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Assessment of Climate Disaster Resilience In Dhaka City: A Case Study of Ward No. 28 of Dhaka South City Corporation

Md Moynul AHSAN[1], S. M Shah MAHMOOD[2] and Nehir VAROL[3]

Abstract
Dhaka is one of the fastest growing cities in the world, faces persistent urban environmental challenges. Environmental degradation, environmental pollution, flooding, high temperature, erratic rainfalls etc. on life and livelihoods of the city people have posed Dhaka a risky, vulnerable, unsustainable, unlivable and fragile city. In this context, this paper tries to measure resiliency through identifying Climate Disaster Resilience Index (CDRI) of ward no. 28 under the jurisdiction of Dhaka South City Corporation (Old Ward no. 64 of Dhaka City Corporation) considering five dimensions-Physical, Social, Economic, Institutional and Natural. This ward is representing the old Dhaka scenario which represents a segment of the capital of Mughal Bengal. There are some major factors under every dimension that have been considered to measure the index. By giving different weightage to different aspects finally CDRI has been measured for ward no. 28. The result shows that the overall average CDRI value for ward no. 28 is 2.65, which indicates that the natural disaster resiliency level is moderate. It also been suggested that by improving communication and accessibility, enforcing zoning and density control by the concerned Development Authority, partnership and collaboration with the people by social capital enhancement program; savings liked insurance programs; leveraging of existing strength in terms of external institutional networks, internal networks etc. can strengthen climate disaster resiliency in ward no. 28.

Keywords: Environmental Degradation, Dhaka, Climate Disaster Resilience Index (CDRI), Weightage Average Method

Dhaka Şehrinin İklimsel Afet Dirençliliğinin Değerlendirilmesi: Güney Dhaka 28 No.lu Bölge Örneği

Özet
Dhaka, dünyanın en hızlı büyüyen şehirlerinden birisidir ve kalıcı kentsel çevre sorunları ile karşı karşıya bulunmaktadır. Çevrenin bozulması, çevre kirliliği, sel, yüksek sıcaklık, düzensiz yağışlar

[1] PhD Student, Department of Political Science and Public Administration, Ankara University, Ankara, Turkey
İlgili yazar / Corresponding author: moynulurp01@gmail.com
[2] Police Officer, Department of Environment Protection, New York, USA
[3] Asst. Prof. Dr., Emergency and Disaster Management Dept., Ankara University, Ankara, Turkey

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gibi faktörler, Dhaka'yı riskli, kırılgan bir şehir haline getirmiştir. Bu bağlamda, bu çalışma kapsamında İklimsel Afet Direnç İndeksi (CDRI) tanımlanarak şehrin afetlere karşı dirençliliği ölçülmeye çalışılmıştır. Dirençlilik, fiziki, sosyal, ekomonik, sistemsel ve coğrafik bağlamda 5 farklı katagoride ele alınmıştır. Direnç indeksinin belirlenmesinde her faktör farklı ağırlıklandırmalar verilerek hesaplanmıştır. Değerlendirmeler sonucu bölgenin iklimsel afet direnç indeksi 2.65 olarak hesaplanmıştır. Bu sonuç, bölgenin orta seviyede bir afet direnci olduğunu göstermektedir. Ayrıca, haberleşme ve erişilebilirliğin geliştirilmesi, bölgede yerleşime açılma ve nüfus oranlarının Kalkınma Bakanlığı tarafından kontrolünün sağlanması, vatandaşların kaynaklardan yeterince yararlanması, işbirliklerinin arttırılması, sigorta sisteminin güçlendirilmesi, dış kurumlarla iletişim ağının geliştirilmesi, bu bölgenin iklimsel afet direncinin daha da güçlenmesi sağlayacaktır.

