CLIMATE DISASTER RESILIENCE: FOCUS ON COASTAL URBAN CITIES IN ASIA

RAJIB SHAW and IEDM Team*

International Environment and Disaster Management (IEDM) Laboratory,
Graduate School of Global Environmental Studies, Kyoto University,
Yoshida Honmachi, Sakyo-Ku, Kyoto 606-8501, Japan
shaw@global.mbox.media.kyoto-u.ac.jp

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Abstract

Recognizing the ever-increasing vulnerability of coastal urban cities in Asia due to climate change impacts and variability and also due to fast-growing urban development, this study focusing on climate disaster resilience is conducted in order to measure the existing level of climate disaster resilience of the targeted areas using a Climate Disaster Resilience Index. The index is developed based on five resilience-based dimensions: natural, physical, social, economic and institutional. The scope of this study is limited to climate-induced disasters, such as cyclone, flood, heat wave, drought and heavy rainfall induced landslide. For each individual city case, resilience information is presented as overall resilience, and separate physical, social, economic and institutional resilience. Higher values of resilience are equivalent to higher preparedness to cope with climate and disasters and inversely. Based on the results, policy points and recommendations are suggested by the authors and provide encouragement of city governments' engagements in specific cist services, institution and capacity building. Not only are outputs from this study useful for city governments, but they also provide valuable knowledge and information to other local and national stakeholders having a similar target: the enhancement of community resilience.

Keywords: Resilience; Urban; Disaster; Climate change, Coastal cities

1. Introduction

Asia is the epicenter of the current urbanization surge where some 1.1 billion people will move to cities in the next 20 years.[1,2] Its urban areas are experiencing ever increasing risk due to changing climate.[3] According to the United Nations Human Settlements Programme 2007, 'there is a constant pressure to keep pace with, if not lead, change in regional and global economic development. This, in turn, can be a force contributing to uncontrollable urban expansion and the generation of more vulnerability to disasters'.[4] Moreover, since Asia is the most disaster-prone region, the incidences of climate-induced disasters are also high compared to other regions. Past disaster trends suggests that high density population in Asian cities increases the mortality and the number of affected people in a typical disaster event, which in turn also result in increasing economic losses in the region. There is a serious concern that the targets of Millennium Development Goals may not be effectively achieved if disaster risk reduction is not prioritized in development planning in general and urban development in particular.

Moreover, climate change is occurring, accompanied by significant changes in precipitation, temperature, and changes in the frequency and intensity of some extreme events. These changes will affect natural and human systems independently or in combination with other determinants to alter the productivity, diversity and functions of many ecosystems and livelihoods around the world. Yet these impacts will not be

distributed or felt uniformly, as those 'with the least resources have the least capacity to adapt and are the most vulnerable'.[5]

Settlement on marginal or unstable land such as coastal areas, mountainous areas, river basin and urban slums heightens their exposure to the impacts of climate hazards. With limited capacities and resources at their disposal to respond to stresses such as droughts, floods, typhoons and rainfall-induced landslides, their ability to meet basic needs and improve their lives is constrained. Climate change impacts and variability, therefore, threaten to exacerbate existing vulnerabilities and further entrench development disparities.[6] Thus, there is a need to build a resilient community that would be efficiently capable to face climate change and associated disaster risk. For that, city governments need to be aware of current and future potential risk and take more initiative in order to enhance the resilience of the urban systems and communities.

Despite growing recognition of 'building resilient communities and enhancing adaptation to climate change', Asian urban communities are not yet receiving adequate attention. These climate change impacts will also affect their livelihoods, property, environmental quality and future prosperity since climate change is expected to alter the frequency, severity and complexity of climate-related hazards. Livelihood systems that do not have built-in buffering mechanisms are especially vulnerable.[7]

In most cities in developing countries, the size and vulnerability of informal settlements appear to greatly increase their susceptibility to risk. These are generally built in unstable areas such as coastal zones, flood-prone planes and ravines, and geologically unstable slopes.[8]

Many definitions of 'resilience' can be found in the literature. This study looks at different dimensions of resilience from the lens of urban communities and is mainly focused on three characteristics: (i) capacity to absorb stress or destructive forces through resistance or adaptation; (ii) capacity to manage or maintain certain basic functions and structures during disastrous events; and (iii) capacity to recover or 'bounce back' after an event.[9] In the attempt of building a resilient community, key questions that need to be answered are:

- How to enhance resilience of the community?
- What are the indicators that need to be addressed to be able to characterize and measure Climate Disaster Resilience?
- How can we create an effective index to assess the level of climate disaster resilience of a vulnerable urban community?

