

POTENTIAL EFFECT OF SEA LEVEL RISE ON THE LIVELIHOOD OF BEEL DAKATIA AND LOCAL ADAPTATION TECHNIQUES: PEOPLES' PERCEPTION

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ABSTRACT

The South-West coastal region of Bangladesh is adversely affected by Sea Level Rise. To investigate the impacts of sea level rise in Beel Dakatia region, six villages named Kalitala, Kalibari, Krishna Nagar, Tolna (south), Baniapukur and Dakatia were surveyed and peoples opinion regarding SLR induced permanent inundation was analyzed. The livelihood parameters are categorized in five social dimensions. Education and health is considered as human capital; road network, housing and safe water as physical capital; water bodies and agricultural lands are considered as natural capital; income as financial capital and social security is considered as social capital. Considering present resilience of the people as 100%, the resilience of human, physical, natural, financial and socio-economic capitals are estimated to be reduced by 55%, 53%, 87%, 60% and 64%, respectively against one ft permanent inundation. For two ft permanent inundation, the resilience of people at human, natural, physical and socio-economical dimensions are estimated to be reduced by 72%, 71%, 96%, 73% and 73%, respectively. For the adaptation against one ft permanent inundation in the area, local people think that they will be able to cope with the adverse effect applying local adaptation techniques. Most of them think that proper maintenance of three sluice gates situated at Salua Bazar, Amvita and Thukla Bazar can reduce the effect of SLR induced permanent inundation significantly. If two ft inundation occurs and the water stands for a long time then they will have to leave the place.

Keywords: Adaptation, , Beel Dakatia , Climate Change, Livelihood Capitals, Sea Level Rise.

1. INTRODUCTION

Climate change associated with sea level rise (SLR) is one of the major environmental concerns of today. Climate change was projected to impact tropical countries more negatively than the temperate ones. In the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC, 2007) the projected rise of sea level from 1990 to 2100 was estimated from 9 to 88 cm. The SAARC Meteorological Research Centre (SMRC) analyzed sea level changes of 22 years historical tide data at three tide gauge locations in the coast of Bangladesh. The study revealed that the rate of sea level rise during last 22 years are many fold higher than the mean rate of global sea level rise over 100 years. A study by Ahmed and Alam (1998) mentioned one meter change of sea level by the middle of 21st century; it combines a 90 cm rise in sea level and about 10 cm local rise due to subsidence. Pilot study of Department of Environment (DOE, 1993) mentioned that a potential future sea level rise for Bangladesh is 30-50 cm by 2050. An increasing tendency in sea level rise from west to east along the coast has also been found. Bangladesh is highly vulnerable to sea level rise, as it is a densely populated coastal country of smooth relief comprising broad and narrow ridges and depressions (Brammer *et al.*, 1993). World Bank (1998) predicted that for 45 cm rise of sea level may inundate 10-15% of the land by the year 2050 resulting over 35 million climate refugees from the coastal districts. In another investigation, World Bank (2000) predicted 10 cm, 25cm and 1 m rise in sea level by 2020, 2050 and 2100, affecting 2%, 4% and 17.5% of total land mass, respectively. Milliman *et al.* (1989; cited in Frihy, 2003) reported 1.0 cm per year sea level rise in Bangladesh. Agrawala *et al.* (2003) estimated that climate change could affect more than 70 million people of Bangladesh due to its geographic location, low elevation, high population density, poor infrastructure, high levels of poverty and high dependency on natural resources. It is reported that the population living in the coastal area is more vulnerable than the population in other areas. Coastal resources upon which the most people depend are likely to be affected severely due to climate variability and change (Ahmed, 2006).

Beel dakatia is the second largest beel (smallest depression in floodplain) in Bangladesh. It stands on the South-West coastal region of Bangladesh with an area about 17400 hectares or 174000000 square meters under Dumuria, Phultala, and Avaynagar thanas in coastal district of Khulna and Jessore. Beel dakatia includes five

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union named Fultola, Gilatola, Raghunathpur, Rangpur and Damalia. It lies between longitude $89^{\circ}29'E$ and $89^{\circ}35'E$. The elevation of this area is low and topography is almost flat. The surrounding rivers of this area are Solmari, Hamkura and Salta. During tide and saline water from sea comes to the beel through these rivers and during rainy season the excess rainwater is discharged. Figure 1 shows the geographic location of Beel Dakatia in the map of Dumuria Upazila under Khulna District, Bangladesh.