Anahtar Kelimeler: Çevresel Bozulma, Dhaka, İklimsel Afet Dirençliliği İndeksi (CDRI), Ağırlıklı Ortalama Yöntemi

1. INTRODUCTION

Global climate is changing rapidly and making all natural hazards more frequent and severe in nature. Bangladesh is one of the most vulnerable countries in the world as a result of climate change. The geographical location, industrialized development, high population density and low resource base has posed serious climatic impact. Dhaka, is now posing serious climatic impact (Alam and Rabbani, 2007: 81-97). To overcome negative climatic impact, it is needed to prepare a resilient city because a resilient city is able to sustain itself or ensuring safe and secured through its systems by dealing with issues and events that threaten, damage, or try to destroy it. Godschalk (2003) defined that resilience is important for two reasons. First, the vulnerability of technological and social systems cannot be predicted completely, resilience the ability to accommodate change gracefully and without catastrophic failure is critical in times of disaster. If we knew exactly when, where, and how disasters would occur in the future, we could persuade our systems to resist them. Second, people and property should fare better in resilient cities struck by disasters than in less flexible and adaptive places faced with uncommon. Local community resiliency can be a tool with regard to reduce climatic disasters in Dhaka city. Because, local community's habituation and awareness about the proper measures is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life and without a large amount of assistance from outside the community (Mileti, 1999: 32–33).

Disaster resilience analysis has become an important tool in disaster mitigation, risk assessment and decision-making in environmental, social, economic or technological areas (Nelson et al., 2010; Norris et al., 2008; Cutter, Burton and Emrich, 2010).

Rapid climate change and increasingly extreme weather events have serious adverse impacts on communities when poor disaster risk management policies are implemented.

The capital city of Dhaka now faces flood in the regular interval for many years. Besides, geological condition, sea level rise, changing intensity of rainfall pattern, temperature, deforestation in upper stream countries all these factors are acting catalysts behind increasing the intensity of flood. The flood induced disaster which indicates the climate induced disaster is getting more apparent. This study has estimated Climate Disaster Resilience Index (CDRI) for Ward no. 28 of Dhaka South City Corporation (Old Ward no 64 of Dhaka City Corporation) considering the physical, economic, social, institutional and natural dimensions because the vulnerability of cities population mainly depends on the above influential dimensions. In this research, CDRI value has been calculated only considering the flood hazard.

2. METHODOLOGY OF THE STUDY

Resilience is defined by Adger, 2000; Brown, 2016 as ability to withstand shocks and risks and defined by Varol and Kırıkkaya, 2017 as the ability to overcome disasters and emergencies via sociological, psychological and physical capacity of community and the system and ability to re-reach equilibrium succesfully.

Toubin et al. (2014) focused on urban services and networks when discussing urban resilience. Urban services are key to building urban systems; support some urban functions for example; economy, society, and housing (Bruneau et al., 2003). Urban resilience focuses on the ability to promote and maintain the supply and function of services (Kim and Song, 2018).

Tyler et al. (2014) determined urban functions as seven parts: (1) Water supply; (2) Flood prevention and drainage; (3) Public health; (4) Tourism; (5) Solid waste management; (6) Ecosystem management; and (7) Resettlement and Housing.

Shim and Kim (2015) categorized city resilience into the 3 categories: (1) Biophysical; (2) Built environment; and (3) Socioeconomic.

Function classifications for measuring and defining urban climate resilience, shown in Table 1. The divisions of function include the characteristics for maintaining a city's basic services and developing capacities to absorbing future impacts and stress from climate change disturbances (Seelinger & Turok, 2013).

Table 1. Function classifications for measuring and defining urban climate resilience. Kim and Song, 2018.

Function Category	**Definition**	**Sub-Composition**
Basic Function	The most basic function relates to urban residents' minimum needs, i.e., the necessities of life.	Housing, production, consumption (commerce), jobs
Developmental Function	This is based on the mutual relationships that are required to help residents prosper and to ensure the human capital of future generations. This means that people need to actively and continuously accept new things.	Innovation, social interactions, education, creativity
Sustainable Function	This function ensures that people, society, and the economy function well for longer periods of time. Space for living is required.	Culture, leisure, the environment, medical care, welfare, social safety

Maintenance Function	This involves institutional infrastructure, infrastructure, and the physical networks that make up a city, in addition to social and physical complexes and maintenance.	Politics and participation, public administration, disaster prevention and safety, public infrasture

In this study, the selected study area Ward No. 28 is selected mainly for understanding the existing condition of resiliency of old Dhaka (Figure 1). Like other parts of old Dhaka, this ward is characterized by the congested building structures, narrow roads, high population density, mixed land use pattern etc. There are two Panchayets (Community Club) in the ward which contains 5 members who play active role for the community. Here the local people have old culture and tradition and their social bondage is strong.

