban hazard maps, and efficient waste management systems. Knowing about the capacity of the environmental properties of the city is crucial to determining whether or not a potential shock can be absorbed (Cox & Hamlen, 2015).

Data collection and computation

A questionnaire was formulated based on the above framework with five dimensions consist of 25 indicators and 125 variables. A field survey was conducted at the ward level from April 2019 to June 2019 and about 160 responses were gathered mostly in an interview mode. Moreover, the field observation method also utilised to fulfil the purpose of the research. Urban planning officers [the administrative head of the City Corporation] were approached with the questionnaire. As City Corporation Office is bestowed with the responsibility of dealing with all the local level development issues, they contain a wide range of socio-economic data ranging from census, livelihood, land use, public health etc. Other associated administrative officers (e.g., Livestock, Fisheries and agricultural officer etc.) were also interviewed simultaneously to reach a conclusion, particularly for the perspective variables. A Likert scale of 1 to 5 was used to rate each variable (*i.e.,* scoring of the variables); where ‘1’ refers to ‘very poor’ and ‘five’ was designated as ‘very good’. For quantitative indicators, ‘5’ actually represents the best practices and/or examples.

Table 1. CDRI parameters

Dimensions	Parameters
Physical	Electricity Accessibility of roads Water and drainage system Sanitation and solid waste disposal Housing and land use
Social	Population Health Education and awareness Community preparedness Social capital
Institutional	Mainstreaming of DRR Ward's crisis management framework Knowledge dissemination and management Institutional collaboration Good governance
Economic	Income Employment Household assets Finance and savings Budget and subsidy
Natural	Frequency of hazards Intensity of hazards Ecosystem services Sustainable environmental management Environmental policies

Calculating the CDRI

The CDRI questionnaire consists of five dimensions that are equally divided into five parameters; moreover, each question or variable ($X_1, X_2, ..., X_5$) has 5 choices of answer between very poor being 1 to best being 5. In addition, a weighting scheme requires that variables within a parameter, consisting of five variables, have to be ranked ($W_1, W_2, ..., W5$) depending on their importance (low importance [1], high importance [5]) in shaping the final score of a particular parameter and resilience dimension. Because of this simple structured questionnaire with the uniform numbers for each parameter and variable ranging between one and five, it allows a transparent adoption of the formula (Eq. 1) named weighted mean to calculate the CDRI scores for each variable, parameter and dimension in a standardised and harmonised approach (Joerin and Shaw, 2011).

$$\frac{\sum_{i=1}^{n} WiXi}{\sum_{i=1}^{n} Wi} = \frac{W1X1 + W2X2 + W3X3 + W4X4 + W5X5}{W1 + W2 + W3 + W4 + W5} \tag{1}$$

RESULTS

Physical resilience dimension

Electricity, water supply, sanitation and solid waste, roads, housing, and land utilisation are the main assessment indicators of climate disaster resilience in the physical dimension. Among the five indicators, the electricity obtained the highest score (3.41) in the physical dimension (Fig. 2). In the study area about 95% of the households had the electricity accessibility more than 15 hours a day. Barishal power plant ensures the electricity in maximum households in the area as a result electricity parameter obtained relatively high resilience score. But in times of disasters, electricity supply was hampered in this area and sometimes it took a long time to recover the supply. Besides this, although roads were accessible to all community members, in the mean times of flood or other calamities, roads became muddy and sometimes water logged in the roads. It hampered the communication. Thus, the resilience level of the roads showed medium resilience score 2.51 (Fig. 2). Similarly, resilience level for water and drainage system obtained score 2.69 (Fig. 2). The study also revealed about 80% family of the area collected water from tube well for drinking purpose. However, the number of tube wells in the area were limited so the people had to go far away to collect water for drinking and household purpose. Moreover, there was insufficient drain in the area and existing drains had limited proper cover. Wastes thrown in the drain dicovered has blocked the drain. In this area only 13% people followed proper waste management but most people throw their wastes in the river, canal or roads side. This has caused the unhealthy condition and furthermore monitoring of wastes by the City Corporation was very low.Therefore, the area resilience level of this parameter was considered lower and obtained score 2.84 (Fig. 2). Based on the survey result, it was found that the houses were not build according to the area building code which caused the households more vulnerable with resilience level as 2.36 which was relatively lower than other parameters in the physical resilience dimension (Fig. 2).