This study is an attempt to seek answers to these queries by focusing on coastal Asian urban cities. Therefore, the objective of this study is to measure the existing level of climate disaster resilience of the targeted areas using a Climate Disaster Resilience Index (hereafter CDRI) which is developed considering five resilience-based dimensions: natural, physical, social, economic and institutional. The whole process of CDRI is to make city managers and practitioners aware of the existing and future city risk for climate related disasters. The scope of this study is limited to climate-induced disasters (hydro-meteorological disasters), such as cyclone, flood, heat wave, drought and heavy rainfall induced landslide.

2. Rationale of the study

2.1. *Why Climate Disaster Resilience?*

It is predicted that the severity and frequency of climate change induced disasters will increase and those who have the least to cope with would be the most vulnerable. To date, little consensus exist among the developed nations regarding the reduction of greenhouse gases despite the ratification of Kyoto Protocol. Further, scientists also estimated that even if emission of all greenhouse gases stopped today, some degree of climate change would still occur and developing countries would have great sufferings.[10] Also it is said that mitigation is not cost-effective, especially for developing countries.[11] Therefore, developing countries have no alternative rather putting emphasis to adaptation which is found to be closely associated to community's resilience.[12]

2.2. *Why Coastal Urban Communities of Asia?*

Seven out of ten nations having largest urban population in the Low Elevation Coastal Zone (LECZ) are in Asia. Starting from largest these countries are China, India, Japan, Indonesia, Bangladesh, Viet Nam, and Thailand.[13] Among these seven countries except Japan all are still in the group of developing nations. Most of the explosive growth is occurring in developing countries of Asia where also about half of the urban population lives in slum areas (informal settlements).[3] These urban communities are more exposed to crime, forced evictions and natural hazards than the rich. They are more vulnerable to climate change and disasters because they often reside in sites prone to floods, landslides and pollution. In addition to the above group, many of the urban communities also have limited access to assets, thus limiting their ability to respond to hazards or to manage risk.[3] Therefore, focusing to these vulnerable urban communities and developing their climate disaster resilience should be treated as an emergency need.

2.3. *Why Hydro-metrological Disaster?*

The Intergovernmental Panel on Climate Change reported that the number of hydro-meteorological disasters has doubled in last five years whereas, geological hazards remain the same.[14] According to a recent report of UN-Habitat, there has been a 50 percent rise in extreme weather events associated with climate change from the 1950s to 1990s.[3] It is clear that since the majority of world's population will be residents of urban areas, these increased numbers of hydro-metrological disasters (such as flood, drought, cyclone, heat-wave, rainfall-induced landslides, etc.) would be a great threat to the lives and livelihood of a large population. In this context building resilience of the urban communities to these disasters as well as climate change is a foremost priority.

Clearly, valuable studies conducted to date have well described changing climatic hazards and emphasized the need to intervene at city-level. Recognition of climate change induced hydro-metrological disaster risk and exposure of Asian cities is of particular relevance to this study and forms the basis for calibrating intense city-community interventions aiming at reducing vulnerabilities and thus buttressing resilience of urban communities to climate disaster risk.

3. Methodology

In this Section, after a brief introduction of target cities, data collection as well as data processing and analysis are presented.

3.1. *Selection of target cities*

Nine cities were selected from different countries of Asia. Selection was done in a way to have representation of urban communities from large, medium and small cities. In this study, large, medium and small cities are referred to those having a population of less than one million, between one and five million and above 5 million inhabitants respectively. Therefore, the following cities (Table 1) are considered for this study.

3.2. *Data Collection*

As shown in previous sections, the climate disaster resilience of urban communities would be assessed from 5 different dimensions (natural, physical, social, economic, institutional). Each of these dimensions consists of a number of parameter and each parameter would have a number of complex variable and simple variables. These variables are in fact the indicators to assess the climate disaster resilience of urban community.