Both primary and secondary data has been used in this study. All relevant GIS database collected from GaniBangla Limited who has prepared "Detailed Area Plan for Dhaka City (1995-2015)" and necessary demographic and other household information of the study area has been collected from Bangladesh Bureau of Statistics, 2001. Primary data has been collected by a Focus Group Discussion with community leaders consisting of 8 members. Weighted Mean Index (WMI) method and Aggregate Weighted Mean Index (AWMI) have used to compute the scores for each parameter and dimension respectively. The CDRI of the city is the simple average of the indexes of the five dimensions- physical, social, economic, institutional and natural dimensions (Shaw, 2009). The index value ranges from 1 to 5. Higher CDRI values are equivalent to higher preparedness to cope with climate change and disasters. The resilience index has been interpreting below:

Resilience Index: A Resilience Index is an indicator of a community's ability to reach and maintain an acceptable level of functioning and structure after a disaster. Resilience Index may be identified as Low, Medium & High in different categories.

1. ***Low Resilience Index***: A low resilience index indicates that a community should pay specific attention to this category and should make effort to address the areas of low rating. If the critical infrastructure category received this rating, then reoccupation of that community may take more than 18 months before basic services are restored.
2. ***Medium Resilience Index:*** A medium resilience index indicates that more work could be done to improve your resilience in this category. If the critical infrastructure category received this rating, reoccupation of that community may take less than 2 months before basic services are restored.
3. ***High Resilience Index***: A high resilience index indicates that a community is well prepared for disaster. If the critical infrastructure category received this rating, then the community probably will not suffer or will have minimal damage (can be functional in less than two weeks) to basic services.

Needless to say, these results of resilience index are not absolute values, but serve mainly as broad policy guidance. Based on the results, the strengths and weaknesses of the ward of the five dimensions are highlighted. Then some policy points and recommendations are suggested to provide encouragement of city governments' engagements in the specific institution and capacity building.

