MEASUREMENT OF LIVELIHOODS VULNERABILITY INDEX FOR THE COASTAL DISTRICTS OF BANGLADESH

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Acronyms

BIDS	Bangladesh Institute of Development Studies
IPCC	International Panel on Climate Change
LVI	Livelihood Vulnerability Index
NDCV	Natural Disaster and Climate Variability
NGO	Non-Government Organisation
PDO-ICZMP	Program Development Office for Integrated Coastal Zone Management Plan
REF	Research Endowment Fund

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FOREWORD

This research study was funded by the BIDS Research Endowment Fund (REF) which provides a window for the BIDS researchers to conduct policy oriented research on priority development challenges facing Bangladesh.

In 2009, BIDS received Tk. 200 million from the government to create the REF to carry out policy research at the Institute. The creation of BIDS-REF has significantly enhanced our scope of conducting institutional research. Under the BIDS-REF, several research studies have been initiated with the expectation that this will enable the researchers to bring their knowledge into the mainstream of development research and evidence-based policy making in the country through conducting policy relevant works.

These research studies are included in the Annual Research Programmes (ARPs) of BIDS which are prepared every year through a rigorous and participatory process in consultation with the government, civil society, private sector and other concerned stakeholders. As such, several of these studies are undertaken in response to emerging challenges and/or at the request of the government and other agencies.

This is for the first time that BIDS is publishing the BIDS-REF study reports as a part of its commitment to establishing transparency and accountability to its stakeholders including fellow researchers and policymakers who are working towards promoting evidence based policies in Bangladesh. I hope the study report will be useful to all stakeholders concerned with the theory and practice of development in general and of Bangladesh in particular.

I would like to express my deep appreciation to all my colleagues in BIDS who have cooperated and contributed to the preparation and publication of these research studies. I would also like to express my deep gratitude to the Hon'ble Minister of Planning and Chairman of BIDS Board of Trustees and its distinguished members who are providing continuous guidance and support to BIDS in the effort to further concretising its long term vision of being part of a process that places BIDS firmly on the level of engagement in furthering better research and better policy leading to better Bangladesh.

April 2013

Mustafa K. Mujeri
Director General

ABSTRACT

The wider impacts of climate change (e.g., frequent and severe tropical cyclones, heavier and more erratic rainfall) on resource systems and environment are generally known. What is not well understood is how these changes affect livelihoods. To address this and related concerns, vulnerability assessment is required that will help understand the complex set of factors that contribute to adaptive capacity of the households.

Hahn *et al.* (2009) has developed a Livelihood Vulnerability Index (LVI) as a tool for vulnerability assessment. This paper uses and extends this index to measure the vulnerability of the households living in the coastal region of Bangladesh. While this index is effective for understanding regional variations in vulnerability, it does not extend the analysis to other dimensions that are crucial for policy making. For example, in a given region,

- Are rural households more vulnerable to climate change as compared to the urban households?
- Are households living close to the coast more vulnerable than those living away from the coast?
- Are households more vulnerable to floods than to cyclones?
- What are the factors that may explain these differences?

Based on the findings from a survey of 532 households from 12 coastal districts, we have found that households living in the rural areas are more vulnerable than those living in urban areas and households living in coastal districts are more vulnerable than those living in exterior districts. Finally, households affected by cyclones are more vulnerable than those affected by floods. The following factors explain this.

The higher vulnerability of coastal households stems from poor access to health facilities, a weaker social network as well as from natural disasters and climate variability.

The higher vulnerability of rural households is also explained by poor health factors, such as lack of access to sanitary toilets. The rural households also have adverse social and demographic profile (adverse sex ratio, dependency ratios, and so on). They also have a weaker social network which may be explained by relative remoteness of the rural areas in coastal regions of Bangladesh. The rural households are found to be more vulnerable than their urban counterparts from natural disaster and climate variability. The rural households also have difficulty in accessing reliable drinking water.

Weaker social network, unsafe drinking water, etc. explain a higher vulnerability from cyclones as compared to floods.

CHAPTER 1
INTRODUCTION

Bangladesh is widely recognised as one of the most climate vulnerable countries in the world. It experiences frequent natural disasters that cause loss of life, damage to infrastructures and economic assets, and adversely impact on lives and livelihoods, especially of poor and marginal households.

The coastal zone of Bangladesh has an area covering 47,211 km² facing the Bay of Bengal or having proximity to the Bay (Map 1.1). In the last 200 years at least 70 major cyclones hit the coastal belt of Bangladesh and during the last 35 years nearly 900,000 people died due to catastrophic cyclones (PDO-ICZMP 2004).

Climate change will continue to exacerbate many of the current problems and natural hazards the country faces. It is expected to result in:

