Proceedings of 8th IOE Graduate Conference
Peer Reviewed
ISSN: 2350-8914 (Online), 2350-8906 (Print)
Year: 2020 Month: June Volume: 8

Assessing Climate Disaster Resilience of Post-Earthquake Settlement: A Case Study of Bungamati, Lalitpur

Shami Adhikari [a], Dibas Shrestha [b]

[a] *Department of Applied Science and Chemical Engineering, Pulchowk Campus, IOE, TU, Nepal*
[b] *Central Department of Hydrology and Meteorology, TU, Nepal*
Corresponding Email: [a] shami2478@gmail.com, [b] st.dibas@yahoo.com

Abstract
Assessment of climate disaster resilience is one of the major processes for considering climate risks of the cities and consequences of disasters. This paper highlights the significance of measuring the climate resilience to increase awareness on current and future risk for disaster recovery and management. Bungamati, a heritage settlement has salient features towards disaster preparedness and mitigating climate risks. The reconstruction process after the earthquake, 2015 can contribute to increase resilience capacity by mainstreaming climate risks in rebuilding and planning phase. Therefore, the research attempts to measure the existing level of climate disaster resilience of Bungamati, one of the severe hit settlements by earthquake, using widely used Climate Disaster Resilience Index (CDRI). Through literature review, questionnaire survey and direct observation, variables and indicators for the assessment process were identified. The research focuses on physical, social, economic, institutional and natural aspects for assessing and strengthening resilience. In general, the data obtained from the CDRI assessment shows that the resilience level of Bungamati is at average with a climate disaster resilience score of 3.00, which needs additional measures to increase the resilience capacity of the settlement to withstand future climate risks.

Keywords
Resilience, Disaster, Climate change, Risk

1. Introduction

Natural disasters and climate change are among the greatest threats to human settlements. Natural disasters accelerate risks and climate change increases those risks and aggregates them by adding a greater level of uncertainty. Climate change is happening, following notable changes in temperature, precipitation and in frequency and intensity of extreme events. These changes result in declining crop yields, increasing water scarcity, loss of biodiversity and ecosystem services. Globally, the settlement of all urban and rural areas are vulnerable to severe impacts from low to high shocks and stresses, both natural and human-made. Climate risks and disasters are one of the biggest threats to social and economic progress, with adverse effects on poverty and inequality. Nepal is a disaster hotspot and among the most climate vulnerable countries in the world. It is prone to floods, landslides, rockslides, avalanches, glacial lake outburst floods and even earthquakes, which cause loss of life, livelihoods, property and infrastructure. In Nepal, the data trend from 1975 to 2005 shows that the mean annual temperature has been increasing by 0.06 °C and is predicted to be increased between 1.3 °C to 3.8 °C by 2060 and 1.8 °C to 5.8 °C by 2090. While the mean rainfall has been decreasing by 3.7 mm (-3.2%) per month per decade and annual precipitation could reduce by the range of 10 to 20 per cent across the country [1]. Nepal's vulnerability is not only due to its steep, rugged and fragile terrain, but also to anthropogenic factors, such as unsustainable land use practices and low adaptive capacity. However, Government of Nepal (GoN) has formulated number of policies and guidelines to enhance community resiliency along with contribution to reduce greenhouse gas emission. The government has developed National Adaptation Programme of Action (NAPA) followed by National Framework on Local Adaptation Plans for Action (LAPA) to ensure adaptation and resilience are integrated into local and national planning processes.

Nepal experienced a destructive earthquake on 25 April, 2015 pursued by a frequent number of aftershocks affecting mostly 31 districts of the country. A tremendous damage was counted to about 9000 deaths of people and 100,000 were displaced. More than 500,000 private houses were completely destroyed causing extensive damage to physical and economic infrastructure [2]. After this huge disaster, GoN identified the need of post-earthquake reconstruction along with long-term economic development setting the goal of "Build Back Better". Various projects and programs were implemented and non-profitable organizations were engaged in promoting and developing disaster resilient communities in earthquake affected districts in Nepal under different funding supports. Climate change can exacerbate the effect of earthquake on people and the environment. However, the reconstruction process do not mainstream climate risks while implementing projects which makes the settlement more vulnerable to future climate induced disasters. These risks can be taken into account during reconstruction process, in order to build back better, safer and greener. Rebuilding not only addresses the real time problems of the earthquake affected settlements but also creates an opportunity to enhance the resilient capacity of the people by developing new and efficient typologies and creating climate resilient communities.