Figure 1 Location of Beel Dakatia

The main objective of this study was to investigate the impacts of SLR induced permanent inundation on the livelihood of Beel Dakatia based on local people's perception. The vulnerability of the different livelihood parameters was also estimated and the people's opinion on the local adaptation techniques for the mitigation of the impacts was analyzed.

2. METHODOLOGY

A questionnaire survey was conducted in six villages of Beel Dakatia region to accumulate the local peoples' opinion about the effect of SLR induced inundation on their livelihood, and their local adaptation techniques. To investigate the local peoples opinion about their resilience on different livelihood parameters, PRA tool were used. PRA Stands for Participatory Rural Appraisal which aims to incorporate the knowledge and opinions of rural people in the planning and management of development projects and programmes. Five livelihood capitals named Humen Capital, Physical Capital, Natural Capital, Financial Capital, and Social Capital were considered in PRA process. Here, the sub-parameters were chosen based on the recent research of Khan *et al.*, 2010. Education and health were considered as sub-parameter of human capital; Road networks, housing and access to safe water were considered as sub-parameter of physical capital; water bodies and agricultural land were considered as sub-parameter of natural capital; Income were considered as sub-parameter of financial capital; Social security were considered as sub-parameter of social capital. The questionnaire survey includes 2 key scenarios: (a) possible future impacts on livelihood parameters if one ft (30.5 cm) permanent inundation occurs and (b) possible future impacts if two ft (61cm) permanent inundation occurs in the study area. Survey was also conducted to investigate the local peoples' opinion about the future adaptation techniques for SLR.

The vulnerability of the different livelihood parameters due to permanent inundation of one ft (30.5 cm) and two ft (61 cm) is estimated using the method suggested McLaughlin (2001) is used. In this method, three conditions i.e. probability of occurring the hazard of different parameters, risk that might occur and preparedness of the local people were considered. The probability, risk and preparedness are also defined with appropriate ratings to obtain vulnerability. Mathematically,

Vulnerability = Probability \times Risk \times Preparedness

The probability, risk and preparedness are also defined with appropriate ratings. Multiplying the ratings for probability, risk and preparedness of different parameters, ratings are classified into three categories: ≤ 15 , 16 to 30, and ≥ 30 , which are marked as low vulnerable, moderate vulnerable and high vulnerable respectively. The ratings were multiplied for each case and the total values, in descending order, represent the parameters most in need of organization focus and resources for emergency planning.

3. RESULTS AND DISCUSSIONS

Six villages named Kalitala, Kalibari, Krishna Nagar, Tolna (south), Baniapukur and Dakatia under Rangpur, Raghunathpur, Dhamalia, Damodar and Phultola unions were surveyed to study the impacts of SLR induced inundation in Beel Dakatia. Percentages of people in survey at six villages in Beel Dakatia are tabulated in Table 1.

Table 1 Percentage of Peoples Participation.

Name of the Village	Union	Total Population	People Surveyed	No. of Families Surveyed	% of people surveyed
Kalitala	Rangpur	800	88	20	11.00%
Kalibari	Rangpur	1344	216	54	16.07%
Krishna Nagar	Raghunathpur	1900	238	51	12.53%
Tolna	Dhamalia	1200	156	34	13.00%
Baniapukur	Damodar	1201	135	32	11.24%
Dakatia	Gilatola	1524	177	44	11.61%
Total		7969	1010	235	12.67%

3.1 Vulnerability of the Livelihood Parameters

The vulnerability of the different livelihood parameters is determined by using the vulnerability analysis method suggested by *The Joint Commission on Accreditation of Healthcare Organizations (JCAHO)*. Each of the parameters was analyzed and thus obtains a rating that signifies the level of vulnerability. The survey showed the following ratings for different parameters.