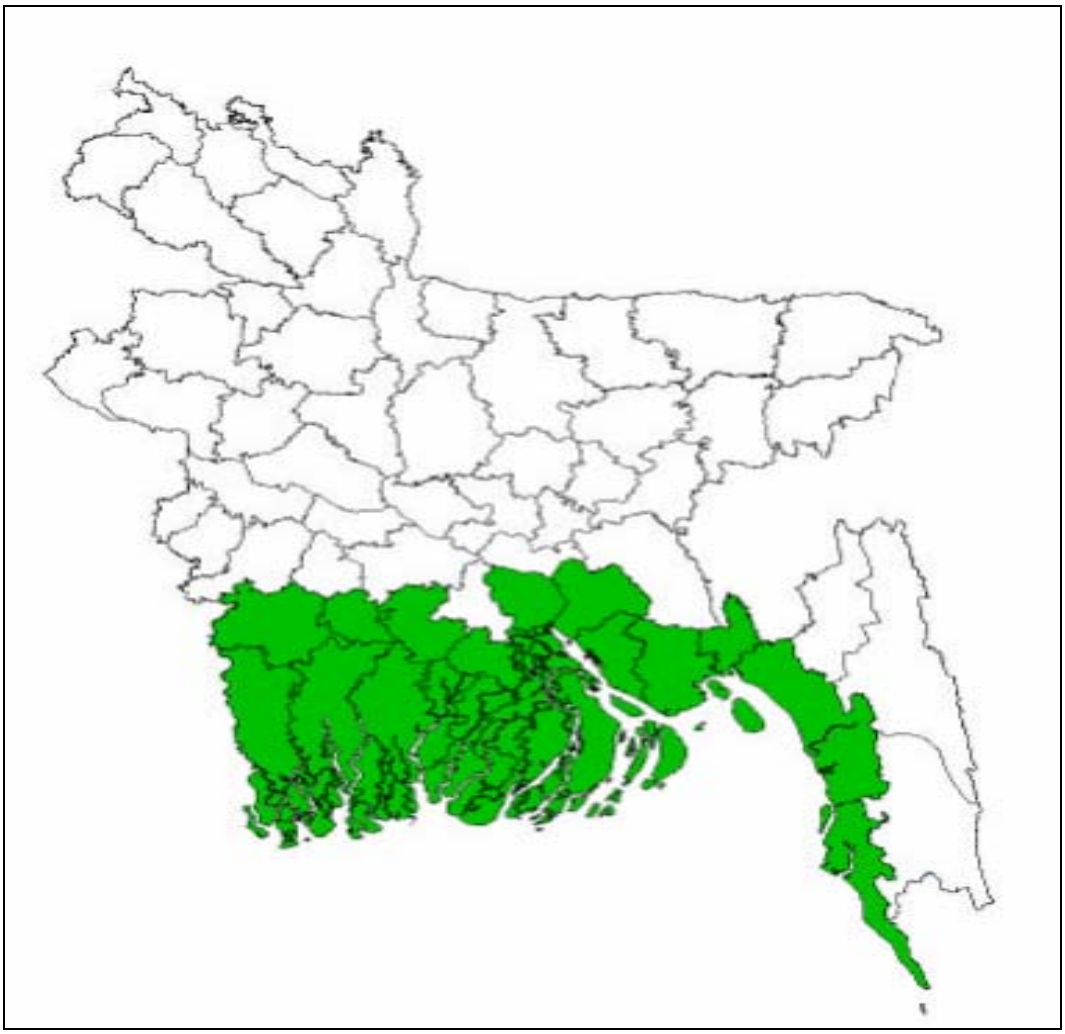
- increasingly frequent and severe tropical cyclones, with higher wind speeds and storm surges leading to more damage in the coastal region;
- heavier and more erratic rainfall in the Ganges-Brahmaputra-Meghna system, including Bangladesh, during the monsoon resulting in:
  - higher river flows, causing over-topping and breaching of embankments and widespread flooding in rural and urban areas,
  - river bank erosion, resulting in loss of homes and agricultural land to the rivers;
  - increased sedimentation in riverbeds, leading to drainage congestion and water-logging;
- melting of the Himalayan glaciers, leading to higher river flows in the warmer months of the year, followed by lower river flows and increased saline intrusion after the glaciers have shrunk or disappeared;
- lower and more erratic rainfall, resulting in increasing droughts, especially in drier northern and western regions of the country;
- sea level rise, leading to submergence of low-lying coastal areas and saline water intrusion up along coastal rivers and into groundwater aquifers: reducing freshwater availability; damage to the Sundarbans mangrove forest, a World Heritage site with rich biodiversity; and drainage congestion inside coastal polders, which will adversely affect agriculture;
- warmer and more humid weather, leading to increased prevalence of disease.

These are wider impacts of climate change on resource systems and environment but the ultimate impact that matters most is on the livelihoods of the people. The crucial issue here is, how do they affect livelihoods? To address this and related concerns,

vulnerability assessment is required that will help understand the complex set of factors that contribute to adaptive capacity of the households. Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine interactions between humans and their physical and social surroundings. Hahn, Riederer and Foster (2009) have developed Livelihood Vulnerability Index (LVI) as a tool for vulnerability assessment.

The approach used by Hahn *et al*. (2009) has several advantages over the past efforts. First, it uses primary data from household surveys to construct the index. This helps to avoid the pitfalls associated with using secondary data. Second, it presents a framework for grouping and aggregating indicators at the regional level. Third, it does not depend on climate models and misses livelihoods complexity at the local level.

Map 1.1: The Coastal Zone of Bangladesh



However, Hahn *et al.* (2009) do not go beyond broader regional level, although they mention of vulnerability differences across several dimensions. Kasperson and Kasperson (2001) show that climate change stressors can disproportionately affect the poor, elderly or marginal households. The extent of poverty is higher in the coastal region (PDO-ICZMP 2003). Besides, there is an additional burden of poverty and vulnerability in coastal areas of Bangladesh (Sen and Yunus 2011). Dependence on agriculture based livelihoods can increase vulnerability of the households who do not diversify (Fields 2005). This analysis can be easily extended to other dimensions. For example, within a region one may expect different vulnerabilities for those living in the urban areas and those living in the rural areas.

We use and extend the scope of this index to measure and explain the vulnerability of the households living in the coastal region of Bangladesh covering three dimensions: rural-urban vulnerability, coastal-interior vulnerability and disaster related vulnerability (flood and cyclones).

1.1 Research Questions

The field of climate vulnerability assessment has emerged to address the need to quantify how communities will adapt to changing environmental conditions. Many of these methods rely heavily on the IPCC working definition of vulnerability as a function of exposure, sensitivity, and adaptive capacity (IPCC 2001).

