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RESEARCH ARTICLE

VULNERABILITY DUE TO LACK OF INFRASTRUCTURE OF COASTAL LIVELIHOOD DURING CYCLONE *AILA* 2009 IN BANGLADESH

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Abstract: This study considers cyclone shelter, primary school/high school, hospital/clinic, and the religious buildings as the Central Infrastructure (CI) of a rural settlement in Bangladesh. People usually take shelter in those places during any disastrous situation. Selected variables were chosen on the basis of understanding the concept of CI in the context of coastal rural area, based on literatures and contemporary experiences and are treated with statistics and GIS to achieve guidelines for further analysis of the indicators. The choice and evaluation of the central functions and the measurement of associations provide a basis for ranking the CI for providing planning provisions for *Gabura union* of Shyamnagor *upazila* in Satkhira, Bangladesh.

Key Words : Infrastructural Vulnerability, Coastal Livelihood, Central Infrastructure, Cyclone Aila, Centrality of Infrastructure

Introduction

Infrastructure refers to the systems needed for the functioning of a community (Scawthorn, 2009) and the community cannot survive long given the wholesale failure of any of these systems (road, water supply, drainage, embankments, telecommunications etc.). These systems are also, in relation with disaster management, termed as "lifelines" and play the role as the "vain" for circulation of disaster mitigation programs. The inadequacy of this infrastructural supports introduce the "vulnerability due to lack of infrastructure". and raises the question of how effectively one can manage the post-disaster activities. These affect population, their livelihoods, socio-economic systems, environments, and health (Mallick *et al.*, 2005). From 1797 to 1998, 67 major cyclone and storm surges particularly in pre-monsoon months of April-May and post-monsoon months of October-November have been reported in Bangladesh (Miyan, 2005). The Bangladesh Meteorological Department (BMD) reported that combined death toll in those storms stands around one million people (Mallick *et al.*, 2005). The number of death caused by tropical cyclone *SIDR* has risen to 3243 affecting 7.0 million people of 1.65 million families. This casualties and damages of houses, livestock, crops, educational institutions, roads and embankments has been reported from 1811 unions of 200 upazilas of 30 districts. Most deaths and damages have been attributed to the storm surge. The death toll due to the cyclone Aila reached 179, but due to high tidal surges many areas of the affected districts (14) were inundated; houses, roads and embankments were damaged. Of the roads in the affected districts 285.5 km had been too battered to be used; besides 509 km embankments had been wrecked and 2155 km damaged (BDMIC, 2007; CRF, 2009). It was occurred due to the wind driven surge which was 4-5 feet above normal astronomical tide. Finally, the road-transport network was collapsed and made the post-disaster activities complicated. Relief did not reach in many remote areas; a lot of

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people remained half-fed. People were forced to drink polluted water to quench their thirst. The water, a few feet high, was starting to smell as the carcasses of animals begin decomposing. But the rescue and rehabilitation programs were hindered due to damaged and inundated road-infrastructure; notably most of the roads are not paved in rural Bangladesh, only the boat or water-transport facilities were helpful to organize the post-disaster activities. All these situations introduced a more complex living environment for the cyclone Aila victims. Normally immediate after the cyclone people try to start to go back to their normal life, but here the situation is completely opposite. The wind velocity, damages and death toll of cyclone Aila in comparison to cyclone Sidr were not too significant, but the consequences of stagnant water put more problems forward. This study seeks to address those problems, which were actually occurred due to lack of public infrastructure, of *Gabura union* in Satkhira district. This *union* was reported as one of the severely affected union by cyclone *Aila*.

Combining the most recent empirical data, this study estimated risk on the basis of available infrastructural facilities i.e. cyclone centre, health care facilities and road network. The equality of the distribution of such facilities in the study area was interpreted by the nearest neighbourhood analysis (Clark and Evans, 1954).

Materials and Methods

Study Area: *Gabura* union of Shayamnagor *upazila* in Satkhira district, is an island, surrounded by two big rivers (*Kholpetua* in western side and *Kapotaskha* in eastern side) (Fig. 1). The annual population growth rate is 1.70%. In the study area population below 10 years of age is 27.80%. Among the population of age 10 years and above those recorded idle are 28.03%, looking for work 1.42%, doing household work 34.79% and employed the remaining 35.76%. The literacy rate of Gabura union is 31.40%. Around 37666 populations live in an area of 41 sq. km. and all of them were affected by cyclone Aila and in aftermath by water-logging. Death toll counted as 24, crops and fisheries damages counted as US$ 32857 and total 35.25 km roads were damaged (*Gabura Union Parishad* 2009). Table 1 provides the sources of data for this study.