Table 1. Selected cities in the study

Name of the city	Country	Population[a]	Relative size of the city
1. Banda Aceh	Indonesia	219,659	Small size
2. Bangkok	Thailand	8,000,000[b]	Large size
3. Colombo	Sri Lanka	647,100	Small size
4. Danang	Vietnam	792,895	Small size
5. Hue	Vietnam	330,836	Small size
6. Iloilo	Philippines	403,196	Small size
7. Mumbai	India	13,000,000	Large size
8. City of San Fernando, La Union	Philippines	114,813	Small size
9. Yokohama	Japan	3,654,326	Medium size

[a]Source: questionnaire survey filled by city officials
[b]Night time population

Addressing all parameters and variables of the above dimensions, a data template was designed for data collection from each urban community (in each city). Questionnaire survey was the prime means of data collection. Secondary data was also collected to supplement collected data. The list of these variables is presented in the following section.

3.3. *Data Processing and Analysis*

Data collected from questionnaire surveys were computed in excel. To better describe Climate Disaster Resilience Index (CDRI), prime goal of this study, some weights were assigned. Aggregate Weighted Mean Index or AWMI (for each dimension) was calculated by using Weighted Mean Index (WMI) method. The calculated AWMI of one dimension is the CDRI of that dimension.

Initially, rating scale has been constructed and weight has been assigned subjectively based on how the city officials perceive the vulnerability of each variable by comparing them one by one. Each dimension (natural, physical, social, economic, institutional) correspond to various variables (Table 2) through which their respective scores are calculated.

Table 2. List of variables considered in CDRI five dimensions

Dimensions	Variable considered
1. Physical	Electricity, Water supply, Sanitation, Solid waste disposal, Internal road network, Housing and land use, Community assets, Warning system and evacuation
2. Social	Health status, Education and awareness, Social capital
3. Economic	Income, Employment, Households' assets, Access to financial service, Savings and insurance, Budget and subsidy
4. Institutional	Internal institutions and development plan, Effectiveness of internal institutions, External institutions and networks, Institutional collaboration and coordination
5. Natural	Hazard intensity, Hazard frequency

For example, under physical dimension of CDRI, there are eight variables including electricity, water supply, sanitation, solid waste disposal, internal road network, housing and land use, community assets, and warning system and evacuation. These variables were chosen to better describe the vulnerability in each city as far as natural, physical, social, economic, institutional dimensions of resilience (to hydrometeorological disasters) are concerned. Rating scales are given the numbers 1, 2, 3, 4 corresponding to very low, low, high and very high respectively. Therefore, WMI was calculated by summing the product of the weights (given by city officials) to the index of each variable (obtained from the sum of rating scales under any given variable divided by the

number of elements) and finally dividing the whole by the number of variables in each dimension. Overall CDRI values are obtained after averaging each of the five dimensions' resilience values.
It is important to note that the questionnaires were filled up by the city officials. The quality of results is very much dependent on the data quality, and proper understanding of the questionnaires. Needless to say, results presented in this paper are not absolute values, but are broad policy guidance and scope of improvements in selected sectors of the climate and disaster related problems in the respective cities.

For each city individual case, resilience information is presented as overall resilience (combination of all five dimensions), and separate physical, social, economic and institutional resilience. Overall resilience factor varies between 0 and 10. Physical, social and institutional all have a range between 0 to 4, and economic resilience between 0 and 6. Higher values of resilience are equivalent to higher preparedness to cope with climate and disasters and inversely. Policy points and recommendations are based on the results, and provide encouragement of city governments' engagements in specific cist services, institution and capacity building.

4. Results and Discussions

4.1. *Overall results*

Overall climate disaster resilience mapping (Fig. 1) shows higher values for Hue city and City of San Fernando, La Union (hereafter referred to as San Fernando). Both are ranged in the small size city classification. These results reflect higher preparedness to cope with climate and disasters in those cities as far as the five dimensions of CDRI are concerned (Fig. 2). However, individual city analysis revealed higher resilience of other cities such as Yokohama and Bangkok (medium and Large size cities respectively) in physical dimension, Colombo and Banda Aceh (both are small size cities) in natural dimension, Iloilo (small size city) in social dimension, Danang and Yokohama (small and medium size cities respectively) in economic dimension and finally Iloilo in institutional dimension. In general, results showed strength and weaknesses in one dimension or another. These results also show that the level of resilience was not found specifically different for various city sizes. Cities belonging to the same size experience different level of resilience, not only for overall CDRI but also for individual resilience dimensions (physical, natural, etc.).