The LVI uses multiple indicators to assess exposure to natural disasters and climate variability, social and economic characteristics of households that affect their adaptive capacity, and current health, food and water resource characteristics that determine their sensitivity to climate change impacts. These multiple indicators can also be used to estimate vulnerability as defined by IPCC 2001. This approach differs from previous methods in that it uses primary data from household surveys to construct the index.

While this approach is good for understanding regional variation in vulnerability, it does not extend the analysis to other dimensions that are crucial for policy making. For example,

Are rural households more vulnerable to climate change as compared to the urban households?

Are households living close to the coast more vulnerable than those living away from the coast?

Are households more vulnerable to floods than to cyclones?

CHAPTER 2
METHODOLOGY AND DATA

The original data was collected for making a coastal economic risk assessment of the livelihoods due to tsunami/storm surge events. For this purpose, at the first stage, 12 coastal districts were selected. In the second stage, as many as 18 upazilas were selected from these districts (Table 2.1). These upazilas were selected on the basis of their proximity to the coast of the Bay of Bengal. In the third stage, as many as 36 union parishads/paurashavas were selected. As such, the selection process in the first and third stages was purposive. Finally, as many as 532 households were selected with average of 15 households from each union parishad/paurashava. The household questionnaire was designed in a manner to extract information about socioeconomic characteristics of a household, level of exposure to risks and the experience they had on the catastrophic impact of last disaster on their lives and livelihood and how they cope with the disaster. As such, the data is not collected for measuring vulnerability. However, the information contained in the questionnaire can still be used for measuring livelihoods vulnerability index.

Based on available information in the dataset, we used several indicators to assess vulnerability. The following major components are used: *socio-demographic profile*, *livelihood strategies*, *social networks*, *health*, *food*, *water*, and *natural disasters and climate variability*. Each component has several sub-components. These sub-components are selected on the basis of their relevance to contribution to each major component. Obviously, if we had information on some other aspects, the richness of the sub-components could have been easily improved. For example, we could not use rainfall and temperature data because we did not have these data at a disaggregate level that would have been appropriate to capture climate change effects. On the other hand, we had several indicators dealing with losses and damages incurred by the surveyed households from natural disasters. These information are not readily available from secondary sources and at a disaggregate level.

Table 2.1
Spatial Distribution of the Sample Households

Districts	Upazila	Union Parishad/Paurashava
Bagerhat	Sharankhola	Dakshinkhali (15)
		Royenda (15)
Barguna	Amtali	Amtali Sadar (15)
		Haldia (13)
	Patharghata	Patharghata Sadar (15)
		Kalmegha (15)
	Char Fashion	Char Kalmi (15)
Bhola		Char Manika (14)
	Tazumuddin	Chandpur (15)
		Chanchra (15)
Chittagong	Banshkhali	Katharia (15)
		Saral (14)
	Port Thana	Paurashava (Two Wards) (29)
	Sitakunda	Barabkunda (15)
		Muradpur (15)
Cox's Bazar	Cox's Bazar Sadar	Khurushkul (15)
		Chaufaldandi (15)
	Maheshkhali	Dhalghata (14)
		Kutubjhum (15)
	Sonagazi	Sonagazi Sadar (14)
Feni		Char Chandia (15)
	Dakope	Banishanta (15)
Khulna		Sutarkhali (15)
	Ramgati	Char Ramiz (15)
Laxhmipur		Char Alexander (15)
	Companyganj	Char Fakira (15)
Noakhali		Char Kakra (15)
Patuakhali	Dashmina	Dashmina (15)
		Banshbaria (15)
	Kala Para	Khaprabhanga (15)
		Lata Chapli (15)
Pirojpur	Mathbaria	Tushkhali (15)
		Bara Machhua (15)
Satkhira	Shyamnagar	Buri Goalini (14)
		Atulia (15)
Total		432

Note: Size of the sample in each union parishad/paurashava is in the parentheses.

CHAPTER 3
LIVELIHOODS VULNERABILITY INDEX (LVI)

LVI here includes seven major components: Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water, Natural Disasters and Climate Variability. Each is comprised of several indicators or sub-components, as shown in Table 4.1. This explains how each sub-component was quantified, survey questions used and original source of the survey question. To calculate the LVI, we used a balanced weighted average approach where each sub-component contributes equally to the overall index though each major component is comprised of a different number of sub-components. As each sub-component was measured on a different scale, we first standardized each as an index using the following equation:

$$Index_X = \frac{X - X_{\min}}{X_{\max} - X_{\min}} \quad (1)$$

X is the original sub-component, $X_{\min}$ and $X_{\max}$ are the minimum and maximum values, respectively, for each sub-component. For example, the value of the sub-component "number of natural disasters during the last 20 years" ranged from 1 to 25. These minimum and maximum values were then used to transform this indicator into a standardized index to integrate it into the major component "Natural Disaster and Climate Variability." For variables that measure frequencies such as the "per cent of female headed households," the minimum value is set at 0 and the maximum at 100. Sub-components like "average agricultural livelihood diversity index" are created because an increase in the crude indicator, i.e. the number of agricultural livelihood activities undertaken by a household in this case, is assumed to decrease vulnerability. This means that a household who produces rice in the fields and culture fish in the ponds is less vulnerable than a household who only produces rice. We have taken an inverse of this number (1/ (1+1+1) =0.33. Note that 1 is added to the denominator to avoid indeterminate ratios for households who do not pursue any agricultural livelihoods. The inversion generates a number that assigns higher values to households who pursue a lower number of agricultural livelihoods.