Table 2 Vulnerability of different livelihood sub-parameters for villages surveyed (here C1 and C2 indicate the vulnerability ratings for one ft and two ft permanent inundation cases respectively)

	Ratings for parameters (out of 45(maximum))																	
	Education		Health		Water Bodies		Agricultural Land		Road Netwo.		Housing		Safe Water		Income		Social Security	
Village	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
Kalitala	12	22	19	27	38	43	38	44	13	16	25	31	26	29	22	29	23	29
Kalibari	14	18	15	22	36	40	40	44	08	19	23	28	28	30	25	31	22	33
Krishna Nagar	15	24	23	25	37	43	42	41	13	15	31	33	19	25	28	33	26	34
Tolna	12	21	13	24	30	39	37	40	9	14	21	36	25	33	21	30	28	36
Bania Pukur	13	17	17	22	29	40	35	39	12	17	25	34	22	30	24	28	24	30
Dakatia	12	18	15	24	30	35	42	42	17	21	29	36	24	33	30	35	21	30
Avg. Ratings	13	20	17	24	34	40	39	42	12	17	26	33	24	30	25	31	24	32

Table 2 shows the vulnerability ratings for different livelihood sub-parameters of which water bodies and agricultural land are seem to be most vulnerable with respect to other sub-parameters. Out of a maximum rating

value of 45, water bodies obtained 34 and 40 ratings for one ft and two ft permanent inundations, respectively. Whereas, agricultural land obtained 39 and 42 ratings for one ft and two ft permanent inundations respectively. Considering total score of all the parameters, from Table 2 it can be concluded that Krishna Nagar, Dakatia and Kalitala are relatively more vulnerable areas than the other villages studied. Figures 2 and 3 illustrate the rating conditions for different sub-parameters graphically.

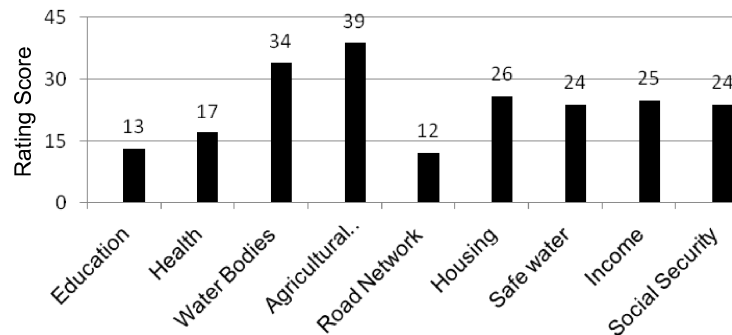


Figure 2 Vulnerability ratings of the different sub-parameters if one ft permanent inundation occurs.

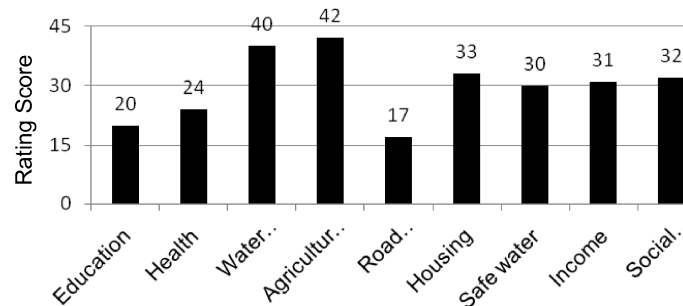


Figure 3 Vulnerability ratings of the different sub-parameters if two ft permanent inundation occurs.

Table 3 Sub-parameters classification according to Low, Moderate and High Vulnerability

Conditions	Low Vulnerable	Moderately Vulnerable	Highly Vulnerable
Classification for one ft Permanent Inundation	Education and Road Network	Health, Housing, Safe Water, Income, Social Security	Water Bodies and Agricultural Land
Classification for 2 ft Permanent Inundation	Nil	Education, Health, Road Network,	Water Bodies, Agricultural Land, Housing, Safe Water, Income and Social Security

Different village have different topography and water level. The height of the roadway system and the livelihood of the local people are also different for every village, and that's why the vulnerability of the different villages is different for any single sub-parameter. Table 3 shows the degree of vulnerability for different sub-parameters due to permanent inundation of one ft and two ft. This table indicates that the water bodies and the agricultural lands are the most vulnerable sub-parameter in the Beel Dakatia region. All the parameters are found to be moderate to highly vulnerable for two ft SLR induced permanent inundation situation.