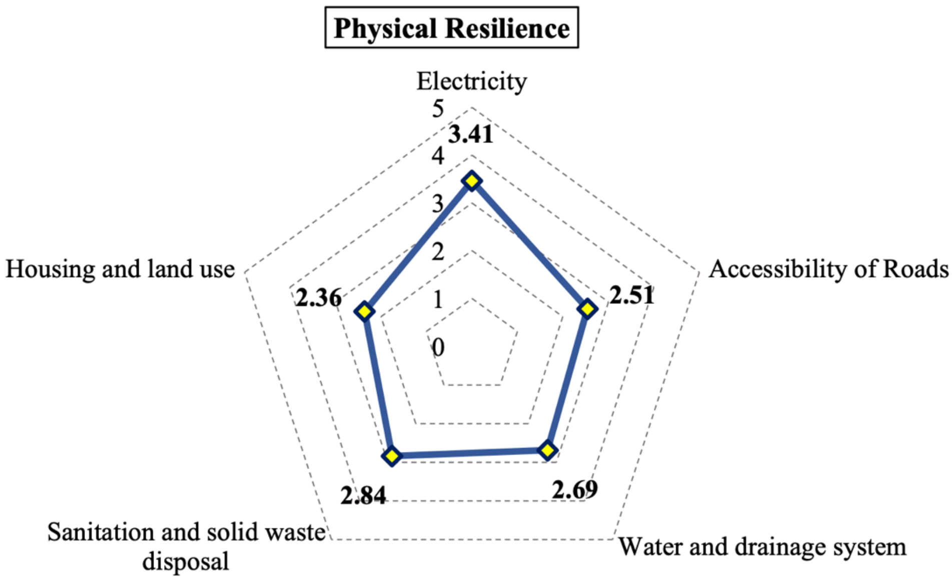

Figure 2. Physical resilience of the study area

Social resilience dimension

In this study, the parameters considered to measure social resilience are the population, health, education and awareness, community readiness, and social capital. The parameter population score is 3.5 which was relatively higher because of the level of awareness of people but community preparedness scored 2.26 (Fig. 3) which was relatively lower than other parameters because community had no necessary equipment to prepare for emergency situations. Some people of the community participated in training on disaster preparedness but outcomes of the training were not shared with other people. Thus, preparedness measures were relatively low in this area. In addition, there was health related awareness in the community but there limited sufficient health care centre and existing health care canters mostly had inadequate facilities to carry out their roles in emergencies. Therefore, the score of health parameter is 2.68 which was not in satisfactory level. The education and awareness score were 3.12 (Fig. 3) and about 42% people had primary education whereas 22% had no education. Moreover, in the community social bonding, social relation and cooperation of the area was good but most of the people live in extremely vulnerable condition and their vulnerable state with insufficient skills make it difficult to support each other during and after the disasters. This hampered the social capital parameter causing relatively low resilience level scored of 2.41 (Fig. 3).