A number is then created by taking inverse of the crude indicator, which assigns higher values to households with a lower number of livelihood activities. After all the sub-components are indexed, the sub-components had been averaged to calculate the value of each major component as shown in equation 2:

$$MC = \frac{\sum_{i=1}^{n} Index_{Y_i}}{n} \quad (2)$$

where MC is one of the seven major components [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W), or Natural Disaster and Climate Variability (NDC)], index Y_i represents the sub-components, indexed by i, that make up each major component, and n is the number of sub-components in each major component. For example, if we want to calculate for the major component 'SDP', it would be:

SDP= (Percentage of female members in the household + dependency ratio + average education of a household + average age of household heads) / 4

Once values for each of the seven major components were calculated, they were averaged using Eq. (3) to obtain the LVI:

$$LVI = \frac{\sum_{i=1}^{n} W_{mi} M_i}{\sum_{i=1}^{n} W_{mi}} \quad (3)$$

It can also be expressed as:

$$LVI = \frac{W_{SDP}SDP + W_{LS}LS + W_{SN}SN + W_H H + W_F F + W_W W + W_{NDC}NDC}{W_{SDP} + W_{LS} + W_{SN} + W_H + W_F + W_w + W_{NDC}NDC} \quad (4)$$

LVI is the Livelihood Vulnerability Index, equals the weighted average of the seven major components. W_{mi}, or weights of each of the major components are determined by the number of sub-components that make up each major component. For example, SDP has four sub-components, so W_{SDP} will be 4. Weights are included so that all sub-components contribute equally to the overall LVI. In this paper, the LVI is scaled from 0 (least vulnerable) to 0.5 (most vulnerable).

One major limitation of this method is the use of equal weights. Not only the sub-components but also the major components are weighted equally. Eakin and Bojorquez-Tapia (2008) use a fuzzy logic method for deriving unequal weights on the factors. Vincent (2007), on the other hand, suggested use of expert opinions in determining the weights.

As pointed out by Vincent (2007), the indicators (major and sub-components) oversimplify a complex reality and there is inherently no straightforward way to validate indices comprised of disparate indicators. Also, as the sub-components are averaged into one major component score, the indexing approach does not incorporate variance between study populations. The selection of sub-components and the assignment of directionality from less to more vulnerable involve normative judgment.

CHAPTER 4

MAJOR COMPONENTS AND SUB-COMPONENTS COMPRISING THE LIVELIHOOD VULNERABILITY INDEX (LVI)

In this study we have considered seven major components: social and demographic profile or SDP, livelihoods strategy or LS, social network or SN, health (H), food (F), water (W), and natural disaster and climate variability (NDCV). Each major component has several sub-components, as shown in Table 4.1. The number in parenthesis indicates the number of sub-components that belong to the respective major component. For example, the major component social and demographic profile or SDP has four sub-components and each of the sub-components is described in subsequent columns.

Table 4.1
Major Components and Sub-components Comprising the Livelihood Vulnerability Index (LVI)

Major Components	Sub-Components	Explanation of Sub-Components	Survey Question	Relationship/ Explanation
1. Social and Demographic Profile, SDP (4)	1.1.Dependency ratio	Ratio of the population under 15 and over 65 years of age to the population over 15 and below 65 years of age	Information collected from household roster on age of each member	Positive (Higher dependency ratio increases vulnerability)
	1.2. Per cent of female members in households	Percentage of female members to total members in the household	Information collected from household roster on sex of each member	Positive (Higher proportion of female members increases vulnerability)
	1.3. Average education of the head of the household	Percentage of households where the heads of household report that they have attended zero years of formal schooling	Information collected from household roster on the level of education of each member, including the head of the household	Positive (More illiterate head of the households increase vulnerability)
	1.4. Average age of household heads	Average age of head of households	Household roster collected information on age of each member, including the head of the household	Positive
2. Livelihood Strategies, LS (5)	2.1. Agricul-tural livelihood diversification index	The inverse of the number of agricultural livelihood activities +1 reported by a household. For example, a household that cultivates rice, vegetables and has aquaculture in pond will have a livelihood diversification index = 1/ (3 + 1) = 0.25.	What are the crops that you cultivate? How much land do you devote in each crop and aquaculture?	Positive (More agricultural livelihoods reduce vulnerability but here an inverse is considered)

Major Components	Sub-Components	Explanation of Sub-Components	Survey Question	Relationship/ Explanation
	2.2. Natural resource and livestock index	The inverse of the number of natural resource and livestock ownership+1 reported by a household. For example, a household that has livestock, poultry and tree will have a natural resource and livestock index = 1/ (3 + 1) = 0.25	What are the different livestock or natural resources that you own? What are they? How many?	Positive (More natural and livestock resources reduce vulnerability but here an inverse is considered)
	2.3. Percentage of agricultural livelihoods	Percentage of agricultural livelihoods undertaken by a household compared to its total number of livelihoods	What is your occupation? What are the occupations of your family members?	Inverse (Non-agricultural livelihoods have higher incomes)
	2.4. Agricul-tural and fishing equipment value index	Inverse of value of total fishing and agricultural equipment owned by a household + 1	The household stated the number of such equipment owned and their unit price	Positive (More agricultural and fishing assets reduce vulnerability but here an inverse is considered)
	2.5. Transpor-tation assets value index	Inverse of the value of total transportation equipment of households+ 1. Transport equipment includes rickshaws, vans and so on	The household stated the number of transport equipment owned and their unit price	Positive (More transportation assets reduce vulnerability but here an inverse is considered)
3. Social Network, SN (3)	3.1. Availabi-lity of amenities	Inverse of the total number of types of amenity available. For example, if the village has primary school and primary health care centre, amenity= 1/ {1+ (1+1) =0.33	Do you have primary school, high/junior school, primary health care, doctor's chamber, cyclone shelter, general hospital, bazar, fire services in your village?	Positive (More amenities reduce vulnerability but here an inverse is considered)
	3.2. Sources of assistance received	Inverse of the sources of assistance that the household received from government agencies/NGOs/financial institutions+1	Did any of the following institutions help you after the natural disaster?	Positive (More sources of assistance reduce vulnerability but here an inverse is considered)
	3.3. Total assistance received	Inverse of the total number of type of assistance received plus 1	This considers the loans received from NGOs, other assistance received from NGOs and so on	Positive (More assistance reduces vulnerability but here an inverse is considered)
4. Health, H (2)	4.1 Access to sanitary latrine	Percentage of households without a sanitary latrine	What is the type of latrine you use? The response “no latrine” is reckoned here	Positive (Higher the proportion of households without access to sanitary latrines, higher is the vulnerability)
	4.2. Total person days of injury in the households	Number of days someone in the household is injured	What is the duration of illness due to injury in days?	Positive (Higher the duration of illness due to injury/sickness, higher is the vulnerability)