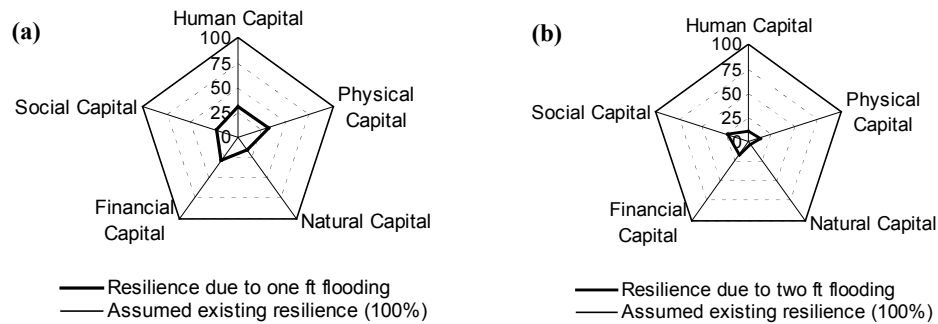
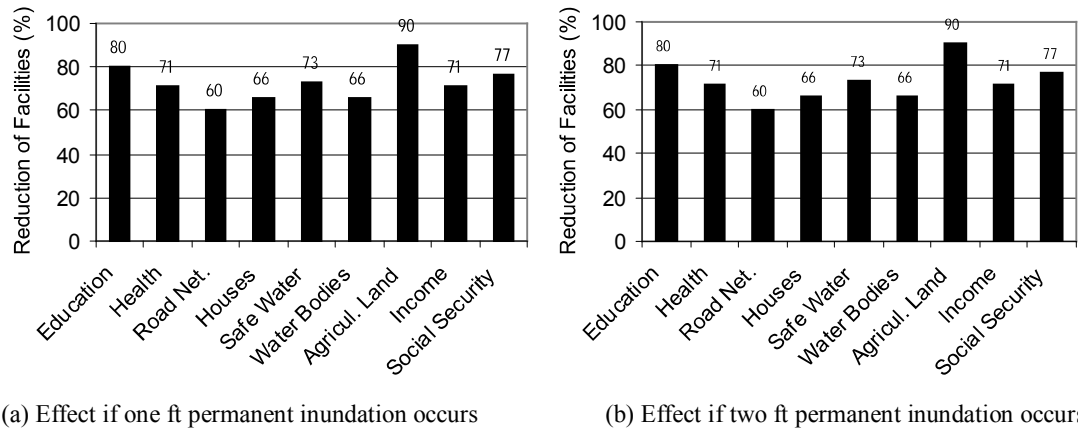
The vulnerability of livelihood capitals is given in Table 4. It is observed that the natural capital is relatively more vulnerable than other capitals.

Table 4 Ratings for the livelihood parameters

Livelihood Parameters		Ratings for the livelihood Parameters (Out of 45 (maximum))
Human Capital	one ft inundation	15
	two ft inundation	22
Physical Capital	one ft inundation	21
	two ft inundation	27
Natural Capital	one ft inundation	37
	two ft inundation	41
Financial Capital	one ft inundation	25
	two ft inundation	31
Social Capital	one ft inundation	24
	two ft inundation	32

3.2 Impact of Sea Level Rise on the Livelihood of People of Six Villages

Impacts on different livelihood parameters due to possible SLR induced permanent inundation have been studied on six villages. The impact on dakatia beel is calculated as average stress of these six villages. The result is presented in next sub-sections for the most and least affected villages as well as the overall impact on dakatia beel.

**Figure 4** Reduction of peoples resilience if (a) one ft and (b) two ft permanent inundation occurs (Kalitala, Rangpur).**Figure 5** Stress on different sub-parameters if one ft and two ft permanent inundation occurs (Kalitala, Rangpur).