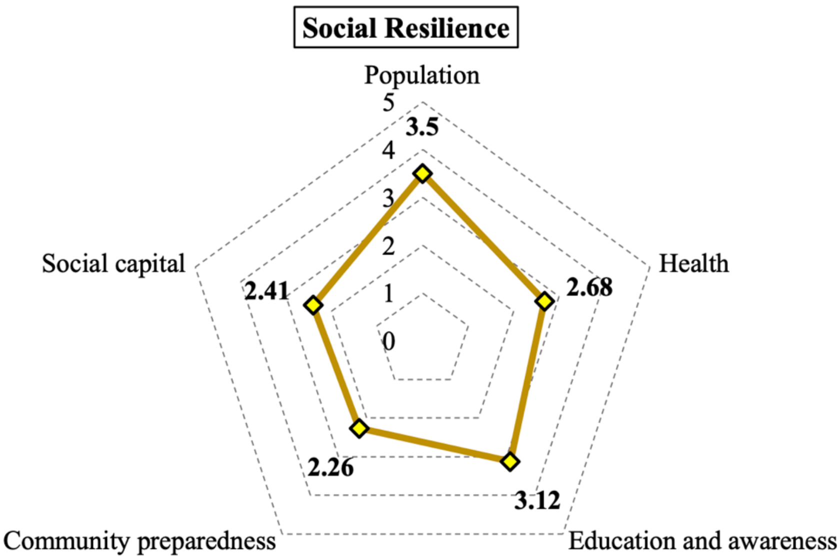

Figure 3. Social resilience of the study area

Institutional resilience dimension

The area showed a medium level of economic resilience with a relatively higher score of 3.24 in the ward crisis management framework and a lower score of 2.52 in mainstreaming of DRR and CCA (Fig. 4). About 63% of people followed the crisis management framework and NGOs and local authorities were responsible for managing the framework. Therefore, the crisis management framework scored relatively higher. On the other hand, only 20% of households of the area mainstreamed DRR in development activities. Climate change adaptation was also not followed by all in their livelihood practices and this is due to lack of education and awareness. Livelihoods and developments hampered for these reasons to a greater extend. The knowledge dissemination and management parameter, institutional collaboration, and good governance obtained score 2.67, 2.82, 2.72 respectively which showed a medium level of resilience under the institutional dimension (Fig. 4). A large percentage of people did not obtained any training on DRR in this area. Hence, there was lack of scientific knowledge on risk reduction among the people. During the field observation, the researchers discovered some tradition and knowledge from the community which have been used for managing risk reduction. Illiterate people of the area did not think DDR knowledge and dissemination of the knowledge is necessary. For this, knowledge dissemination and management parameters also scored relatively low in CDRI. The survey also found the existing trained organizations including Red Crescent, Bangladesh Rural Advancement Committee (BRAC), and Association for Social Advancement (ASA). However, most of the time they worked individually to help the community people in emergencies like a fire, accident, flood, etc. If they work together, problems in the area would be solved. Furthermore, the response and relief activities of councillors and mayor of this area were not enough to reduce the suffering of the people.