Major Components	Sub-Components	Explanation of Sub-Components	Survey Question	Relationship/ Explanation
5. Food, F (3)	5.1. Number of months with adequate food supply	Number of months a household had adequate food supply through production and purchase	How many months on average was it possible to provide sufficient food to family members?	Inverse (Higher food security results in lower vulnerability)
	5.2. Number of months with adequate food supply from own production	Number of months a household had adequate food supply through production only	How many months on average was it possible to provide sufficient food to family members from own production?	Inverse (Higher food security results in lower vulnerability)
	5.3. Extent of crop damage	Value of crops damaged due to natural disaster	What are the amounts of crop damaged? What are the prices per unit of the crops?	Positive (Higher the extent of crop damage, higher is the vulnerability)
6. Water, W (4)	6.1. Unsafe source of drinking water	Whether the household has access to safe drinking water. Sources of water such as from pond, water-tank or river/canal/marshland etc. are considered unsafe.	What is the source of your drinking water? Several choices are given which are classified as safe (tap, tube-well, etc.) and unsafe (pond, river, etc.)	Positive (So higher percentage of households drinking unsafe water implies higher vulnerability.)
	6.2. Distance to source of natural water	Self Explanatory	What is the distance (in km) of source of drinking water from your home?	Positive (Longer the distance, the higher is the vulnerability)
	6.3. Whether experienced scarcity of water	Self Explanatory	Is the water supply from the source you use adequate?	Inverse (More adequate source of water supply reduces vulnerability)
	6.4. Whether the household spent money to get water	Amount of money spent on getting water	Did you spend any money on drinking water in the last 12 months? If Yes, how much?	Positive (Higher the amount of money spent on getting water, higher is the vulnerability)
7. Natural Disaster and Climate Variability, NDCV (9)	7.1. Number of natural disasters during the last 20 years	Natural disasters include, among others, flood, draught, cyclone, surge, etc.	How many natural disasters occurred in your village during the past 20 years?	Positive (Higher the incidence of natural disasters, higher is the vulnerability)
	7.2. Number of times affected by disaster	Total number of times the household is affected by natural disasters in the past 20 years	In the past 20 years, how many times have you been affected by natural disasters?	Positive (A household more affected by disaster is more vulnerable)
	7.3. Value of crops damaged	Value of the crops damaged due to natural disaster	Was any crop damaged due to natural disasters?	Positive (Higher the value of crops damaged, more vulnerable is the household)
	7.4. Value of pond fish damaged	Value of the fishes in pond damaged due to natural disaster	Was there any damage of pond fishes due to natural disasters?	Positive (Higher the value of fishes in pond damaged, more vulnerable is the household)

Major Components	Sub-Components	Explanation of Sub-Components	Survey Question	Relationship/ Explanation
	7.5. Value of livestock damaged	Value of the livestock damaged due to natural disaster	Was there any damage to livestock due to natural disasters?	Positive (Higher the value of heads of livestock damaged, more vulnerable is the household)
	7.6. Value for damaged agricultural equipment	Value of cultivation machineries and equipment damaged due to natural disaster	Was there any damage of equipment due to natural disasters?	Positive (Higher the value of cultivation machineries and equipment damaged, more vulnerable is the household)
	7.7. Value for damaged fishing equipment	Value of fishing machineries and equipment damaged due to natural disaster	Was there any damage of equipment due to natural disasters?	Positive (Higher the value of fishing machineries and equipment damaged, more vulnerable is the household)
	7.8. Value for damaged household items	Value of the household items damaged due to natural disaster	Was any household items damaged due to natural disasters? Amount of damage in numbers?	Positive (Higher the value of household items damaged, more vulnerable is the household)
	7.9. Indicator of vulnerable house	Indicates how vulnerable a house is to natural disasters. Inverse of (strong walls+ strong roof + strong floor+1). For example, if a house consists of strong walls, weak roof and strong floor, the value will be {1/ (1+0+1+1)} = 0.33.	What is the wall of your house made of? What is the roof of your house made of? What is the floor of your house made of?	Positive (A stronger house reduces vulnerability but here an inverse is considered)

CHAPTER 5
RESULTS AND ANALYSIS

As already mentioned, the main purpose of this study is to measure LVI of the selected coastal districts in Bangladesh. We would also like to see whether LVI varies by coastal and interior regions or by rural and urban locations or by the type of natural disasters (flood and cyclone). Estimates of the major components and the sub-components are provided in Table 5.1.

5.1 Coastal and Interior Vulnerability

Are households living close to the coast more vulnerable than those living away from the coast? If so, why? What are the factors that may make a household living in the coastal areas more vulnerable to a household living in an interior area?

LVI estimates show that the households living more close to the coast are more vulnerable than those living away from the coast. The LVI for households living close to the coast is 0.348 as against 0.324 for those living in the interior.