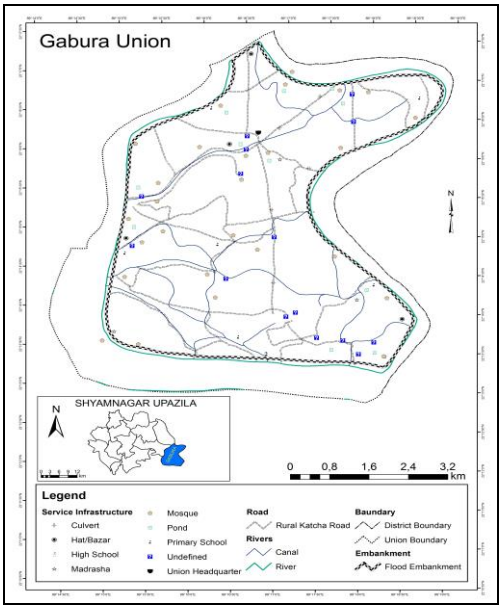

Fig. 1. Map of *Gabura union*, Shamnagar Upazila, Satkhira, Bangladesh.

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Table 1. Summary of data sources

Data Type	Unit	Source
Socio-economic data	per union	Upazila Statistics Office, Shyamnagor, Satkhira
Damages and Losses due to Cyclone Aila	Per union	Upazila Statistics Office, Shyamnagor, Satkhira
Upazila Map	Per union	LGED
Field Survey	Household (HH) level	Field Survey conducted by Researcher during March – August 2009, a total of 484 households

Method: *Nearest neighbourhood scale* (R) by Clarks and Evans (1954) was followed in assessing the equality of distribution of the cyclone centres and health care facilities and Bhat (2003) was followed in assessing the weight for each facilities. The indicators for the analysis of "uniformity of distribution" of respective infrastructure are presented in Table 2.

Table 2. Indicators for the analysis of *uniformity of distribution*

Total Surveyed Household (SH)	No. of surveyed HH are possessing a primary school/cyclone shelter within 500 m
No. of surveyed HH are possessing a High School within 1000 m	No. of surveyed HH are possessing a Primary Health Care Facilities within 1000 m
No. of surveyed HH are possessing a Religious Institute (i.e. Madarasa) within 500 m	No. of surveyed HH are possessing a Religious Building (i.e. Mosque, Temple) within 1000 m
No. of surveyed HH are possessing Safe Drinking Water source (i.e. Pond-Sand-Filter) within 500 m	No. of surveyed HH are possessing Rural Market place within 1000 m
No. of surveyed HH are possessing the accessibility of Paved Road (i.e. not Mud) within 100 m	

No. = Number

Here 500 m distance for primary school/cyclone shelter is considered because of the standard of cyclone shelter design. It is explained in the design manual that people who resides within 500 m distance from a cyclone shelter can be able to take shelter safely during any cyclone in a cyclone shelter, though there should have good road communication. For primary health care facilities, 1 km radial distance was considered. Presently the local government and health ministry of Bangladesh had implemented only one primary health care facility for each *union*. The distance for other institution and infrastructure (i.e. high school, market place, mosque, paved road etc.) group discussion outcomes were considered which was found to be within hundred meters from the houses. The discussant also voiced their requirement of a market within a km from their houses so that they could buy the necessary goods to prepare for the disaster.
Uniformity of distribution was calculated as follows:

$$Ri = \frac{SHi}{SH}$$

where, *Ri*= Uniformity of Distribution Value of the ith infrastructure, *SH* = Total Number of Sample, *SHi* = No. of sampled HH are possessing the chance of ith infrastructure. The Ri varies between '0 to 1' ($0 \geq Ri \leq 1$). So, if the value of $Ri = 1$, then the ith infrastructure is equally

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distributed and support 100% of the total population; similarly if Ri = 0, then there is no support of the ith infrastructure. *Demand index* for each infrastructure to analyze the "centrality of functions (infrastructure/Institutions)", was calculated as follows:

$$Di = \frac{Ei * SH}{SHi}$$

Where *Di* = Total Demand of the ith infrastructure according to the existing support services in the study area without considering the population growth; *Ei* = Total Number ith infrastructure is presently exist in the study area. By using the *Di* and *Ei* value, a 'degree of demand (DD)' of the *i*-th infrastructure (DDi) is calculated as:

$$DDi = \frac{Di - Ei}{Di}$$

The DD*i* varies between '0 to 1' ($0 \leq DDi \geq 1$).So, if the value of DDi = 0, then the ith infrastructure supports 100% of the total population; similarly if DDi = 1, then there is no support of the ith infrastructure. It also explains that the *Ri* value is contra productive with DDi value.