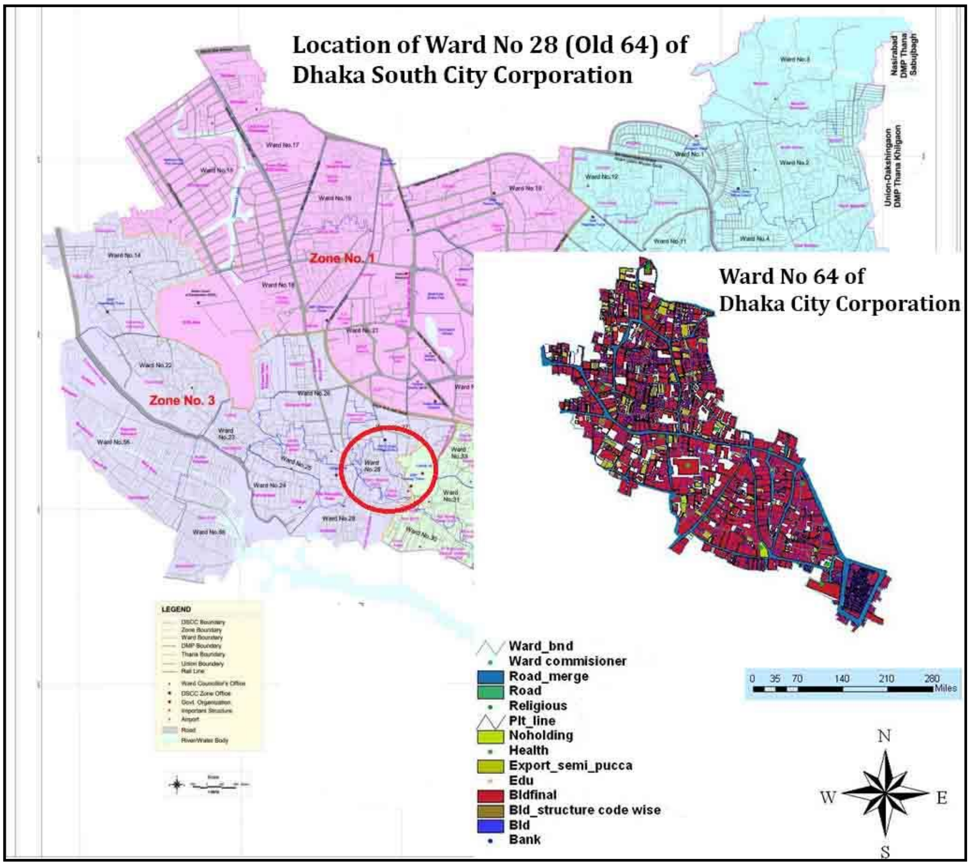


Figure 1. Map of ward number 28 of DSCC.

3. ANALYZE CLIMATE DISASTER RESILIENCE INDEX

Measuring the climate disaster resilience for flood hazard is critical due to multi-dimensional Analyses. At first, the identification of indicators that affect the disaster resilience of the study area has been done. Then, calculation of CDRI value has been conducted to measure the resilience. In this study, five dimensions have been identified including five individual parameters under each dimension.

3.1. Physical dimension of the study area

Physical dimension includes different infrastructural components such as: electricity, water, road network, accessibility and roads, housing and land use etc.

- **Electricity:** It was informed from FGD participant's opinion that, in ward no. 28, power disruption occurred more than five times between 8:00am and 5:00pm and in 24 hours on an average 12 hours of interruption has commonly occurred per day in study area. In this situation, there are only 15% extent of the capacity of alternative emergency electric supply systems (own or community group) to keep emergency service.
- **Water:** The scarcity of water has taken an acute problem in the study area for the last few years causing immense sufferings to the dwellers on the advent of the sweltering summer. From the FGD, it has been identified that about 6 hours of interruption in water supply has

commonly occurred per day in this area and only 25% extent of the capacity of alternative emergency of safe water supply systems in ward no.28.

- **Solid waste disposal:** Around 80% solid waste was collected by the Dhaka City Corporation (New DSCC) and remaining waste is left unattended and locally or openly dumped in this study area. However, up to 15% of solid waste was treated before dumping.
- **Accessibility of roads:** According to FGD opinion, about 10.93% of total land area was used for transportation network in the study area. Almost all roads were paved. More than 71% of roads have remained accessible during normal flood affected areas. On an average, 3-4 hours of interruption have occurred after heavy rainfall in affected areas.
- **Housing and land use:** About 86 % of people lived in their own house. Like other parts of old Dhaka, mixed category land use prevailed. On the other hand, less than 10% of non-permanent structures were available. More than 71% of houses could access during normal flood or water logging.

3.2. Social dimension of the study area:

The social dimension includes different social components, such as: population, Health, education and awareness, social capital, community preparedness etc.