Heritage settlements are under a major threat due to the rebuilding process after the earthquake. The settlement is losing its identity due to haphazard modern construction and ineffective bye-laws and policies. The traditional features of the settlements like water bodies, open spaces and conservation practices, which aids mitigation measures have been vulnerable. Bungamati is declared as one of the heritage settlement by GoN. Although, Lalitpur lies in low vulnerability ranking according to NAPA report, 2010 [3], these traditional settlements in Lalitpur need to be conserved. There has been various studies done on the core heritage settlement of Bungamati after the Nepal Earthquake, 2015. But no studies have been made on post-earthquake settlement from perspective view of climate change and resilience. This research will help to find out the existing resilience capacity of the post-earthquake settlement of Bungamati against climate risks to withstand future disasters.

Resilience is defined as the capacity of a social, economic, and environmental systems to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation [4]. Resilience is closely related to the vulnerability of people or communities: the greater their vulnerability to the impacts of climate change, the lower their resilience, and vice versa. Climate resilience is the capacity of a system to cope with, or recover from, those effects, while retaining the essential components of the original system. Climate resilience of any area or settlement can be overviewed by identifying climate resilience indicators through use of existent and accessible data. The overall procedure for use of climate resilience indicators includes: selection of relevant indicators, calculation of aggregated index scores, presentation and interpretation of results. Among the several climate resilience assessment tools adopted in the different parts of the world, this study utilize Climate Disaster Resilience Index (CDRI) to measure the climate disaster resilience of the study area [5]. CDRI has been developed from 5 resilience dimensions (physical, social, economic, institutional and natural), 25 parameters and 125 variables. The main objective of this research is to measure existing level of climate disaster resilience of Bungamati using CDRI.

2. Data and Methodology

2.1 Study area

The old town of Bungamati is represented by a typical Newar settlement with compact row housing, town forms, courtyards, street patterns, temples, traditional water sources and socio-cultural values. Bungamati, ward no. 22 of Lalitpur district, is located in the northern part of Kathmandu valley on the bank of Bagmati river. The settlement is surrounded by cultivable land from the west and by green forest from North. Almost 100m below the village terrace flows Bagmati river. Settlement of Bungamati is located at a higher ground level making it safe from flooding. The majority of the buildings are individual structures encircling the open spaces with multiple entry accesses. The streets are narrow and the patterns are according to the festival and jatra routes. Before April 25, 2015, Bungamati was a picturesque Newari village of almost all traditional houses made out of mud brick with tiled roofs, stone-paved streets, ponds, temples and stupas. But after the reconstruction, many brick, mud mortar buildings and ancient temples were collapsed in the earthquake which has been attracting to many residents towards concrete construction. One of the major threats in the traditional settlement of Bungamati is ongoing urbanization process where it is losing its identity. The Earthquake affected the settlement of around 6000 inhabitants and around 90% of houses were either damaged or collapsed, including the important monuments such as the famous Rato Machhindranath Temple, the Hyangriv Bhairab Temple and the Manakamana Temple [6]. National Reconstruction Authority (NRA) has highly prioritized the reconstruction of traditional heritage settlement of Bungamati with an integrated and sustainable approach, while retaining the traditional architectural fabric and cultural identity of the area.

Figure 1: Satellite (Google) image of core area of Bungamati,2020

2.2 Methodology

The proposed research is based on an inductive research approach. An inductive research approach works moving from specific observations to broader generalizations. The study uses both qualitative and quantitative methods of data collection for the study. The research area was observed and interpreted using case study research strategy. Case study methodology helps to study in depth and explore the reality. Various primary and secondary data were collected. Primary data was collected from field observation and questionnaire survey of the households to explore the existing scenario of the study area. Key informant survey and interview was carried out to further acknowledge their views on disaster preparedness and collaboration with organizations and stakeholders. Similarly, secondary data was collected from published research materials, journals, articles, government policies, and reports and papers from the government institutions like NRA and non-profitable organizations. Secondary information about the annual municipal development plan of Lalipur was collected from Lalitpur Municipality [7].