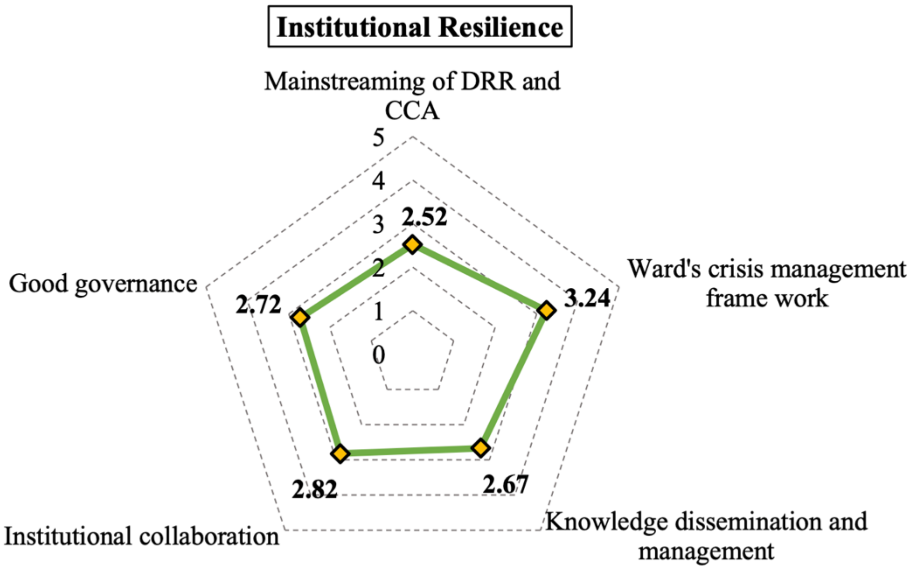

Figure 4. Social resilience of the study area

Economic resilience dimension

The economic resilience dimension was measured under five parameters named income, employment, household assets, finance and savings, also budget and subsidy. Although there was exist diversified livelihood practices, most people in the study area were in labour class and they generate income from a single major source of livelihood. Their livelihoods were diversified not resistive against hazards. Again, about 36% of people earned less than 5000 BDT per month. For these situation income parameters score of 3.02 and employment score of 2.86 (Fig. 5). Besides these, as most of the people of the study area were at a low-income level, their household assets quality to cope with disasters was at a medium level and they had no insurance policies and physical protection measures to protect these assets. For this, the household asset parameter under the economic resilience dimension score of 2.43 which is relatively lower (Fig. 5). The score of finance and savings and budget and subsidy showed a low score of 2.23 and 2.12 respectively (Fig. 5). People of the area have not occupied enough money for saving to use in future needs. For this reason, some assistance was needed from different organizations or others to pass their life in better condition. Besides this, there was a low budget allocated for risk reduction activities, emergency responses, and post-disaster relief and recovery at ward level. Ward's office was not given the budget for any development work due to limited resources at the ward body. Subsidies for residents to rebuild houses and livelihood after a disaster were not available. Credit facilities in the ward’s financial institutions to face disaster were also not available. For these reasons, the resilience level of finance and savings, as well as budget and subsidy parameter, scored lower than other parameters under the economic resilience dimension.

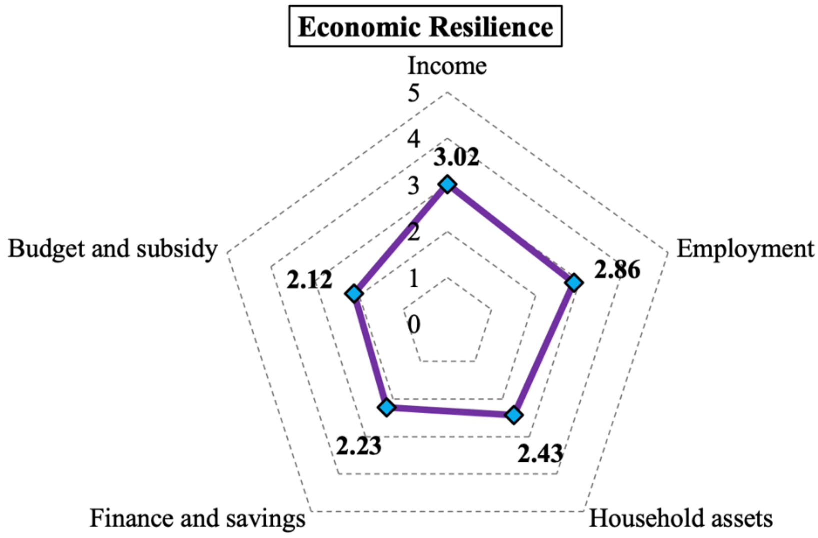

Figure 5. Economic resilience of the study area

Natural resilience dimension

While conducting the study, it was found that the area frequently faces different types of hazards with diverse intensities. According to the frequency-intensity matrix, it was found that the main hazards of the area include flash flood, cyclone, tornado, heavy rain, waterlogging, drainage congestion, etc. Unemployment was the big problem in this area and always exists in the community. On the other hand, salinity intrusion and building collapse never occurred. For these reasons' intensities of hazards of the slum area score of 3.13 which is relatively higher (Fig. 6). Moreover, environmental policies score of 1.99 which was relatively lower than other parameters. In addition, the score of the frequency of hazards is 2.56, ecosystem services are 2.65, and sustainable environmental management is 2.62 under the natural resilience dimension (Fig. 6). A relatively higher CDRI score of intensity and the lower score of the frequency of hazards showed that the area was more exposed to the risk of disaster events with low intensity and high frequency. Natural resources of the area were depleting gradually due to lack of maintenance, low awareness level, and indiscriminate use of the resources. Moreover, the extinction of wetlands of the area was caused due to indiscriminate filling up of lowland. Green places in the area where vanished due to the expansion of infrastructure and housing. These cause the resilience of ecosystem service parameters relatively low. The survey result also found that the environmental policy was not applied in the area. Local government including councillors of the ward, mayor of BCC and other government and non-government officials were not concern to apply the policy in the area. As a result, the area faced disasters frequently every year and the degradation of the environment also increased gradually in the study area. This causes the environmental policies parameter to have the lowest resilience among all 25 parameters under CDRI.