- **Population:** The population of this ward has been 25,599 with a high population density of 625 people/ acre in which 62% are male and 38% are female. In the case of age distribution, around 62% population ranges from 18 to 60 years and only three percent population are above 60 years (BBS, 2003). The population growth has calculated 4-5.9 % annually. Percentage of population under 14 and over 64 is 29%. Percentage of population living in informal settlement was only 4% (BBS, 2003). Most of the people have lived by inheritance. So, the percentage of informal settlement rate was low in this ward.
- **Health:** From the FGD opinion, it has been found that the capacity of the ward's health facility is poor because the responsible authority did not take any initiatives about disaster management activities.
- **Education and awareness:** Though literacy rate is 76.89% but awareness of knowledge of population about the threat and impacts of disaster is poor (BBS, 2003). Still, most of the people live with their traditional belief and knowledge. From FGD, the participants informed that they are interested to alter their traditional knowledge. Because, it hampers their livelihood activities if any natural or manmade disasters occur in the area. Five years have passed ward office organized a public awareness program. Afterward, no other activities were taken for awareness program of disaster.
- **Social capital:** People sometimes participate at community level which is good practice compared with other parts of Dhaka City. In the study ward 28, two Panchayet Committees are involved in various community activities. From FGD participants, the extent of the ward's population participates in community activities are more than 41% which measured from FGD. Local political leaders also have a very influential role in the area
- **Community preparedness during a disaster:** From FGD participant's opinion, it has been found that people are not prepared for a disaster in terms of logistics, materials and management. Local people are not aware of disaster due to lack of preparation.

3.3. Economic dimension of the study area

Economic dimension includes the following the components related to economic activities such as income, employment, household assets, financial savings, budget and subsidiary.

- **Income:** About 50-74% of households have both primary and secondary sources of income. Most of the people are engaged in business activities in Chawk Bazaar (one of the oldest business hubs in old Dhaka). As a result, their average income level is higher than their surrounding area.

- **Employment:** From the BBS (2003), there were about 30% of unemployed labors exist in the study area. Women employment levels have been very low. They are mainly housewife. Women education rate is very low in this study area.
- **Household assets:** More than 92% households have television and mobile phone; 31-40% have motorized vehicle and less than 30% have non-motorized vehicle in the ward.
- **Finance and savings:** Access to credit facility has been found poor of financial institutions to prevent disaster in the ward. The effectiveness of credit facility is poor during a disaster for urban poor. From FGD, around 10% of residential households are under any sort of insurance scheme.
- **Budget and subsidy:** Ward commissioner did not allocate any portion of annual budget targeting disaster risk management. No fund is available for climate change related disaster risk reduction measures.

3.4. Institutional Dimension of the Study Area

It is evident that if the institutional set up has a good condition of a ward then it can be considered that the area is more capable of disaster management. The flowing indicators are considered to measure the resiliency of disaster.

- **Mainstreaming of Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA):** All the concerned aspects and principles should be taken incorporated for the development control to mainstream Disaster Risk Reduction and Climate Change Adaptation. Nevertheless, the ward 28 has not incorporated unexpectedly. Also the people of the ward have the poor ability or opportunity to produce development plans for their area. The logistic support for this has also opined poor. Even the ward does not incorporate the disaster management plan.
- **Effectiveness of Ward's Crisis Management Framework:** In the ward, there are many young people to work for the community on voluntary basis. The people in Panchayets are enthusiastic to help neighbors. In old Dhaka, the community sense is historic among the residents. The social bondage is a great strength for them. During any disaster, the people come forward to help others. Though there is no formal team to work in case of emergency but the Panchayet committee is the informal team to work for the purpose.
- **Knowledge Dissemination and Management:** People of old Dhaka have experienced many disasters. But it is quite ambiguous matter about their learning from those. It is because of their weak infrastructural condition. The major accidents occur and turn to hazard in old Dhaka due to congestion of buildings, narrow roads etc. The people who are enthusiastic to help others do not have proper training about the task in case of disaster. There is no effective system of knowledge dissemination about disaster management by any government authority.
- **Institutional Collaboration with Other Organizations & Stakeholders:** From FGD participant's opinion, it has been found that institutional collaboration was very low with other organizations for managing any disaster.
- **Good Governance:** Without ensuring governance, good management system cannot be achieved. Good infrastructures are needed to ensure good governance. But in this ward it is found that there is no early warning system for the disaster, no mock drills.

3.5. Natural Dimension of the Study Area

- **Intensity or Severity of Natural Hazards:** The impact of flood hazard is normal. There may be one occurrence of flood in every five years. The inhabitants of ward no 28 didn't experience any severe flood after 2004 because authority constructed drainage channel towards the Buriganga River subsequent of flood. This drainage network was functioning well with its full capacity. Water logging or flash flood was rare case and if there is water logging due to heavy rainfall within short time, the severity was not much as the local people do not treat it as to obstruct their daily normal activities.