The required sample size for the survey was determined by the formula given below, derived by Cochran's formula [8]. The population of the core area of the study area was found to be 3908, according to the report of UN Habitat, Nepal [6]. Since the population of Bungamati was found to be dense in the core traditional area, the sample size was taken from that area. The households were randomly selected following the appropriate random method of sampling.

$$n_o = \frac{z^2 pq}{e^2} \tag{1}$$

where,
n_o = Sample size,
z = selected critical value of desired confidence level (1.96 for 95% confidence level),
p =estimated proportion of an attribute that is present in the population, (0.5 assuming maximum variability).
q = 1-p and
e = desired level of precision (0.05)
The correction formula to calculate the final sample size is given below

$$n = \frac{n_o}{1 + \frac{n_o - 1}{N}} \tag{2}$$

where, N is the population size

Table 1: Sample size calculation

Confidence level	95%
Critical value (z)	1.96%
Population size	3908
Sample size	70

2.3 Climate Disaster Resilience Index (CDRI)

Climate Disaster Resilience Index (CDRI) is one of the assessment tools to measure the climate and disaster resilience at the city level, national level, and microlevel [5]. Measuring the resilience level of the city allows stakeholders to acknowledge and assess the current and future climate and disaster risks [9]. CDRI has five dimensions and five parameters under each dimension with a version of (5*5*5 matrix) which helps to explore the ability of the study area to cope with disasters. It has been tested and studied in different cities of South East Asia. Dimensions, parameters and variables are listed in Table 3. The simple structure of the CDRI assessment required to choose a score between 1 (low) and 5 (high) for each variable [10]. The index value ranges from 1 to 5 for each dimension and parameters. For example, if all (100 %) of the residents of the study area have access to electricity at their home a score of 5 would have resulted. Each variable (x1, x2, x3, x4, x5) provides five choices answers starting from not available/very poor (1) to best (5). The formula, weighted mean index (WMI) is used to calculate scores for each parameter which is shown below.

$$WMI = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \tag{3}$$

where, w stands for the weight attributed to the score of a certain variable x.

This study considers three variables for each parameter (5*5*3matrix) based on literature available on its relevance to resilience and availability of data from national data sources and household surveys. Using data collected from the survey, the scores for each dimension and parameter were computed. Each variable are given equal weightage and rating scales are given the numbers 1, 2, 3, 4, 5 corresponding to very poor, poor, moderate, good and high as in Table 2. These variables provide 5 answer choices starting from not available/very poor (1) to best (5). For example, if (>80 %) of the households of the study area have access to electricity at their home, a score of 5 would have resulted. Similarly (4 for 62-80 %), (3 for 41-60 %), (2 for 20-40 %) and (1 for <20 %) are rated for the number of households (Table 1). From the results obtained, radar diagrams were plotted to show Bungamati's overall resilience in terms of physical, social, economic, institution and natural aspects.

Table 2: Criteria for score of parameters and CDRI in the field.

Population (weightage)	<20%	21-40%	41-60%	61-80%	>80%
Score	1	2	3	4	5
	Very poor	Poor	Moderate	Good	High

Table 3: List of dimensions, parameters and variables for CDRI (Source: [5])

Dimensions	Parameters	Variables
Physical	Electricity	access, availability and supply, alternate capacity
	Water	access, availability and supply, alternate capacity
	Sanitation and Solid Waste Disposal	access, availability and supply, alternate capacity
	Accessibility of Roads	transportation network, paved roads, roadside covered drains
	Housing and Land Use	building codes, house ownership, housing type
Social	Population	annual growth rate, population density, population under 14 and above 65
	Health	access to health facilities, preparedness for disaster, functionality of health facilities
	Education and Awareness	literacy rate, awareness of disasters, availability of public awareness programs
	Social Capital	participating in community activities/clubs, mixing and interlinking of social classes, ability of community to build concensus and participate in city's decision making process
	Community Preparedness	preparedness in terms of logistics, materials and management
Economic	Income	number of income sources, population below poverty line, income derived from informal sector
	Employment	youth unemployment, women employment, employment in formal sector
	Household Assets	households with television or mobile phone, motorized vehicle, non-motorized vehicle