3.2.1 One of the most effected Village: Kalitala under Rangpur Union

Kalitala is one of the most vulnerable areas in the Beel Dakatia region. Generally, the village goes completely under water along with most of the internal roads under a inundation depth of one to two ft during monsoon period. Figure 4 (a) demonstrates the possible reduction of resilience of the people if one ft permanent inundation occurs, and Figure 4 (b) demonstrates the resilience of the people if two ft permanent inundation occurs in the Kalitala under Rangpur Union. The survey results show that if one ft permanent inundation occurs, the local people's resilience on human capital, physical capital, natural capital, financial capital and social capital are likely to be reduced to 30%, 32% 16%, 29% and 23% respectively. Note that the present resilience of the people is considered here as 100%. If two ft permanent inundation occurs then the local people's resilience on human capital, physical capital, natural capital, financial capital and social capital will be reduced to 10%, 13% 3%, 17 % and 23 % respectively. Effect on every sub-parameter are also drawn as bar charts in Figure 5. From the figure it is observed that the natural capital (agricultural lands) is in greater risk than the other parameters for one ft permanent inundation. For two ft inundation, almost all the parameters are in highly stressed that causes the reduction of peoples resilience to the access of different livelihood parameters.

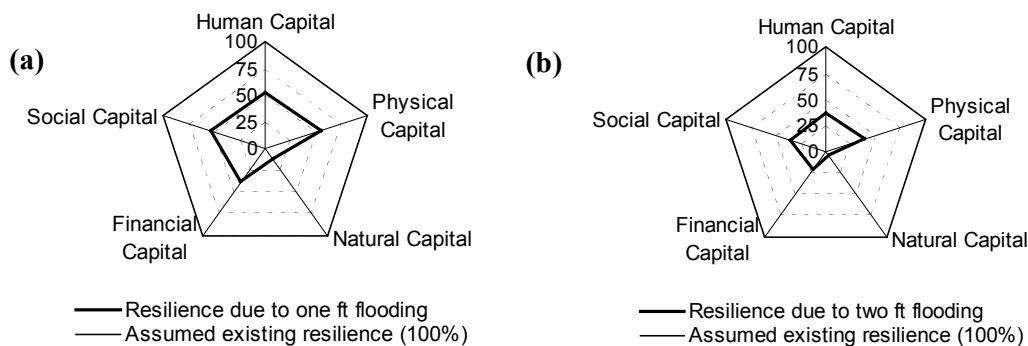


Figure 6 Reduction of peoples resilience if (a) one ft and (b) two ft permanent inundation occurs (Tolna, Dhamalia Union)

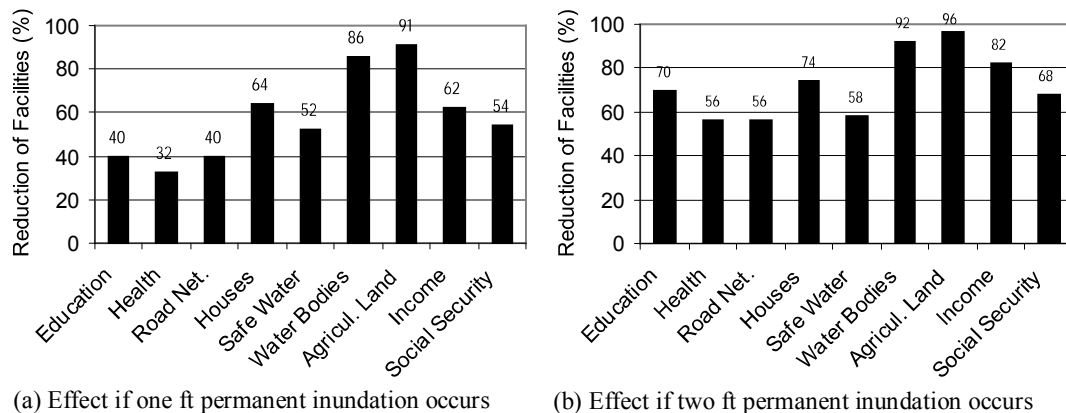


Figure 7 Stress on different sub-parameters if one ft and two ft permanent inundation occurs (Tolna, Dhamalia union)