Results and discussion

Distribution and demand of selected infrastructure: The spatial pattern of intra-institute variations in the inter-household distances as well as by nearest institute reveals the tendency towards uniformity in distribution (R) of the selected supportive institutes. The R value varies here from 0.59 to 0.16 in the study area (Table 2). These variations can be explained by differences in public infrastructural supports taken by the government. The highest R-value is equal to 0.59 refers to 59% of the community people have the chance to possess the benefit of the respective infrastructure and there is a provision of further development for the rest 41% community people, i.e. the DDi value for the same infrastructure is 0.41 (Table 2).

Table 2. Uniformity of Distribution (R) and Degree of Demand (DD) of selected public infrastructure

Infrastructure	*Shi*	*Ei*	*Ri*	*DDi*	% of HH possessing the support in the community
Primary school/Cyclone shelter	219	6	0.45	0.55	45
High school	132	1	0.27	0.73	27
Primary health care center	78	1	0.16	0.84	16
Religious Institute (i.e. Madarasa)	176	3	0.36	0.64	36
Religious Building (i.e. Mosque, Tempel)	236	27	0.49	0.51	49
Safe Drinking Water source (i.e. Pond-Sand-Filter)	168	12	0.35	0.65	35
Rural Market	194	5	0.36	0.64	36
Accessibility of Paved Road	25	*	0.05	0.95	5

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* Only 2% of the total road was constructed with brick-soling (Upazila LGED Office, Shyamnagor, 2009).