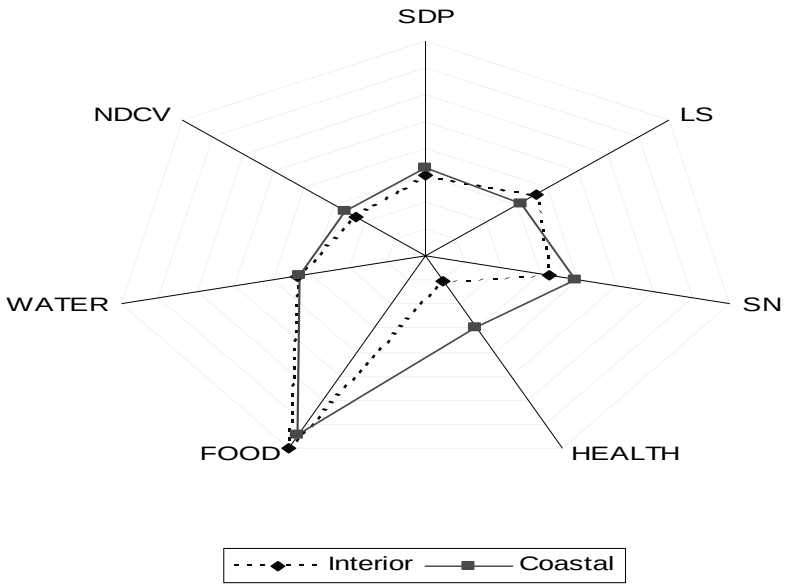
The crucial issue here is the health factors. It is the lack of access to sanitary latrines that makes the households more vulnerable in the coastal areas. Note that the households living in the interior are slightly more vulnerable to injury but it is the sanitary condition of the toilets that makes health conditions worse in the coastal region.

The households in the coastal areas also have weaker social networks. These are reflected in the number of amenities such as the number of primary, junior and high schools, primary health care facilities, doctor's chambers, cyclone shelters, general hospitals, bazaars, fire services, etc. available to the households. These amenities are less available in the coastal region as compared to the interior. The coastal households also received assistance from fewer sources. Government organisations, non-government organisations (NGOs) or the banks did not provide enough assistance to them.

The households in the coastal areas are found to be more vulnerable to natural disasters and climate variability factors. For example, they faced more disasters in the last 20 years, they were more affected by these disasters, and the extent of damage to crops was higher. The extent of damage to livestock, household items were high. On the other hand, they live in more vulnerable houses.

The relative contribution of the major components is shown in the spider diagram (Figure 5.1). The diagram depicts differential vulnerability between the households living in interior and coastal regions.

Figure: 5.1 Vulnerability Spider Diagram of the LVI for Interior and Coastal Regions



5.2 Urban and Rural Vulnerability

Are rural households more vulnerable to climate change as compared to the urban households? What factors explain the difference?

The LVI for the rural households has been estimated at .337 as compared to .324 for the households living in urban areas. Thus our estimates of LVIs suggest that a household living in the rural areas is more vulnerable than a household living in urban areas. We will now analyse the factors that explain this difference.

The key factor here is the health services available to urban and rural households. The rural households are more vulnerable than the urban households due to higher prevalence of unhygienic toilets. Also, the members of rural households have more injuries to natural disasters.

The rural households are also vulnerable because of adverse social and demographic profile. The rural households have more female members in the households; dependency ratio is also higher. Urban household heads have more years of schooling. The average age of the urban household heads is also lower.

The rural households have been found to have a weaker social network. This may be explained by relative remoteness in the rural areas of the coastal regions of Bangladesh. Although the rural households are better positioned in terms of the number of sources of

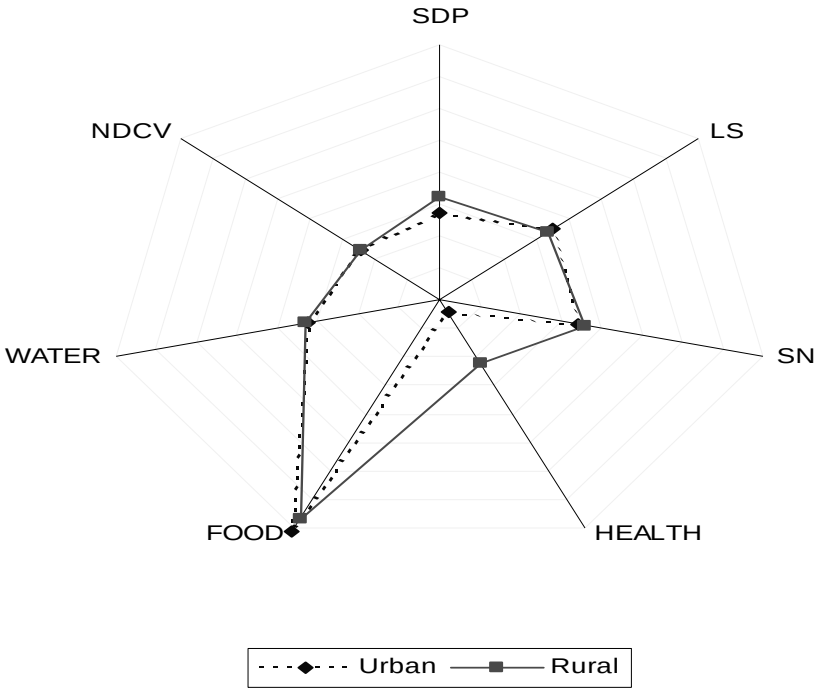
assistance received and also in terms of total assistance received, they are worse off in terms of availability of amenities such as the number of schools, health care, etc. These amenities are available more to the households living in the urban areas.

The rural households are also more vulnerable than their urban counterparts from natural disaster and climate variability. While in some respects the urban households are more vulnerable (number of disaster, damaged household assets and fishes in ponds), in others it is the other way round (crops, livestock, fishing equipment damaged). The crucial factor here is the weaker housing structures in the rural areas. The houses are not as strong as urban houses and this increases vulnerability.

Rural households are more vulnerable in terms of better source of drinking water. A larger percentage of households in the rural areas reported that they depend on unsafe source of drinking water such as ponds or river.