Policy recommendations for each city were based on these inputs to encourage city governments, and other policy, decision makers to strengthen their engagements and orient their efforts in a way that current and future potential risks are considered and coped with in order to enhance the resilience of the urban systems and communities.

4.2. *Resilience analysis for each city*

In each of the nine cities analyzed in this study, a brief description of their resilience according to the five dimensions of CDRI is presented. Based on those results, policy recommendations for decision makers are suggested in order to assist these stakeholders in their efforts to enhance the resilience of their respective cities.

4.2.1. *Banda Aceh*

Analysis result for Banda Aceh

Although the city shows an overall high value in CDRI, various points need to be mentioned. In physical dimension, while other parameters seem to show a relatively promising level, warning system and evacuation and water supply appear to have lower scores. Tsunami recovery programs have helped in building stronger social capital, enhanced community and household assets and better employment opportunities. However weaker education and awareness and health status reduces the city's overall social dimension of resilience. Likewise, budget and subsidy as well as income source showed lower scores. Institutional dimension of resilience was handicapped by a lower internal institutions and development plan value. This illustrates the gaps in the incorporation of disaster risk and climate change into development plans. Finally, Banda Aceh's natural dimension of resilience was found higher compared to other cities'.

Policy recommendations for Banda Aceh

- Banda Aceh experienced tsunami and recovery process and has contributed significantly to the disaster risk reduction aspects. However, Banda Aceh's institutional and physical resilience have scope for further improvement along with more investment in risk reduction initiatives. There is a need to have additional focus on early warning and water supply system which would collectively improve the city's overall resilience.
- Dedicated budget and subsidies may be offered to boost investment in risk reduction activities and increase present level of household income.
- Education and awareness, as well as health status in general are dwindling the social dimension of resilience. The city needs to address root causes of the problem to reduce vulnerability and enhance awareness and health.
- Effective mainstreaming of risk reduction in governance and institutions is required which will lead to enhance economic resilience as well.

4.2.2. *Bangkok city*

Analysis result for Bangkok

Considering overall dimensions of resilience, Bangkok city appears to be quite exposed to hazards which could undermine the city's efforts to enhance resilience. Similar to the case of Banda Aceh, internal institutions and development plan – proxy for the incorporation of disaster risk and climate change into the city's development plan – was shown with less consideration. Early warning and evacuation system run down the overall physical dimension of resilience. Unlike the other elements of social dimension, community participation appeared to be slightly low. Access to financial services as well as less income source was among the fragile points as far as economic dimension of resilience is concerned

Policy recommendations for Bangkok

- Inputs for strengthening institutional capital and increasing budgetary incentives for disaster risk reduction is important to enhance resilience of Bangkok.