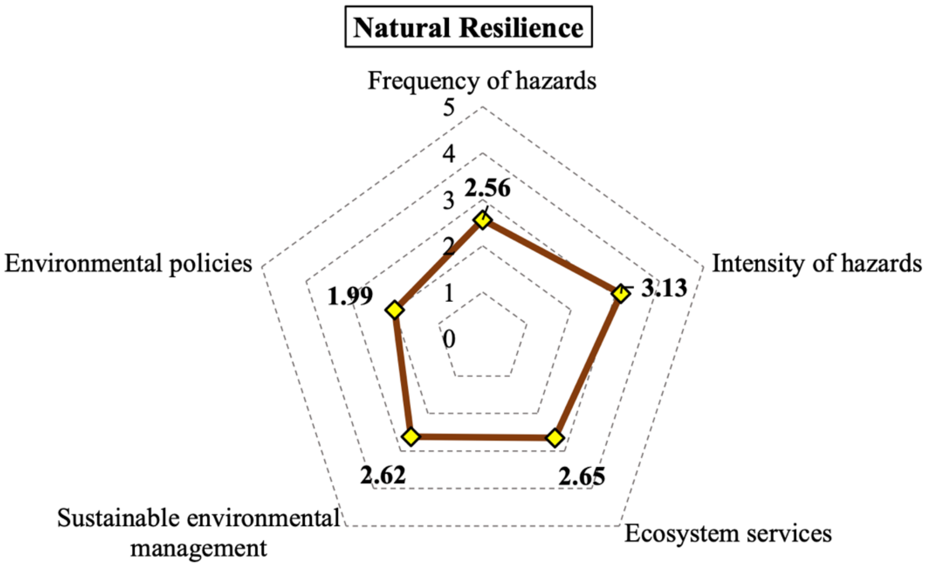

Figure 6. Natural resilience of the study area

Overall Climate Disaster Resilience Index (CDRI)

Higher CDRI values are equivalent to higher preparedness to cope with climate-related urban disasters. The highest resilience was shown for electricity, income, accessibility of roads, ward crisis management framework, education, and health in the study area. The lowest resilience was for DRR related budget and subsidy, finance and savings, community preparedness, water, and drainage system, environmental policies, and mainstreaming of disaster risk reduction and climate change adaptation, etc. Overall resilience analysis using CDRI of the slum Bangabandhu Colony, BCC showed that the resilience level of physical dimension score was 2.76, the social dimension score was 2.79, the institutional dimension score was 2.29, economic dimension score was 2.53 and natural dimension scored 2.59 (Fig. 7). Although scores showed that, all the dimensions were in a medium level of resilience according to CDRI, the resilience level of social dimension was relatively higher than the physical dimension, physical dimension was higher than the natural dimension, natural dimension was higher than the economic dimension and economic dimension was higher than the institutional dimension. The resilience level of the social dimension was relatively higher than other dimensions due to social bonding, cooperation, awareness, and health protection measures. On the other hand, institutional resilience level was relatively lower (Fig. 7) for the lack of institutional collaboration, the gap in knowledge dissemination, weak crisis management framework, lack of considering DRR and CCA in development activities, and absence of good governance. The CDRI scores indicated that the resilience level should be enhanced and promoted to a high level in order to cope with the adverse impacts of urban disasters.