- **Frequency of Natural Hazards:** Average urban soil quality in terms of industrial contamination is medium. Average urban air quality during the daytime is poor and urban heat island effect prevails in the Ward. As the paved surface area is very high and green area is very low, it has reduced the absorption capacity of soil in case of heavy rainfall and increased the surface runoff.
- **Ecosystem Services:** Ward 28 is located close to the river Buriganga. This river becomes contaminated not only by the industrial waste generating from the area's hazardous industries but also polluted by the hazardous waste from other parts of Dhaka City. In case of the other water bodies situated in the locality, they are polluted mainly for dumping of domestic wastes.
- **Land Use in Natural Terms:** Average intensity of land use- urban morphology (built area) is 71-90 %. Less than 10% settlements are located on hazardous ground (e.g. steep slope, flood prone area) in the study ward. Vegetation condition is very poor and less than 1% of total area has green space.
- **Environmental Policies:** There is no implementation of environmental conservation policies in this ward. Waste management system is poorly efficient in terms of Reduce, Reuse and Recycle. Reduce is not yet documented in the waste management system of DCC. A section of the poor people collects re-useable and re-cyclable waste materials form the dustbins/containers and as well as from the streets and dumping sites. Still there is no formal attempt for reusing the waste. Panchayet Committee collects domestic wastes from house to house with minimum charge. After house to house collection of wastes, they are dumped into the dustbins that are placed by Dhaka City Corporation (New DSCC) on roadside.

4. CLIMATE DISASTER RESILIENCE INDEX (CDRI) CALCULATION

The Climate Disaster Resilience of ward no. 28 has been calculated based on five dimensions under which individual score of five parameters was measured. The score of parameters has measured by determining the score of selected indicators under each parameter.

The score of a indicator Si_1 = $$\frac{Ci_1 \text{ X } Wi_1}{Wi_1 + Wi_2 + \dots\dots\dots Wi_n} \qquad (1)$$

Where,

Si_1 = Score of Indicator i_1 under specific parameter of a specific dimension

Ci_1 = Choice for indicator i_1

Wi_1 = Weight factor of indicator i_1

The same procedure is followed for other indicators under the identified parameters. Scores of all indicators are then used to determine the score of parameters using following equation:

The score of parameter SP_1 = $$\frac{i_1 \text{ X } Wpi_1}{Wpi_1 + Wpi_2 + \dots\dots\dots Wpi_n} \qquad (2)$$

SP_1 **=** Score of Parameter 1 of specific dimension

Wpi_1 = Weight factor of parameter1

Scores of parameters were aggregated to obtain the total value of CDRI of identified dimensions.

$$\sum_{i=1}^{n} P_n$$

CDRI of dimension, Id_1 =

$$= P_1 + P_2 + P_3 + P_4 + P_5 \quad (3)$$

Where,

Id_1 = Index value of Dimension 1

This procedure is followed to determine the Index value of other four dimensions.

Overall CDRI of the ward = Average CDRI of the ward = $\sum_{i=1}^{n} Id_n$

$$= \frac{Id_1 + Id_2 + Id_3 + Id_4 + Id_5}{\text{Total No. of Dimensions}} \quad (4)$$

Table 1. Calculation of Climate Disaster Resilience Index (CDRI) for Each Dimension