The relative contribution of the major components is shown in the spider diagram (Figure 5.2). The contrast in vulnerabilities in urban and rural regions is also depicted.

Figure 5.2 Vulnerability Spider Diagram of the LVI for Urban and Rural Regions



5.3 Vulnerability from Floods and Cyclones

Are households more vulnerable to floods than to cyclones? If so, what key factors explain these differential vulnerabilities?

LVI calculated for the cyclones (.339) is found to be higher than the LVI calculated for floods (.320).

Social networks do not work well during cyclones as compared to floods. Vulnerabilities from all the sub-components of the major component social network are found to be higher for cyclones as compared to floods.

Water is also a crucial factor. Safe source of drinking water becomes more problematic during cyclones as compared to floods. Besides, there is more scarcity of drinking water during cyclones. More households have to pay for water during cyclones as compared to during floods.

The relative contribution of the major components is shown in the spider diagram (Figure 5.3). It shows the major components that explain the difference in vulnerability of the households under flood and cyclone situations.

Figure: 5.3 Vulnerability Spider Diagram of LVI from Flood and Cyclone

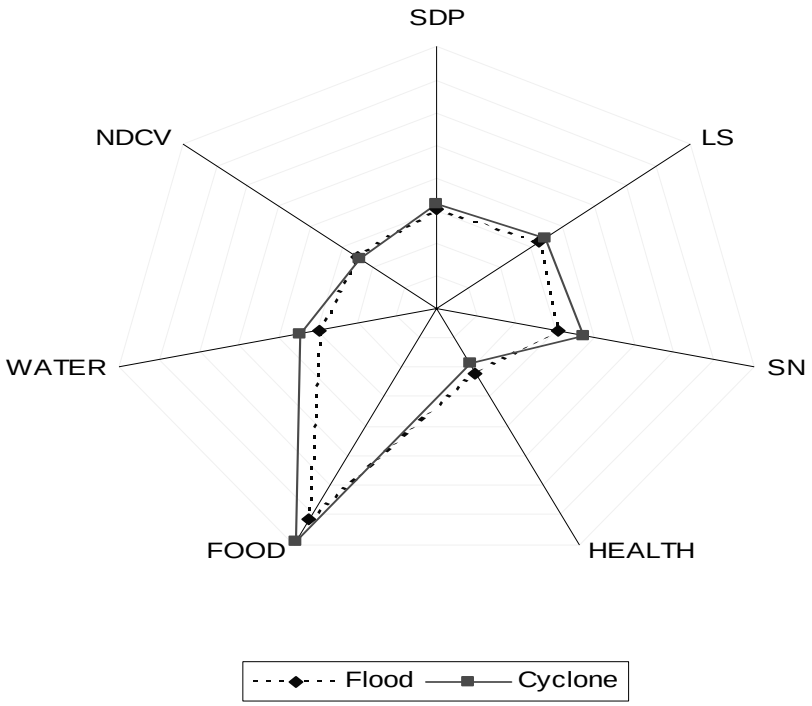


Table 5.1

Indexed Sub-components, Major Components, and Overall LVI for the Regions Interior, Coastal, Urban, Rural, Flood Prone and Cyclone Prone

Major Components	SL	Sub-components	Units	Interior	Coastal	Urban	Rural	Flood	Cyclone	Overall
Livelihood Vulnerability Index, LVI				***0.324***	***0.348***	***0.324***	***0.337***	***0.320***	***0.339***	*0.335*
	1.1	Dependency ratio	Average	0.498	0.498	0.487	0.500	0.514	0.493	0.498
	1.2	Per cent of female members in households	Per cent	0.159	0.176	0.096	0.181	0.153	0.170	0.167
	1.3	Average education of the head of the household	Average	0.149	0.215	0.109	0.194	0.172	0.182	0.180
	1.4	Average age of household heads	Average	0.398	0.434	0.407	0.416	0.382	0.423	0.415
1. Social and Demographic Profile, SDP (4)				**0.301**	**0.330**	**0.275**	**0.323**	**0.305**	**0.317**	**0.315**
	2.1	Agricultural livelihood diversification index	Ratio	0.731	0.641	0.758	0.675	0.748	0.673	0.689
	2.2	Natural resource and livestock index	Ratio	0.308	0.218	0.280	0.263	0.169	0.291	0.266
	2.3	Percentage of agricultural livelihoods	Per cent	0.046	0.071	0.016	0.066	0.050	0.059	0.057
	2.4	Agricultural and fishing equipment value index	Ratio	0.709	0.664	0.852	0.656	0.661	0.695	0.688
	2.5	Transportation assets value index	Ratio	0.933	0.936	0.955	0.930	0.881	0.948	0.934
2. Livelihood Strategies, LS (5)				**0.545**	**0.506**	**0.572**	**0.518**	**0.502**	**0.533**	**0.527**
	3.1	Availability of amenities	Ratio	0.163	0.241	0.031	0.233	0.179	0.205	0.200
	3.2	Sources of assistance received	Ratio	0.484	0.593	0.644	0.514	0.483	0.549	0.536
	3.3	Total assistance received	Ratio	0.316	0.352	0.351	0.329	0.248	0.355	0.333
3. Social Network, SN (3)				**0.321**	**0.395**	**0.342**	**0.359**	**0.304**	**0.370**	**0.356**
	4.1	Access to sanitary latrine	Per cent	0.191	0.580	0.080	0.432	0.422	0.362	0.374
	4.2	Total person days of injury in the households	Average	0.019	0.010	0.014	0.015	0.020	0.014	0.015
4. Health, H (2)				**0.105**	**0.295**	**0.047**	**0.224**	**0.221**	**0.188**	**0.194**
	5.1	Number of months with adequate food supply	Average	0.656	0.577	0.680	0.607	0.430	0.668	0.619
	5.2	Number of months with adequate food supply from own production	Average	0.879	0.879	0.902	0.875	0.917	0.869	0.879
	5.3	Extent of crop damage	Average	0.857	0.778	0.848	0.814	0.799	0.825	0.820