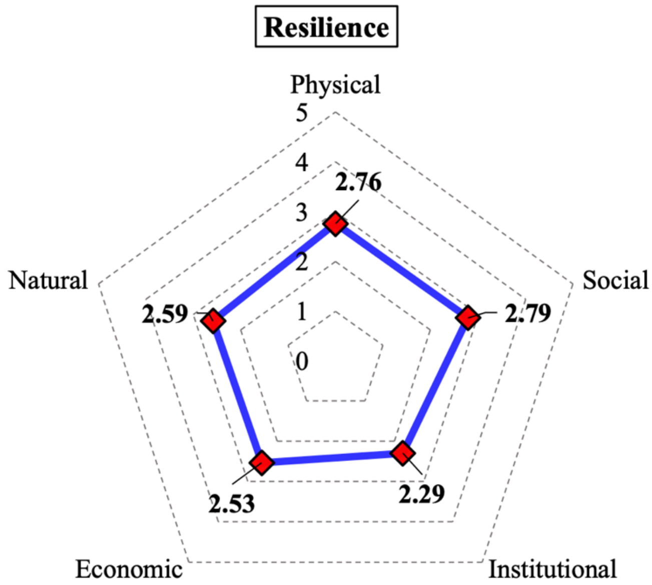

Figure 7. Natural resilience of the study area

Important aspects to enhance resilience

During the survey and assessment, each of the respondents was asked to rank variables and parameters based on the importance to enhance slum's disaster resilience. The man councillor prioritized some initiatives for increasing the resilience of the slum area which include repairing roads, filling up the wholes of roads, widen the space of walking, covering the drains in order to stop drain water coming in the roads, recycling household water, collecting rainwater, repairing the piping system, using water-efficient methods, improving community water system and upgrading family wells. Rainwater harvesting, excavating near water body, and keeping the water body clean were the possible solutions suggested by the woman councillor to improve the physical resilience level. Local elites also believed that increasing awareness of people, increasing frequency of dredging, levelling the whole area, proper hygiene practice, and unsubsidized private investment could improve the drainage system and reduce the problem of waterlogging. Youths of the slum area suggested, if education level could be increased, awareness about natural or man-made hazards would automatically increase and it would enhance future resilience to urban disasters in the study area. Some additional measures like implementing laws related to building codes, various risk management and risk reduction programs, community activities, and disaster preparedness were suggested by local people for increasing social and institutional resilience levels. While conducting assessment respondents also realized that arrange different training programs, campaigns, debates, seminars, and open discussions and teaching the people about the importance of cooperation in times of different emergency situations where necessary to enhance slum resilience. They also realized the need for social relations, bonding, and cooperation to survive after any disaster. Besides these, the study revealed that institutional collaboration, crisis management framework, good governance, budget allocation for disaster risk reduction, provision of subsidy and insurance, credit facility to face disasters, budget for any development work provided by the city corporation and subsidies for residents to rebuild houses and livelihood after a disaster are a way to enhance slum's resilience.

DISCUSSION

In the urban areas, disaster impacts depend upon several factors including intensity and frequency of natural hazards, climate change, and urban stresses, among others. However, it is also assumed that resilient cities can effectively address urban stresses and impact of climate change (Joerin & Shaw, 2011). To build a resilient city, it is essential to assess their resilience level. In this study CDRI framework was used for measuring the level of resilience in urban area. The CDRI analysis of Bangabandhu Colony under Barishal City Corporation shows resilience level of all five dimension is medium. Similar study was done in low-income neighbourhoods in Bangkok affected by the 2011 flood (Sitko, 2016). A methodology and a set of indicators were also applied to countries within the South-eastern United States for measuring baseline characteristics of urban communities that foster resilience (Cutter et al., 2010). A study also highlighted the underlying factors that inhibit resilience and means on improving the future disaster management and planning of Malaysian cities to become a disaster resilient city. Climate Disaster Resilience Index (CDRI) was used in this paper to measure urban resilience (Wan Mohd Rani et al., 2018). Another paper showed measurement of the current level of urban disaster resilience of Dhaka North City Corporation (DNCC) in Bangladesh using Urban Disaster Resilience Index (UDRI) model which is based on Climate Disaster Resilience Index (CDRI) (Kabir et al., 2018).