3.2.2 The least affected village: South Tolna under Dhamalia Union

During monsoon, many parts of this village goes under water, although the main roads and some elevated parts of the village remain unaffected. Figure 6 (a) demonstrates the possible reduction of resilience of the people if one ft permanent inundation occurs, and Figure 6 (b) demonstrates the resilience of the people if two ft permanent inundation occurs in the South Tolna under Dhamalia Union. The survey results show that if one ft permanent inundation occurs then the local people's resilience on human capital, physical capital, natural capital, financial capital and social capital are likely to be reduced to about 53%, 55% 12%, 38% and 54% respectively. Note that the present resilience of the people is considered here as 100%. If two ft permanent inundation occurs then the local people's resilience on human capital, physical capital, natural capital, financial capital and social

capital are likely to be reduced to about 37%, 38%, 4%, 20% and 36 % respectively. Effect on every sub-parameter are also drawn as bar charts in Figure 7. It is observed that, like other villages, in Tolna natural capital i.e. water bodies and agricultural lands are in greater risk than the other parameters both for one and two ft permanent inundation. On an average, the estimated stress on different livelihood parameters in Tolna village is about 20% less than that of Kalitala village, both for one ft and two ft permanent inundation cases.

3.2.3 Overall Impact on Livelihood of Beel Dakatia

Combining the survey results of six villages, overall impact on the peoples resilience capacity of Beel Dakatia is prepared. Figure 8 demonstrates the possible reduction of resilience of the people if one ft permanent inundation occurs, and Figure 9 demonstrates the resilience of the people if two ft permanent inundation occurs in Beel Dakatia region. The survey results show that if one ft permanent inundation occurs then the local people's resilience on human capital, physical capital, natural capital, financial capital and social capital are likely to be reduced to about 45%, 47%, 13%, 40% and 36%, respectively. Note that the present resilience of the people is considered here as 100%. If two ft permanent inundation occurs then the local people's resilience on human capital, physical capital, natural capital, financial capital and social capital are likely to be reduced to about 28%, 29%, 04%, 27% and 27%, respectively. Among all the parameters, natural capital is found to be the most affected parameter. From the graphs, it is found that, natural capital's resilience is reduced to 13% for one ft to 4% for two ft permanent inundation. On an average, for one ft permanent inundation the peoples resilience is likely to be reduced from 100% (assumed present resilience) to 36%. The peoples capacity will be further reduced by 13% if two ft permanent inundation occur.

Effect on every sub-parameter are also drawn as bar charts in Figures 10 and 11. Figure 10 shows that, agricultural land is the mostly affected with respect to other sub-parameters while water bodies and social security takes the second and third position respectively in reduction of facilities. For two ft permanent inundation, it is found that almost all the sub-parameters are highly vulnerable due to SLR induced permanent inundation. Agricultural land and water bodies are found to be highly affected with respect to others.

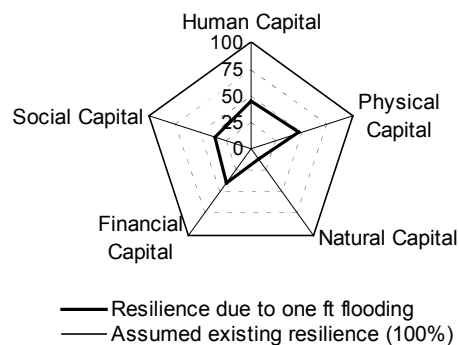


Figure 8 Estimated Reduction of peoples resilience if one ft permanent inundation occurs in Beel Dakatia region

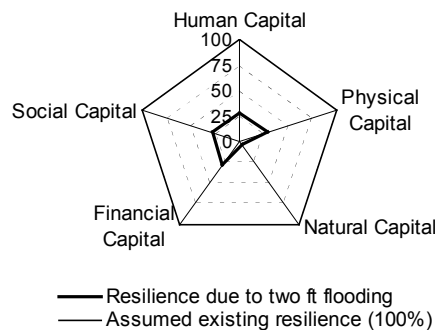


Figure 9 Estimated Reduction of peoples resilience if two ft permanent inundation occurs in Beel Dakatia region