Dimensions	Parameters	Variables
	Finance and Savings	availability of credit facilities to prevent disasters, savings of households, accessibility to credits or households properties insured
	Budget and Subsidy	city's annual budget for CCA and DRR, alternative livelihood, availability of subsidies to rebuild houses
Institutional	Mainstreaming of DRR and CCA	mainstreaming in city's land use, housing policies, environmental plans
	Effectiveness of city's crisis management	existence of disaster management plans, efficiency of trained emergency workers during disaster, effectiveness of emergency team during and after disaster
	Effectiveness of a city's institution to respond to a disaster	capacity (book, leaflets etc.)to disseminate disaster awareness programs (disaster education), trained emergency workers, disaster training programmes
	Institutional collaboration with other organisations and stakeholders	dependence on external institutions, collaboration with national government, NGO's, private organizations, collaboration and interconnectedness with neighbouring areas
	Good Governance	implementation of DRR plans, frequency of disaster drills, effectiveness of early warning systems
Natural	Severity of natural hazards	floods, rainfall induced landslides, droughts (water scarcity)
	Frequency of natural hazards	floods, rainfall induced landslides, droughts (water scarcity)
	Ecosystem services	quality of urban biodiversity, water bodies, air
	Land-use in natural terms	available urban green space, loss of urban green space in last 50 years, area vulnerable to climate hazards/settlements in hazard prone areas
	Environmental policies	existence of environmental preservation policies, implementation of waste management system(RRR), implementation of mitigation policies to reduce air pollution

3. Results and discussions

After the successful household survey of a total of 70 households of the core area of Bungamati and with the help of secondary data sources from the literature review, the dimensions, parameters and variables for CDRI assessment were selected for the study. This research has focused on the study of climate and disaster resilience capacity of Bungamati after the Gorkha earthquake, 2015. Based on the research carried out for CDRI under five dimensions on physical, social, economic, institutional and natural, the following results have been found:

3.1 Physical dimension

The physical dimension is composed of five parameters such as electricity, water, sanitation and waste disposal, accessibility of roads, and housing and land use (table 3 and 4). These parameters act as a key role in overall development of the study area and assist people to cope with disasters. More than 80% of the households were found to have access to electricity and water. Water was noted to score a good resilience in comparison to electricity because of the access and the alternate capacity for supply with the presence of traditional water sources like ponds, wells, stone spouts and rajkulo. These sources of water were used for washing, cleaning and irrigation purposes. Ponds act as a water reservoir that can also be used for disaster management like fire and also contributes to reducing climate change impact. Even so, only a few households (<20%) have access to alternative emergency electric supply systems. Whereas, scores for other components of sanitation and waste disposal, accessibility of roads and housing and land use were found to be satisfactory (moderate). More than 80% of household lived in their own house and had the provision of toilets. About 40% of households lived in their old vernacular house while others replaced by RCC (Reinforced Cement Concrete) structures. Even though waste collection was done by Nepal Pollution Control and Environment Management Centre (NEPCEMAC) twice a week, open dumping and unmanaged debris was found at open spaces. Almost all roads were paved, yet, most parts of the roadside drains were uncovered and unmanaged. Among the parameters, water and sanitation and solid waste disposal sectors acquired the highest CDRI scores (3.67) followed by housing and land use (3.33) and electricity (3.00) and accessibility of roads (3.00) (table 4 and figure 2). In summary, the physical dimension showed a moderate score in terms of climate risk resilience.

Table 4: Assessment of Physical dimension

Parameters	CDRI Score
Electricity	3.00
Water	3.67
Sanitation and Solid Waste Disposal	3.67
Accessibility of Roads	3.00
Housing and Land Use	3.33

3.2 Social dimension

Under the social dimension, five parameters of CDRI were identified as population, health, education and awareness, social capital and community preparedness. In the social dimension while other parameters such as health, education and awareness and community preparedness showed a relatively optimistic level, population and social capital seem to have lower scores due to growing population and high population density of the study area as shown in table 5 and figure 3. Although, percentage of the population under 14 and above 65 was found to be only 28%. Health posts were accessible within walking distance but the preparedness of community for disasters was not satisfactory. Education and awareness were noted to have the highest score under social resilience. Though literacy rate was found to be 81% in Bungamati but awareness of knowledge of population about disasters and availability of public awareness programs was low. About 30% of the households were partly involved in community activity and clubs and though people participate in community activities but their ability to participate in city's decision making process was disappointing, which makes social capital poor. It was also found that people were not prepared for disasters in terms of logistics, materials and management. However, the community was fully supported by Non-Governmental Organizations (NGO) and Community Based Organizations (CBO) like UN-Habitat Nepal, Lumanti, Centre for Integrated Urban Development (CIUD), Bungmati Foundation Nepal, Bungamati Rebuilding Committee and others.