This study showed current resilience level of a specific area in Barishal city by assessing the challenges and potentialities in different aspects of urban system using Climate Disaster Resilience Index (CDRI). The study also showed some aspects of enhancing resilience which includes public safety programs, awareness raising programs, health awareness programs, disaster drills, different seminars, campaigns and meetings. Beside these, some fundamental measures like institutional collaboration, economic safety, good governance, proper budget, and sustainable environmental managements which will expand urban resilience of the area against different natural and manmade disasters. Sharifi and Yamagata 2016 showed some measures to reduce the impacts of urban centred disasters and to increase urban resilience. These include coordination capacity, diversity, foresight capacity, independence, connectivity, collaboration, agility, adaptability, economic safety, good governance, proper budget, crisis management framework, self-organization, creativity, efficiency, and equity.

CONCLUSIONS

The slum Bangabandhu Colony under Barishal City Corporation faces different climate induced disasters like a flash flood, cyclone, fire, accident, waterlogging, etc. due to unplanned urbanization and forcibly displaced populations moving in this area. Proper sanitation system, proper waste disposal, pure drinking water source, and hazard resilient livelihood practice was very rare in the area. Besides this, flood, heavy rain, drainage congestion, unemployment problem, and poor hygiene practice, etc. were very common here due to lake of education and awareness. Through conducting the research by following the CDRI method in the study area it was found a medium level of resilience. This research discovered that public safety programs, awareness-raising programs, health awareness programs, disaster drills, different seminars, campaigns, and meetings will increase the resilience level of the area. Alongside these, some fundamental measures like institutional collaboration, economic safety, good governance, a proper budget, crisis management framework, and sustainable environmental management which will improve urban resilience of the area against different disasters. In conclusion, it can be noted that the findings of this research identified a way to measure urban resilience against different disasters and to discover a better way of future urban disaster resilience.

ACKNOWLEDGMENT

The first author would like to express his sincere gratitude to the Department of Disaster Resilience and Engineering, Faculty of Environmental Sciences and Disaster Management, Patuakhali University of Science and Technology for allowing to conduct this research. The authors also would like to thank the City Corporation Administrative Officers of Barishal for their administrative assistance during the field survey. The paper is part of the first author's honours thesis.

REFERENCES

Ahmed, S. S., & Ahmed, M. (2017). *Urbanization and Economic Development of Bangladesh: The Primacy of Dhaka and Competitiveness*. Retrieved November.

BBS. (2013). District Statistics 2011. In *Ministry of Planning, Government of The People's Republic of Bangladesh*.

Bosher, L., & Dainty, A. (2011). Disaster risk reduction and "built-in" resilience: Towards overarching principles for construction practice. *Disasters*, *35*(1), 1–18. https://doi.org/10.1111/j.1467-7717.2010.01189.x

Cox, R. S., & Hamlen, M. (2015). Community Disaster Resilience and the Rural Resilience Index. *American Behavioral Scientist*, *59*(2), 220–237. https://doi.org/10.1177/0002764214550297

Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster Resilience Indicators for Benchmarking Baseline Conditions. *Journal of Homeland Security and Emergency Management*, *7*(1). https://doi.org/10.2202/1547-7355.1732

Helal, Z., Tariqul, A., & Jahirul, I. (2010). Urbanisation in Bangladesh: Present Status and Policy Implications. *ASA University Review*, *4*(2), 1–16.