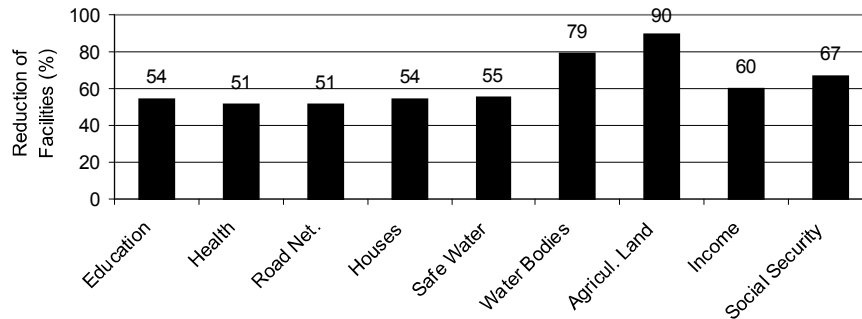


Figure 10 Estimated Stress on different livelihood sub-parameters for one ft permanent inundation in Beel Dakatia

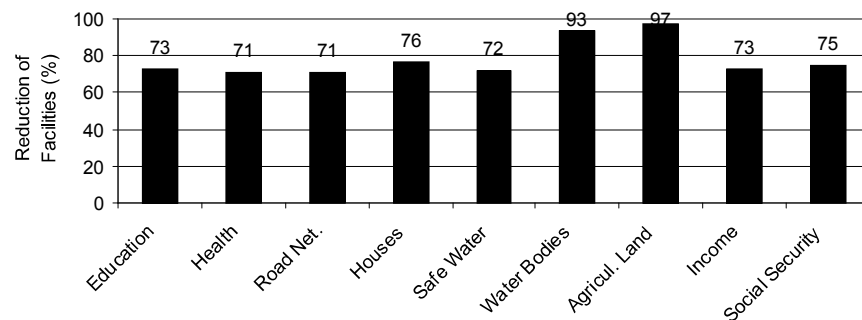


Figure 11 Estimated Stress on different livelihood sub-parameters for two ft permanent inundation in Beel Dakatia

4. EXISTING STATUS OF SLUICE GATES

There are three sluice gates around Beel Dakatia. They are at Salua Bazar, Amvita and Thukla Bazar. Present conditions of the sluice gates are not satisfactory due to lack of maintenance. There were a lot of wastes around and into the drainage channel and river that blocked the flows in sluice gates. Water hyacinths made it their own place to breed. As a result, siltation of the underlying rivers took place, which causes the drainage problem of three sluice gates. Figures 12 to 14 show the present condition of sluice gates at upstream and downstream sides. The local peoples are looking for government intervention regarding the proper maintenance of the gates as well as for dredging the drainage channels for proper discharging the monsoon water to the river.

5. LOCAL ADAPTATION TECHNIQUES

5.1 Housing

Housing systems in the Beel Dakatia region is mainly the 'Mud-House'. Mud-Houses are highly vulnerable as their resistance against water is very low. They can easily collapse if water level rises from one to two ft. 'Semi-Pacca' houses are also exist there, which possess relatively more resistance to water and ensure better safety. The numbers of 'PACCA' houses are very little in the Beel Dakatia region with respect to 'Mud-House' and 'Semi-Pacca' houses. Residents of 'PACCA' and semi-Pacca house owners think that raising the plinth level of their houses can reduce the effects. Residents of mud-house think that they will have to take shelter in the nearby shelter center or roads until water drained out.

5.2 Access to Safe Water

Beel Dakatia region has scarcity of pure drinking water. The suitable aquifer in this zone is almost 1000-1400 ft deep below the ground. So, pure drinking water is not available everywhere. At present people has to fetch water from a distant parts of the village where any deep tube well is installed. So if flooding occurs they will face

severe scarcity of fresh water. In the hazard moment, people of Beel Dakatia think that they will face scarcity of fresh water and will have to use available contaminated water for drinking and other purposes. They also think that the existing tubewells also need to be raised up their base to get the contamination free water during flooding.