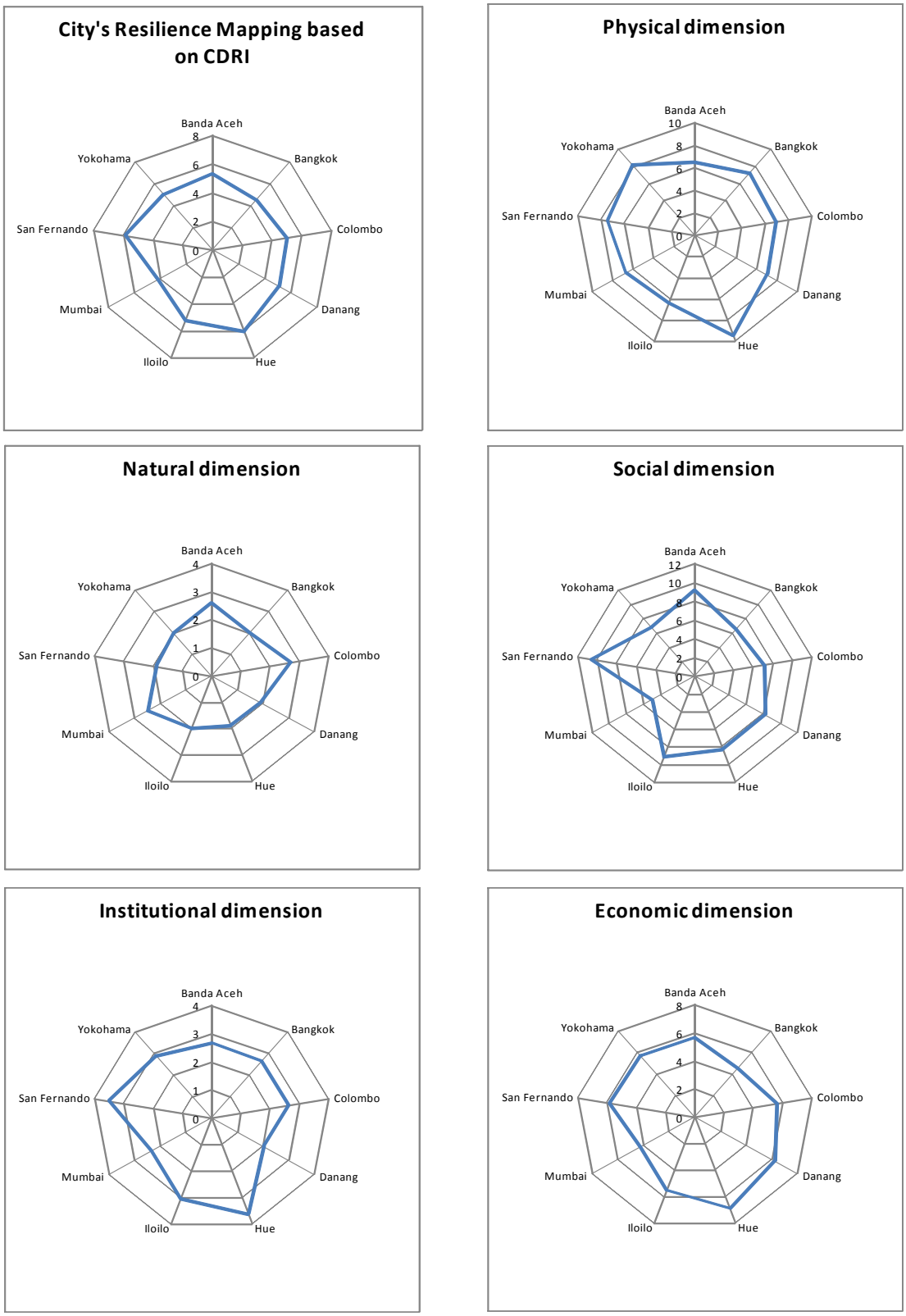

Fig. 1. Overall Resilience Mapping for the cities

- Significant efforts are underway to improve health status and education levels. However, additional focus through proactive community participation programs might help building city's social resilience.
- Disaster risk reduction mainstreaming with existing developmental activities and planning will be a major incentive that Bangkok needs to offer quickly. Similarly internal institutions may be further developed to take lead in this aspect.
- Widening insurance base for risk coverage and improvement of warning and evacuation system will play complimentary role in building physical and economic resilience of the city as a whole.
- Enhanced access to financial services could be linked with built-in risk reduction mechanism to complement resilience in different spheres.

4.2.3. *Colombo city*

Analysis result for Colombo

Colombo city shows the highest natural dimension of resilience as compared to other cities considered in this study. As for the physical dimension, warning and evacuation system, followed by solid waste disposal showed lower values compared to other variables. Also, community participation seems to be fragile in the city. While employment and household assets were well considered, savings and insurance, budget and subsidy and diversification of income source presented lower scores. Finally, the inclusion and consideration of risk and uncertainty was less reflected in the city's development plan.

Policy recommendations for Colombo

- Overall, Colombo's climate disaster resilience requires synergetic yet parallel attention to physical, social, economic and institutional dimensions.
- Institutional resilience needs considerable attention along with support from economic front i.e. diversified sources to raise incomes, budget and subsidy to risk reduction activities, and widening savings and insurance base.
- Municipal services especially water supply and solid waste management needs upheaval to ease stress in daily lives of the communities and enhance physical resilience.
- Warning and evacuation system needs an overhaul with corrective measures to built social capital through massive awareness across sectors and scales.

Resilience based development planning and effective involvement of multiple stakeholders will be an asset to strengthen the institutional resilience of Colombo.

4.2.4. *Danang city*

Analysis result for Danang

Physical dimension of resilience is threatened by the fragile warning systems and solid waste management. Similar case is observed for education and awareness in social dimension and income source, budget and subsidy in economic dimension. Institutional collaboration during disasters appears to be the fragile element for institutional dimension.