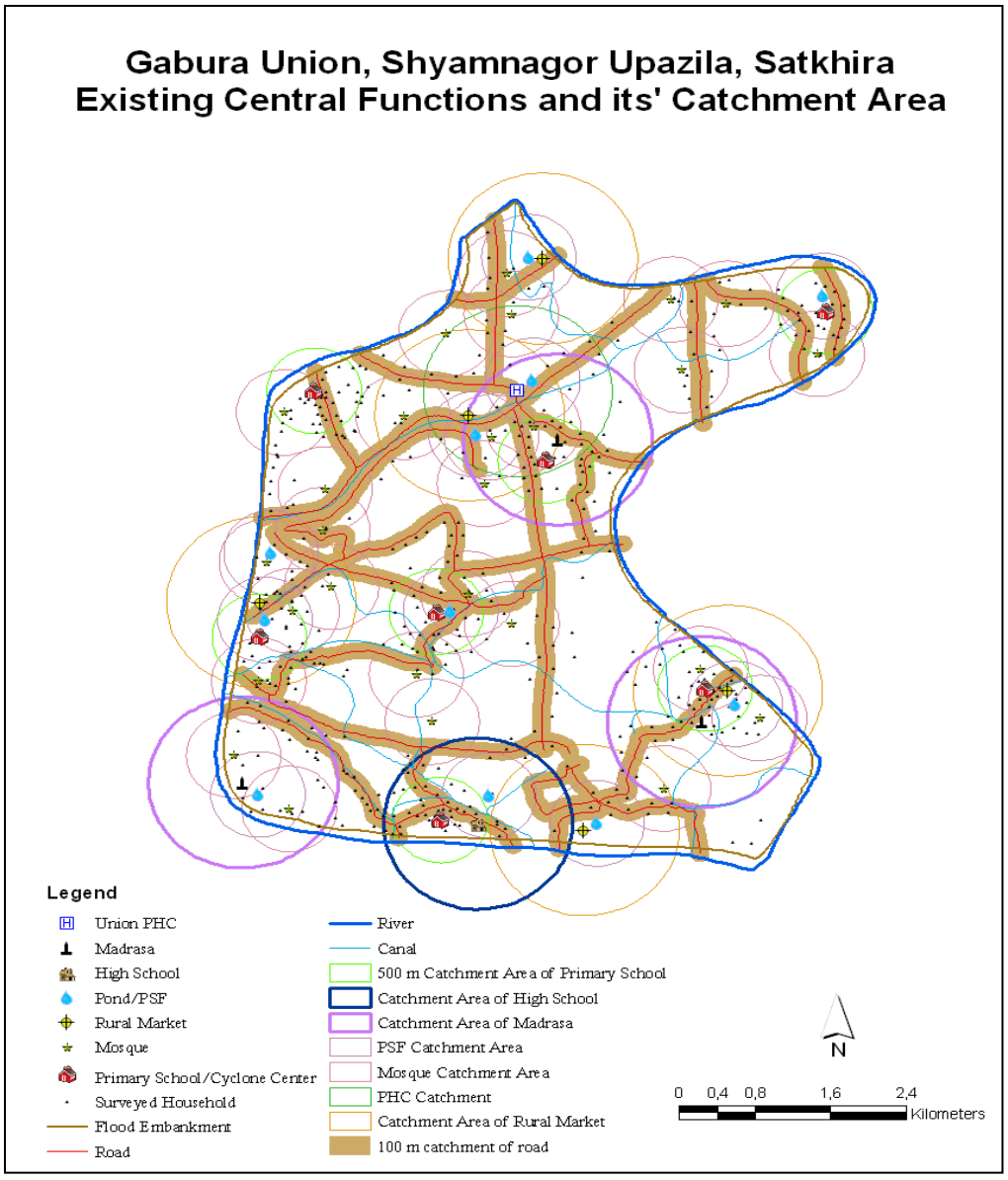

Fig. 2. Existing central functions and its catchment area.

It has been observed that none of the selected infrastructure can support 50% of the total population i.e. the significance of vulnerability due to lack of infrastructure (VoI) is very high. Firstly primary school or so called cyclone shelter, and religious building places are more equally distributed as well as support services than any other selected public infrastructure in the area. The absence of good road infrastructure is remarkably found here, it supports only 5% of the

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community. None of those were meeting the demand of the community and raised the importance of further provisions. The same observation was also drawn by using the catchments area analysis of the existing public infrastructure in ArcGIS (Fig. 2).

The method of analyzing of degree of demand index (DDi) is applied here to express the importance of further provision of the respective infrastructure and how much they are neglecting from the central functions of such public infrastructure (Table 2).

Perception and response to cyclone Aila: Though the people understood the existing weather signal, they were not timely alerted about Cyclone Aila by the metrological department. After receiving the emergency weather information usually they try to make them safe. Table 3 shows their response to *Aila*.

Table 3. Receiving warnings of *Aila* and immediate response of the respondents

Immediate response	News received (% of respondent)	
	Yes (87)	N0 (13)
Discuss with family members and decide to stay in your home	57.1	2.3
Discuss with neighbours	2.8	0
Take decision by self	15.4	2.4
Do not pay any attention about the news	11.7	8.3

According to the Table 3, majority of people of the study area received news of Aila and their immediate responses was only a simple discussion of family members and decides to stay at home. After receiving news only 16% household took initiative to save their family. Mostly they were decided to bring their family members to the cyclone shelter and neighbour's house. None of them had taken initiative to save their livestock, 50% had tried to save their house, 21% had reserved food and 23% preserved drinking water. Though people received news in time but they did not pay attention, which is the first cause of extreme losses. Another factor is the distance of safe shelters. Here the public infrastructures were counted as safer place. The average distances are reported in following Table 4. The cyclone shelter was counted as an average distant of 1.18 kilometres, whereas the primary health care centre reported as 2.33 kilometres distance. Minimum distance counted as 100 meter for every infrastructure except the primary health care support, which minimum distance denoted as 800 meter. Such spatial distribution of public infrastructural facilities explains the low level of infrastructural supports in the study area.

Table 4. Distance of central infrastructure from the respondent's house

Distance from the respondent's house	Distance in kilometres		
	Minimum	Maximum	Mean
Primary school	0.10	1.50	0.7300
High school	0.10	3.00	1.0591
Cyclone shelter	0.10	3.00	1.1824
Religious Institute	0.10	7.00	1.0816
Health centre	1.50	8.00	2.3341

Vulnerability due to Infrastructure: How were the victims being affected due to the inadequate infrastructural supports during an emergency or disaster period? It may be answered by calculating the damages and loss. However, we tried to address this question in terms of the interrelation between the infrastructural supports and societal information, so that further planning