Table 5: Assessment of Social dimension

Parameters	CDRI Score
Population	2.67
Health	3.33
Education and Awareness	3.67
Social Capital	2.67
Community Preparedness	3.00

3.3 Economic dimension

The assessment on economic dimension includes income, employment, household assets, finance and saving and budget and subsidy parameters. The economic resilience of the study area was assessed with relatively lower rating (table 6 and figure 4). About 60 % of the household holds more than one source of income with the majority of people engaged in woodcarving and other business activities. More than 70% of the youths were employed whereas only a few of the population were involved working in the formal sector, which creates a threat to their income source after the occurrence of disasters. More than 80% of the household have television or mobile phone and motorized vehicle whereas very few of them own non-motorized vehicles like bicycles. Lack of credit facilities, finance for disaster risk and low insurance schemes lead to lower scores in the economic sector. However, few subsidies to rebuild houses within the heritage site were available by the government and also minimal annual budget was allocated for the disaster risk reduction sector.

Table 6: Assessment of Economic dimension

Parameters	CDRI Score
Income	3.33
Employment	2.67
Household Assets	2.67
Finance and Savings	2.00
Budget and Subsidy	2.67

3.4 Institutional dimension

Overall, institutional resilience of the study area was obtained to be the lowest with the assessment on parameters such as mainstreaming of DRR and CCA, effectiveness of city's crisis management and institution to respond to a disaster, institutional collaboration with other organizations and stakeholders and good governance (table 7 and figure 5). From the report of secondary data sources, there seems to be an attempt for mainstreaming Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) in land use planning and housing policies in Lalitpur. Also, environmental plans as Environmental and Social Management Plan (ESMP), Solid Waste Management Service Improvement Plan (SWM-SIP-LSMC) were introduced. The earthquake in 2015 offered an opportunity for collaboration with different organizations and stakeholders for rebuilding the area. However, the scores suggest the need to focus on the effectiveness of a city's institution to respond to a disaster and governance to cope with future disasters. Lack of disaster training programs, disaster drills and early warning systems lead to score low under this dimension.

Table 7: Assessment of Institutional dimension

Parameters	CDRI Score
Mainstreaming of DRR and CCA	3.00
Effectiveness of city's crisis management	3.00
Effectiveness of a city's institution to respond to a disaster	2.00
Institutional collaboration with other organizations and stakeholders	2.67
Good Governance	2.00

3.5 Natural dimension

For the natural dimension, the assessment comprises of parameters on intensity/severity and frequency of natural hazards, ecosystem services, land use in natural terms and environmental policies. Results from the natural dimension indicates that the study area is resilient in terms of intensity and frequency of hazards as shown in and table 8 and figure 6. However, drying of water spouts and ponds in recent decades indicates that water stress could happen in future. Since the settlement of Bungamati is located at a higher ground level, there is a low risk of flood, yet sometimes there was an occurrence of flood due to heavy rainfall and unmanaged debris. Comparatively, ratings were found to be low for ecosystem services and environmental policies (table 8). The waste generated from brick factories at Bungamati were responsible for increasing air pollution, degradation of agricultural land and contamination of nearby Bagmati river. In the case of water bodies, people still use it for washing and cleaning purposes, yet revitalization was done according to cultural rituals by the community and by other organizations. Also, the air quality index of Lalitpur was found to be unhealthy for sensitive groups. The presence of green and open spaces, courtyards are responsible for attaining a good level in terms of land use, yet these open spaces were found to be insufficient and unmanaged. The implementation of few environmental policies and plans was reflected in development plans according to the secondary data sources of Lalitpur Sub Metropolitan City (LSMC). Waste management policies and system for 3R (reduce, reuse, and recycle) were introduced in the solid waste management plan for Lalitpur but its implementation was found to be poor. However, the distribution of two red and green color bins was done by ward office for waste segregation.