(Cont. Table 5.1)

Major Components	SL	Sub-components	Units	Interior	Coastal	Urban	Rural	Flood	Cyclone	Overall
5. Food, F (3)				**0.798**	**0.745**	**0.810**	**0.765**	**0.715**	**0.787**	**0.773**
	6.1	Unsafe source of drinking water	Per cent	0.319	0.016	0.057	0.200	0.046	0.210	0.177
	6.2	Distance to source of natural water	Average	0.872	0.932	1.000	0.881	0.991	0.877	0.900
	6.3	Whether experienced scarcity of water	Per cent	0.142	0.368	0.227	0.252	0.119	0.281	0.248
	6.4	Whether the household spent money to get water	Average	0.015	0.010	0.038	0.007	0.010	0.013	0.012
6.Water, W (4)				**0.337**	**0.332**	**0.330**	**0.335**	**0.291**	**0.345**	**0.334**
	7.1	Number of natural disasters during the last 20 years	Average	0.123	0.297	0.238	0.198	0.353	0.166	0.205
	7.2	Number of times affected by disaster	Average	0.191	0.320	0.292	0.243	0.435	0.204	0.251
	7.3	Value of crops damaged	Average	0.015	0.029	0.019	0.022	0.020	0.023	0.022
	7.4	Value of pond fish damaged	Average	0.020	0.018	0.029	0.017	0.023	0.018	0.019
	7.5	Value of livestock damaged	Average	0.035	0.053	0.030	0.046	0.029	0.047	0.043
	7.6	Value for damaged agricultural equipment	Average	0.004	0.000	0.000	0.002	0.000	0.002	0.002
	7.7	Value for damaged fishing equipment	Average	0.026	0.018	0.016	0.024	0.020	0.023	0.022
	7.8	Value for damaged household items	Average	0.011	0.015	0.039	0.008	0.004	0.015	0.013
	7.9	Indicator of vulnerable house	Ratio	0.436	0.511	0.218	0.522	0.322	0.510	0.471
7. Natural Disaster and Climate Variability, NDCV (9)				**0.096**	**0.140**	**0.098**	**0.120**	**0.134**	**0.112**	**0.117**

CHAPTER 6
POLICY IMPLICATIONS

Social networks play an important role in determining vulnerabilities in the coastal districts in Bangladesh. In order to improve the social networks of people living in the coastal regions, more amenities have to be made available there. Such assistance includes cyclone shelters, markets, fire services, health care facilities, schools and so on. On the other hand, the government should increase various assistance given to the coastal households and the NGOs should be requested to increase their support. Improving these amenities will reduce vulnerability amongst the households living in the coastal regions, particularly those living in the rural areas.

Access to safe drinking water, particularly during natural disasters, plays a key role in reducing vulnerabilities. Improving the quality of drinking water will reduce rural vulnerability. The government can install more tub-wells in the rural areas or distribute water purifying tablets during natural disasters.

The issue of sanitary services has been identified in this study. The government should improve the sanitary conditions in the coastal regions. Also, more clinics and hospitals should be built in the coastal regions, particularly in the rural areas, so that days lost in injuries can be reduced.

The government should invest in disaster preparedness and early warning and increase the number of cyclone shelters in the coastal region. Investment in education in the rural areas in the coastal regions will also reduce vulnerability. We have also found that stronger houses reduce vulnerability. The government should make stronger houses during rehabilitation or provide incentive to the rural households for making stronger houses.

CHAPTER 7
LIMITATIONS OF THE STUDY

A balanced weighted average approach was used in the construction of the LVI where each sub-component contributes equally to the overall index. If these weights were derived from other methods such as discussion with the stakeholders, this would have improved the index.

We could not use rainfall and temperature data as these are not available at the sub-district levels. It was also not possible to classify the coastal regions in a meaningful way so that the rainfall and temperature data could be incorporated.

Finally, although we used primary data, it was not collected for measuring vulnerability. As information was available that could be used to measure LVI, we have used this opportunity. However, this resulted in the absence of more detail explanation of the factors that could better explain differential vulnerabilities. The sub-components were not determined by making field level qualitative exercises but, to our judgement, they do reflect different dimensions of vulnerability in the coastal region of Bangladesh. It is intuitive that coastal households are more vulnerable than the households in the interior or that the rural households are more vulnerable than the urban households respectively. This we have shown to be true with the data generated from the survey and using the LVI.

Given these limitations, the study has shown the usefulness of survey data in measuring LVI. It has also shown that LVI can be used to explain differences in vulnerability beyond region and capture dimensions of location (coastal and interior, urban or rural) or even types of disasters (flood and cyclones).

CHAPTER 8
SUMMARY AND CONCLUSIONS

Climate change is explained by changes in temperature and rainfall and its variability and unpredictability. These make the livelihood of those affected vulnerable. While massive changes are brought about, often slowly over a longer period, to resource systems and ecology, the final impact is on people. The pathways to this impact come from a wide range of factors. They include demographic, health, water and other factors. These are included in the construction of a LVI or livelihood vulnerability index. In this paper we have measured the LVI of 12 coastal districts of Bangladesh from a survey of 532 households. We have found that households living in coastal region are more vulnerable than those living in the interior region and those living in the rural areas are more vulnerable than those living in the urban areas. We have also found that vulnerability from cyclones in the coastal region is higher than vulnerability from floods. Moreover, this paper has identified the factors that explain the vulnerability. For example, health facilities, access to water, quality of the houses built by the households ,etc. play a major role in explaining vulnerabilities. Policies have been suggested to address these issues.

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