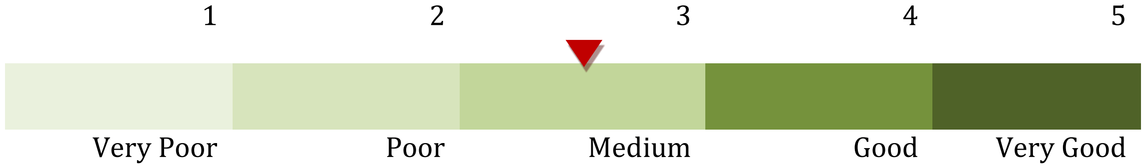
Dimension	***Parameters***	***Index of Parameters (I_p)***	***Weight of Parameters (W_p)***	***I_p x W_p***	***Σ(I_p x W_p)***	***Σ W_p***	***Index, I_d = Σ(I_p x W_p)/Σ W_p***
Utilities & Infrastructure	Electricity	3	1	3	61.06	15	4.07
	Water	3	3	9			
	Solid Waste Disposal	3.83	2	7.66			
	Accessibility of Roads	4.1	4	16.4			
	Housing & Land use	5	5	25			
Social Issues of the Ward	Population	4.17	2	8.34	46.73	15	2.84
	Health	3	1	3			
	Education & Awareness	3.47	4	13.88			
	Social Capital	4.67	3	14.01			
	Community Preparedness during a Disaster	1.5	5	7.5			
Economic Issues of the Ward	Income	3	1	3	27.65	15	1.49
	Employment	1	3	3			
	Household Assets	4.2	2	8.4			
	Finance & Savings	1.9	4	7.6			
	Budget & Subsidies	1.13	5	5.65			

Institutional Issues of the Ward	Mainstreaming of DRR & CCA	1.53	4	6.12	33.59	15	2.24
	Effectiveness of Ward's Crisis Management Framework	3	5	15			
	Knowledge Dissemination & Management	1.67	2	3.34			
	Institutional Collaboration with Other Organizations & Stakeholders	2.6	3	7.8			
	Good Governance	1.33	1	1.33			
Natural Issues of the Ward	Intensity/Severity of Natural Hazards	4	5	20	40.36	15	2.60
	Frequency of Natural Hazards	3	2	6			
	Ecosystem Services	1.83	1	1.83			
	Land Use in Natural Terms	2.67	3	8.01			
	Environmental Policies	1.13	4	4.52			

Calculation of Overall CDRI for the selected Ward:

Overall CDRI = ΣI_d / Number of dimensions = (4.07 + 2.84 +1.49 + 2.24 +2.60) / 5 = 2.65

Physical dimension has 4.07 value in the scale of 5.00, which indicates that ward no. 28 is in good condition regarding its physical dimension. On the other hand, economic condition of this ward is poor having a score of 1.49 in scale 5.00. This type of low CDRI value has explained the vulnerable condition of the ward in a natural disaster like flood. CDRI values of social, economic and institutional dimensions are respectively 2.84, 2.24, and 2.60 which has indicated ward no. 28 is in medium condition considering disaster resiliency. Therefore, the overall average CDRI value for ward no. 28 is 2.65, which indicates that the natural disaster resiliency level is moderate. This has been presented graphically.



5. CONCLUDING REMARKS

Knowing the causes and the impacts of the floods, an important issue remains to be solved which is “how to get people ready for floods before they come” and “how to help people cope with floods”. Two core elements such as flood preparedness and flood emergency management should strengthen to reduce disaster risk, as these are directly address the needs and opportunities for vulnerable communities. It also indicate/guide the strengthening and operations of government agencies at different levels: national, district, sub-district and union. Again, enhancing communication, coordination and cooperation between these stakeholders as well as maintaining consistency with national disaster management and mitigation policy are highly needed. From the study it has been observed that ward. No. 28 of Dhaka city corporation fall in medium condition which indicates that more work could be done to improve resiliency of the ward. The following some recommendations are suggested:

1. Disaster communication in the form of improving early warning systems and evacuation planning and accessibility by well internal access (adequate with) will be a good in building physical resilience. Communication with mobile and media can play effective role in this respect.
2. Planning authority (Capital Development Authority or RAJUK) should enforce zoning regulations and density control in the study area. The Detailed Area Plan (DAP) of RAJUK must implement to reduce disaster risk with required facilities and infrastructures for future.
3. Social capital enhancement program can be launched both in the Ward Commissioner office and Panchayets to engage more partnership and collaboration with the people.
4. Leveraging of existing strength in terms of external institutional networks, internal networks may also be strengthened while making climate disaster resilience a development planning agenda.

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