Table 8: Assessment of Natural dimension

Parameters	CDRI Score
Intensity/ Severity of natural hazards	4.00
Frequency of natural hazards	3.67
Ecosystem services	3.00
Land-use in natural terms	3.67
Environmental policies	2.67

In this study, the scores for each dimensions, parameters and variables ranges from 1(very poor) to 5(high). CDRI index for each dimension was calculated by weighted mean index. The overall scores for each dimension of CDRI are presented in figure 7. Out of the analysis of five dimensions under CDRI, the natural dimension has the highest score while the institutional dimension has the lowest score. Bungamati has moderate natural (3.40), physical resilience (3.33), social resilience (3.07) and low economic (2.67) and institutional (2.53) resilience in the scale of 5 as shown in figures below. As a result, the overall resilience score of Bungamati was obtained as moderate (3.00) from the study. Bungamati, a historic settlement has significant network of streets, public places and water sources, which facilitates emergency response and recovery after disaster. By virtue of its location at higher ground, makes the settlement safe from flooding and also availability of urban green spaces helps to acquire good resilience index. Similarly, high literacy rate and community involvement seems to generate good resilience. Whereas, lack of credit facilities for disaster risk and weak administration results in poor economic and institutional resilience of the study area. In the CDRI assessment tool, integrated management of all resilience blocks contributes to enhancing resilience to climate induced disasters. Since, the resilience of households depends mostly on its resources and preparedness for disasters, these aspects should be strengthen to reduce disaster risk. Implementation of building codes, plans for disaster reduction and climate adaptation ought to get great concern to increase resilience. Likewise, introducing green infrastructures such as planning city parks, street trees and restoring green and blue natural areas of the settlement aids in adaptation for climate change. This research is an attempt at initial level of analysis of resilience index and there is a need of more studies to gain a combined illustration of vulnerability and resilience of the settlement to achieve better results.