Policy recommendations for Danang

- Physical dimension of Danang's resilience calls for immediate improvement specifically in improving warning systems and solid waste management.
- Strong social capital need to be strategically complemented to enhance education and awareness and health status among masses.
- Budgetary provisions for risk reduction are skewed and would require the city to devote incremental share of developmental budget towards this.
- Savings and insurance are promising however, the city need to facilitate access to financial resources.
- Risk reduction is a development agenda for most organizations in Danang but better coordination is also needed for making resiliency concerns more effective.

4.2.5. *Hue city*

Analysis result for Hue

Hue city figures among the cities with the highest values for CDRI despite its fragile position with natural dimension of resilience. This strength may be due to a more pronounced social and institutional resilience. However, incorporation of disaster risk and uncertainty in developmental plans is may weaken the city's institutional resilience. Importantly, income source as well as budget and subsidy may trim down the stable employment, household assets, savings and insurance that are the strength of the economic dimension of resilience.

Policy recommendations for Hue

- Risk reduction should receive high priority in education to aware people as social dimension of resilience in Hue is going to alter overall resilience efforts in the city.
- Warning systems and evacuation has room for further improvement to address growing climate induced risks. Additionally, improvements in housing conditions and land use planning will certainly boost physical resilience.
- Employment rate is high but low income earning opportunities are a cause of concern and can be improved by entrepreneurial development by offering better access to financial services.
- Leveraging on high social capital, augmenting education opportunities, improving health status and making aware common people about impending risks can be initiated.
- Local institutions in Hue can resolve to mainstream disaster risk reduction into development plans and incentivize DRR activities through dovetailing budget and subsidy.

4.2.6. *Iloilo city*

Analysis result for Iloilo

In physical dimension, water supply and warning and evacuation system showed poorer scores and may threaten the enhancement of resilience of communities (Figure 2). A similar case is found with social capital in social resilience. In the case of economic dimension, budget and subsidy as well as savings and insurance both showed lower values indicating the fragility of this dimension. Finally, the inclusion and consideration of risk and uncertainty was less reflected in the city's development plan, thus lessening the institutional resilience of the city.

Policy recommendations for Iloilo

- Social capital of Iloilo needs specific impetus as it has great potential to influence the other dimensions of resilience.
- In general, basic services of the city (especially water supply, sanitation, solid waste management, internal access roads) calls for significant improvement by following participatory community based urban improvement techniques which would also benefit in building social cohesiveness.
- Low-income employment prevails in the city and climate-disaster resilient livelihood options can be generated by improving access to financial services and built-in insurance to safeguard development gains.
- Institutional collaboration can be more effective if networked well with external institutions by dovetailing risk reduction measures in development planning and implementation.
- Updated early warning systems availability with responsible institutions and ensuring effective penetration of warning in vulnerable locations during disasters may be treated as priority.