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problems can be understood well. It was observed from the field data that 76% respondent could not reach in a safer place due to rash of water intrusion and inundation of roads. The effect of saline water intrusion in the settlements caused the destruction of houses, roads, culverts etc. Pressure of high tide reduced the capacity of embankment and washed away mostly all the drinking water source. The adverse effect of salt-water intrusion observed significant in agriculture and fresh water fish production. Again due to the stagnation of water inside the embankment, there seemed to be no end to the catastrophe till several months. Though initially the water started to recede and things seemed to stabilize, but then high tidal waves came in and flooded the place all over again. The embankment, though broken at many points, was overloading with people who had sought shelter there. It added more obstacles for the post disaster activities and also increased the sufferings of the victims. If there were adequate cyclone shelters or rehabilitation centres, the affected people could take shelter and continue other works temporarily. Eighty nine percent of the respondent claimed that they had no access to enter the available cyclone shelter. Firstly, they (67%) were living in average 1 kilometre distance; secondly they (78%) are the poor segment of the society and have different political views (56%). They raised the issues how such local infrastructural development was carried on. During group discussion with the affected people, it was found that the cyclone shelter, even the drinking water support like PSF was also built nearby the rich or powerful elite of the society having economic solvency and access to political power. It ensured the influential role of local power structure in local level planning (Vogt, *et al.*, 2009). Thus, not only the inadequacy of infrastructure was the cause of increasing livelihood problems, also the local social power executed more complications for the general people. Furthermore, 64.98% of the respondents depend on agriculture as the main source of household income with 38.16% on cropping, livestock, forestry and fishery and 26.82% on selling agricultural labour. Other households reported earning main incomes are from non-agricultural labour 6.02%, business 14.60%, employment 3.53%, construction 0.94%, industry 0.61%, rent and remittance 0.20%, transport and communication 1.58%, and others 7.54%. Survey findings indicated that 80% lost their work, 40% bound to change their occupation, and at least one person of the family member were hunting for relief and rehabilitation supports. Shift from farmers to day labour is mostly identical here i.e. 78% of the total, who bound to change their occupation due to water logging situation aftermath cyclone *Aila*.

During normal period ponds are largely used by households as source of drinking water. They used pond water for 90% of their daily activities. For the purpose of drinking water, 54.8% of the respondents used pond-sand-filter (PSF), 43.46% pond-water and the rest of them used other sources like rain-water etc. Till several months' due saline water intrusion into the ponds and PSF was under the water and causes drinking water scarcity to the people of the study area. Such situation also introduces dysentery, cholera, diarrhoea, skin diseases and fever. Water borne diseases were more common. According to respondents' opinion, more than 80% people of the area suffered dysentery and diarrhoea. However, access to medical facilities for the people of the area is very limited, which is also found in earlier section of this article. More than two-third of the respondent did not have the ability to consult with doctors or to buy medicines due to their economic condition, and also because of heavy damages of road networks as well as distance of primary health care facilities.

Sound sanitation system is an essential element for safe and healthy life of people. In study union only 44.84% of households have sanitary latrines and the rest have no arrangement. As per respondents' opinion, the sanitation system of the study area is getting worse over the time period.

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During the field visit, it was found that in some cases people previously having access to safe sanitation system forced to hanging latrine after *Aila*. Cyclone *Aila* and water logging due to infrastructural problems had grasped their shelters including safe sanitation system raised vulnerability for their livelihood. It was mainly occurred due to insufficient institutional as well as infrastructural supports for them. It might change their routine work, their income opportunities, and causes their social as well as geographical displacement.

Conclusion

Many disaster managers and city planners now work toward the goal of sustainable, resilient communities. A sustainable community meets the need of the present without compromising the ability of others to meet their own needs. A sustainable community is one that balances: social equality and equity, economic vitality, environmental responsibility and infrastructural effectiveness. Such an infrastructural effectiveness as well as community resilience is absent in the study area. Obtaining funds to provide sufficient shelters in the future may be a forlorn hope. It may be necessary to consider alternative community-based solutions in the intermediate term. Access to shelters is dominated by the elites and inactive shelter management committees. Minority groups and others may not be granted entry and at the same time, religious centres of minority groups are often not open to outsiders. Unless these issues can be addressed in a community-managed plan, it may be futile to construction further refuges. This might require some resisting of important community infrastructure in more valuable coastal areas but could be planned with local people to determine the optimum placement of these refuges. It sounds good in theory, but it does not come easily. There are many barriers to a community coming to consensus around the common good, but there are also conditions that can be fostered that make such consensus more likely. New academic framework may never fully change the way in which governments and international institutions operate vulnerability intervention, as it has been shown here that they can be considerably influenced by how the local power structure works.

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