Joerin, J., & Shaw, R. (2011). Mapping climate and disaster resilience in cities. In *Community, Environment and Disaster Risk Management* (Vol. 6). Emerald. https://doi.org/10.1108/S2040-7262(2011)0000006009

Joerin, J., Shaw, R., Takeuchi, Y., & Krishnamurthy, R. (2012a). Action-oriented resilience assessment of communities in Chennai, India. *Environmental Hazards*, *11*(3), 226–241. https://doi.org/10.1080/17477891.2012.689248

Joerin, J., Shaw, R., Takeuchi, Y., & Krishnamurthy, R. (2012b). Assessing community resilience to climate-related disasters in Chennai, India. *International Journal of Disaster Risk Reduction*, *1*(1), 44–54. https://doi.org/10.1016/j.ijdrr.2012.05.006

Kabir, M. H., Sato, M., Habbiba, U., & Yousuf, T. Bin. (2018). Assessment o Urban Disaster Resilience in Dhaka North City Corporation (DNCC), Bangladesh. *Procedia Engineering*, *212*(2017), 1107–1114. https://doi.org/10.1016/j.proeng.2018.01.143

Leichenko, R. (2011). Climate change and urban resilience. *Current Opinion in Environmental Sustainability*, *3*(3), 164–168.

Milanovic, B. (1999). *True World Income Distribution, 1988 and 1993: First calculations, based on household surveys alone*. The World Bank.

Panday, P. K. (2020a). The Face of Urbanization and Urban Poverty in Bangladesh. *Springer Books*.

Panday, P. K. (2020b). Urban Slum Upgrading Best Practices in Bangladesh. In *The Face of Urbanization and Urban Poverty in Bangladesh* (pp. 121–139). Springer.

Parvin, G. A., Ahsan, S. M. R., & Shaw, R. (2013). Urban Risk Reduction Approaches in Bangladesh. In *Disaster Risk Reduction Approaches in Bangladesh* (Issue March, pp. 235–257). https://doi.org/10.1007/978-4-431-54252-0_11

Prashar, S., Shaw, R., & Takeuchi, Y. (2012). Assessing the resilience of Delhi to climate-related disasters: A comprehensive approach. *Natural Hazards*, *64*(2), 1609–1624. https://doi.org/10.1007/s11069-012-0320-4

Rahman, M. H., Rahman, M. S., & Rahman, M. M. (2017). Disasters in Bangladesh: Mitigation and Management. *Barisal University Journal Part 1*, *4*(1), 139–163.

Rahman, M. M. (2014). Urban vulnerability assessment in South Asia: Challenges and lessons learnt. *Management of Environmental Quality: An International Journal*, *25*(3), 273–284. https://doi.org/10.1108/MEQ-11-2013-0122

Sanderson, D., Kayden, J. S., & Leis, J. (2016). *Urban disaster resilience: New dimensions from international practice in the built environment*. Routledge.

Sharifi, A., & Yamagata, Y. (2016). Principles and criteria for assessing urban energy resilience: A literature review. *Renewable and Sustainable Energy Reviews*, *60*, 1654–1677. https://doi.org/10.1016/j.rser.2016.03.028

Sitko, P. (2016). *Urban Disaster Resilience: Learning from the 2011 Bangkok Flood*. Oxford Brookes University.

Steiner, A., & Markantoni, M. (2014). Unpacking community resilience through capacity for change. *Community Development Journal*, *49*(3), 407–425. https://doi.org/10.1093/cdj/bst042

Wan Mohd Rani, W. N. M., Kamarudin, K. H., Razak, K. A., Hasan, R. C., & Mohamad, Z. (2018). MEASURING URBAN RESILIENCE USING CLIMATE DISASTER RESILIENCE INDEX (CDRI). *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-4/W9*(4/W9), 237–242. https://doi.org/10.5194/isprs-archives-XLII-4-W9-237-2018

Woolf, S., Twigg, J., Parikh, P., Karaoglou, A., & Cheab, T. (2016). Towards measurable resilience: A novel framework tool for the assessment of resilience levels in slums. *International Journal of Disaster Risk Reduction*, *19*, 280–302. https://doi.org/10.1016/j.ijdrr.2016.08.003