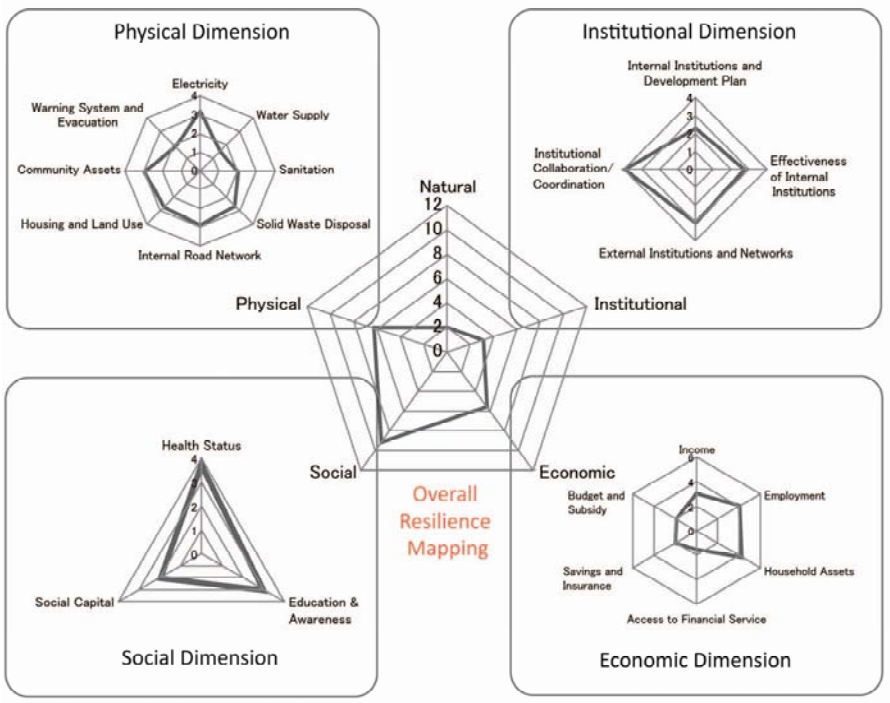

Fig. 2. Resilience mapping for Iloilo city

4.2.7. *Mumbai city*

Analysis result for Mumbai

Overall climate-disaster resilience is relatively low for Mumbai City. It was also the case of social dimension of resilience characterized by a dwindling social capital. Despite being renowned for its status of commercial, financial and entertainment capital of India, Mumbai city appears to lack of financial services, budget and subsidy as well as savings and insurance. Concerning physical dimension, early warning system and

evacuation, internal road network, solid waste disposal and water supply demonstrate the low extreme values which will have tremendous effect on the city's resilience. Similarly, aside from external institutions and networks, the city represents a fragile institutional dimension of resilience.

Policy recommendations for Mumbai

- Overall climate-disaster resilience of Mumbai is relatively low and calls for an urgent attention of stakeholders from and beyond the city. Sustained efforts are specifically needed to strengthen physical, social and institutional dimensions of resilience.
- Dismal picture of city-wide basic services is a major stumbling block on the road to physical resilience and solid waste management, water supply, internal roads, sanitation and warning mechanism requires immediate interventions for improvement.
- Recurring floods have already helped create awareness among common people. By capitalizing on this, civic societies and local government should focus on building social resilience.
- The city needs to leverage on existing reasonable level of income and employment opportunities for crafting savings and insurance mechanism for the urban poor the augment their economic resilience.
- Local institutions responsible for city development have good external network, but need to effectively address climate-disaster issues by wider and broader cooperation with other institutions and also by mainstreaming disaster risk reduction in the development agenda.

4.2.8. *City of San Fernando, La Union*

Analysis result for San Fernando

Early warning systems and evacuation procedures, sanitation, and solid waste disposal put the city at a hard position and may alter its efforts in enhancing resilience as far as physical dimension is concerned. Although granted with a well characterized social and institutional dimension, San Fernando shows a fragile natural and economic resilience. The latter is characterized by low budget and subsidy as well as savings and insurance.

Policy recommendations for San Fernando

- Overall, San-Fernando should benefit from its high social capital and institutional capacities to improve physical and economic dimensions of resilience.
- Early warning systems, evacuation procedures, sanitation, solid waste management and housing calls for sustained investment for fortifying physical resilience.
- Budget and subsidy on risk reduction, income levels of people and savings and insurance patterns - all affects economic resilience and requires improvement.
- Leveraging on existing high social capital, education and health status of the populace can be upgraded further.
- In order to get most out of present institutional strengths, 'climate-disaster resilience' should be accorded a development planning priority.

4.2.9. *Yokohama*

Analysis result for Yokohama

Physical dimension of resilience is relatively well equipped compared to other cities, with the exception of lower warning system and community assets. Less diversification of income, lack of budget and subsidy and access to financial service are the burden that may lessen economic dimension of resilience. Also, despite having stronger networks, the city exhibits less incorporation of disaster risk and uncertainty in development plans. This fact may alter the institutional dimension of resilience of the city.

Policy recommendations for Yokohama

- Being a port city from developed country, Yokohama needs to increase financial incentives for insuring lives and assets to climate induced disasters.
- Livelihood diversification to widen the employment base and income levels may be considered as probable options to promote economic resilience.
- Warning and evacuation system strengthening and community asset building are two prominent areas that require attention to addressing shortcomings in physical resilience.
- Developmental planning organizations of the city are although networked well, also needed better external linkages and placing disaster risk resilience at forefront.
- Innovative means of education and awareness tools will help in uplifting and renewing existing social capital and interest of well informed and literate communities of Yokohama.