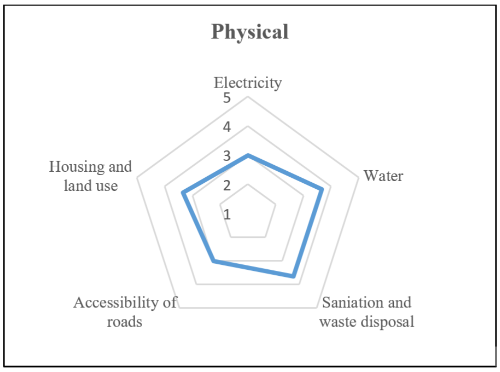

Figure 2: Assessment of Physical dimension

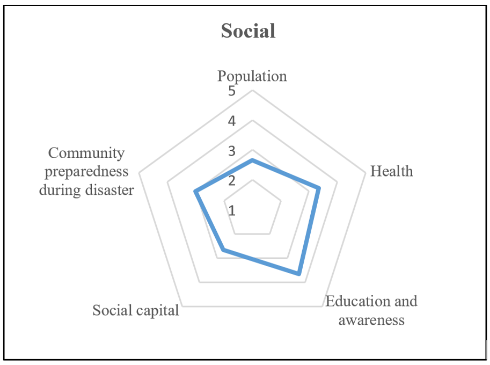

Figure 3: Assessment of Social dimension

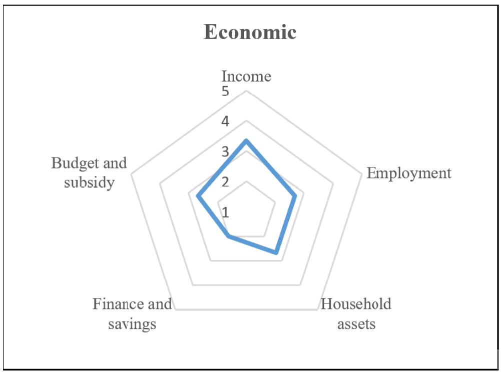

Figure 4: Assessment of Economic dimension

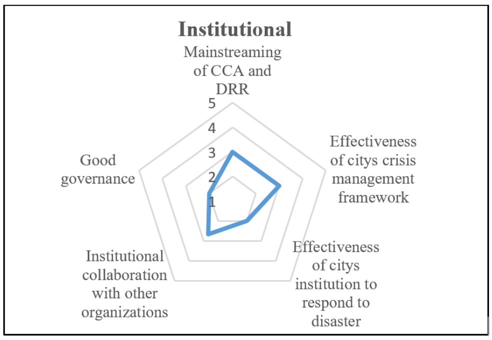

Figure 5: Assessment of Institutional dimension

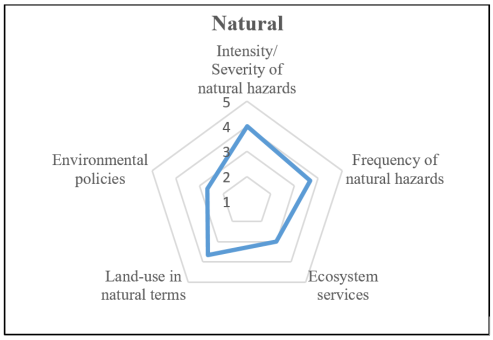

Figure 6: Assessment of Natural dimension

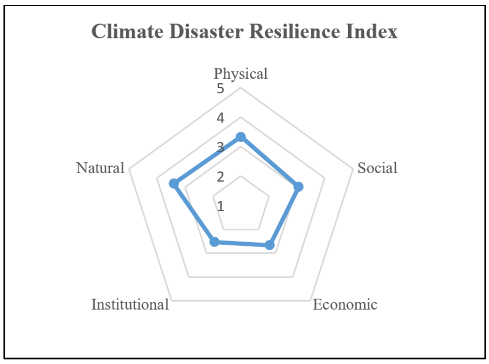

Figure 7: CDRI analysis (Bungamati)

4. Conclusion

This study assess the climate disaster resilience in the core area of heritage town, Bungamati, Lalitpur, Nepal after Gorkha Earthquake, 2015 using widely used CDRI. CDRI assessment helps to realize the capacities and vulnerabilities as well as strength and weakness of the study area. Based on the results and findings of the CDRI assessment, the resilience level of Bungamati is at average (moderate). Additional measures need to be taken to make the settlement more resilient to withstand future climate risks and disasters. Traditional knowledge systems in Bungamati also contributes in reduction of disaster vulnerability and increase resilience. Connected public open spaces and water bodies are the essential features of the traditional settlement. Efficient planning of these features leads to inhibit disaster and aid to reduce climate risks. Community involvement in the planning and reconstruction process can help to strengthen the social capacity in the future. It is important to incorporate Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) into planning, rebuilding and development policies along with coordination between stakeholders. Eventually more focus is required to build up institutional capacity and enhance good governance. Some methods to improve institutional capacity could be more investments in community in this sector. It is obvious that the term resilience is multidimensional and the process of satisfactory assessment is complex. Therefore, strengthening the physical, social, economic, institutional and natural aspects of the settlement and integrating in development planning helps to improve the resiliency of the area. There is also a need to collaborate with related officials during the reconstruction process and consider these aspects to preserve heritage settlements in disaster recovery against future climate risks.

Acknowledgment

The authors express sincere gratitude to Department of Applied Science and Chemical Engineering, Institute of Engineering for this opportunity.

References

[1] Central Bureau of Statistics. National climate change impact survey 2016, a stastical report. page 1, 2016.

[2] T Dorji, S Joshi, M Khadka, B Mishra, N Neupane, G Rasul, and B Sharma. Strategic framework for resilient livelihoods in earthquake-affected areas of nepal: Icimod working paper 2015/6. page 58, 2015.

[3] Ministry of Environment. National adaptation programme of action (napa). page 11, 2010.

[4] Intergovernmental Panel on Climate Change. *Annexes*. Cambridge University Press, 2015.

[5] Jonas Joerin and Rajib Shaw. Climate and disaster resilience in cities. 2015.

[6] CIUD UN Habitat et al. Comprehensive heritage settlement recovery plan of bungamati. 2019.

[7] Lalitpur Municipality. Annual municipal development plan. 2019.

[8] G. Choudhury H. K. Sarmah, B. Bora Hazarika. An investigation on effect of bias on determination of sample size on the basis of data related to the students of schools of guwahiti. *International Journal of Applied Mathematics & Statistical Sciences*, 2013.

[9] W. N. M. Wan Mohd Rani, K. H. Kamarudin, K. A. Razak, R. C. Hasan, and Z. Mohamad. Measuring urban resilience using climate disaster resilience index (cdri). *ISPRS International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII4/W9:237–242, 2018.

[10] Yukiko Takeuchi Jonas Joerin, Rajib Shaw and Iramasamy Krishnamurthy. Action-oriented resilienceassessmentofcommunities in chennai, india. *Program evaluation and organizational development, Florida cooperative extension service. Gainesville (FL): Institute of Food and Agricultural Sciences, University of Florida*, 2012.