5. Conclusions and Implications

Findings in this study showed that various types of vulnerability were found for each target city. Based on those differences, policy points and recommendations to be provided to city governments and other stakeholders also differ. However, overall recommendations are converging to one goal: the enhancement of community resilience in the face of climate related disasters.

This climate and disaster resilience initiative is in its development stage. Through the data collection and questionnaire analysis, city resilience mapping is conducted, which has different components of physical, social, economic, institutional and natural aspects. Based on these findings, policy suggestions were made.

As mentioned earlier, the data is mainly based on questionnaire survey. Where the questionnaires were incomplete, secondary sources and subjective observations were made. Needless to say, there are further scopes to improve the methodology and data collection process.

User feedback on the CDRI methodology is of utmost importance. The goal of the whole process of CDRI is to make city managers and practitioners aware of the existing and future city risk for climate related disasters. The policy suggestions should be linked to specific actions at the city and community level.

As implications of the present climate disaster resilience study, CDRI can be further developed in two specific ways:

- City based in-depth data collection, which can focus on the organization of small city level workshops to validate the data, and improve the methodology through mutual learning among the city professionals and researchers;
- To use CDRI in ward or neighborhood level. Since CDRI is non-scale, it can be used for a city, ward or neighborhood level. Ideally, it is desirable that CDRI be used in the neighborhood level, and through detailed data collection, the city should

be able to get a clear resilience map of its own, and identify the vulnerable areas as well as future potential areas.

References

1. ADB, *Managing Asian Cities: Sustainable and Inclusive Urban Solutions*. (Asian Development Bank, 2008)
2. The World Bank, *World Development Report 2009*. (The World Bank, 2008). Retrieved January 21, 2009 from http://www.worldbank.icebox.ingenta.com/content/wb/bk17607/
3. IDS, *Building Climate Change Resilient Cities*, IDS in Focus Issue 02.6 (2007). Available at www.ids.ac.uk
4. UN-Habitat, *Global Report on Human Settlements 2007, Enhancing Urban Safety and Security,* United Nations Human Settlements Programme (UN-Habitat), (Earthscan, London, 2007).
5. J. T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P. J. van der Linden, and D. Xiaosu (eds.), *Climate Change 2001: The Scientific Basis*, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press: 944, (Cambridge, 2001).
6. IISD, IUCN, SEI-B, Intercooperation [International Institute for Sustainable Development, IUCN–The World Conservation Union, Stockholm Environment Institute–Boston Center], *Livelihoods and Climate Change: Combining Disaster Risk Reduction, Natural Resource Management and Climate Change Adaptation in a New Approach to the Reduction of Vulnerability and Poverty*. (Winnipeg, Canada IISD, 2003). Also available at www.iisd.org/pdf/2003/natres_livelihoods_cc.pdf.
7. ADPC (Asian Disaster Preparedness Center), *Building Disaster Risk Reduction in Asia- A Way Forward ADPC Looks Ahead to 2015*. (Bangkok Thailand, 2004). www.adpc.net
8. A. Kreimer, M. Arnold and A. Carlin (eds.), *Building Safer Cities: the Future of Disaster Risk*, Disaster Risk Management Series, 299pp (The World Bank, Washington USA, 2003).
9. J. Twigg, *Characteristics of a Disaster-Resilient Community*; *a Guidance Note*, version 1 for field testing, for the DFID Disaster Risk Reduction Interagency Coordination Group (Benfield UCL Hazard Research Centre, 2007).
10. S. Huq, A. Rahman, M. Konate, Y. Sokona and H. Reid, *Mainstreaming Adaptation to Climate Change in the Least Developed Countries*. IIED (London, 2003).
11. IPCC, *Impacts, Adaptation & Vulnerability*, IPCC Working Group-II, IPCC 4th Assessment Report, (IPCC, 2007). Available at http://www/gtp89.dial.pipex.com/10.pdf
12. L. Briguglio, *The Vulnerability index and Small Island Developing States*. A Review of conceptual and methodologies issues. (University of Malta, 2003).
13. G. McGranahan, D. Balk and B. Anderson, *Environment and Urbanization* **19**, 1, 7 (2007)
14. IPCC, *Workshop on the Detection and Attribution of the Effects of Climate Change*. Working Group II Workshop Report. GISS (New York. USA, 2003).