Figure 12 Sluice Gates at Salua Bazar (May, 2012)



Figure 13 Sluice Gate at Amvita and Silted up Hamkura River (May, 2012)



Figure 14 Sluice Gate at Thukla Bazar (May, 2012)

5.3 Natural Water Bodies

Water bodies are one of the most vulnerable parameters of Beel Dakatia. For every surveyed village this parameter is found to have very less resilience. The survey result in this study showed that, if water level rises to two ft, about 93% of the total water bodies (Gher, Pond) will go under water. People are thinking of rising the bank of the ponds to mitigate the effects. They also urge for proper maintainance of the sluice gates so that excess water can be drained out to the river by reducing water congestion. They think that this can be the most effective way to save the water bodies from long durational innundation.

5.4 Agricultural Land

Agricultural land is the top most vulnerable among all the sub-parameters considered in this research. This study showed that if two ft permanent flooding occurs, about 90%-97% of all the agricultural land will go under water.

This may cause severe loss of agricultural production. Almost all the people said that the only way to solve this problem is to remove the excess water. They urge to maintain the sluice gates properly to solve the problem. They think that the government and non-government organizations should take necessary initiatives to make the sluice gates functioning properly and operate accordingly.

5.5 Income Level

Peoples of Beel Dakatia are mainly depend on fish-business and agriculture. In fish business they make small ponds locally named 'Gher' and cultivate different types of fishes including prawn for exporting. As seen earlier, in a changed condition, the water bodies and agricultural lands are the most vulnerable sub-parameters, it will not be possible for them to remain on the same profession as they are in at present. To maintain income to meet the daily expenses, they think that they will need to change their profession and they may need to migrate to nearby towns for searching new works.

5.6 Road Networks

Beel Dakatia region is surrounded by embankment which is now using as main road to connect different parts of the region. The road system consists of 'Kaccha' road, brick soling roads and pavements. The internals are generally Kacha roads which are generally submerged during monsoon and on high tide periods. Peoples think that these 'KACCHA' roads should be raised to improve their present communication system in monsoon. Present status of brick soling roads is not satisfactory as it also goes under water in many places during monsoon. Although government initiatives have already been taken to raise this type of road level. Pavements are also used as shelter of dissaster prone peoples during flooding and cyclones. To make all types of roads resistant against permanent innundation, government should take necessary initiatives to raised the road level.

5.7 Education System

People of Beel Dakatia are not educated enough to aware about health, sanitation, social security or effect of climate change. There is a lack of educational institutions, and due to their illiteracy they are not willing to send their children to school. If permanent inundation occurs and local road networks remain unsubmerged, the present education system may continue. To mitigate the problem pertaining permanant innundation, local people think that they need to raise the school premises and plinth level. As they uses school buildings as shelter during dissasters, so they urge to government to build more disaster resistant buildings for using as school cum shelter home.

5.8 Intervention of NGOs

Many NGO'S are working on the Beel Dakatia region. They are BRAC, ASA, Progati, Mohona, Janata, HYSAWA, Salvation Army, Somokal, Jagoron etc. of which very few are working on climate change issue. Most of them are involve in 'Micro-credit' finance system, and after the flood they provide some cash money to revive the usual life of the local people. They did not provide any training to the local people about how to minimize the losses during flood, where to take shelter, how to get pure drinking water and how to improve their sanitation and health system. Among all the NGOs, only one is found to be working on climate change issues. They help the local people with sanitation, health tips and making people conscious about health and sanitation related issues. Another NGO has provided some tube wells and sanitary latrines to the local people of Krisna Nagar to improve their sanitation system and for increase drinking water facilities. However, peoples thinks that the initiatives of NGOs are very limited compared to their need.

6. CONCLUSIONS

To investigate the impacts of sea level rise in Beel Dakatia region, six villages named Kalitala, Kalibari, Krishna Nagar, Tolna (south), Baniapukur and Dakatia were surveyed and peoples opinion regarding SLR induced permanent inundation was analyzed. The result indicates that the water bodies and the agricultural lands are the most vulnerable sub-parameter in the Beel Dakatia region. All the parameters are found to be moderate to highly vulnerable for two ft SLR induced permanent inundation situation. On an average, for one ft permanent innundation the peoples resilience is likely to be reduced from 100% (assumed present resilience) to 36%. The peoples capacity will be further reduced by 13% if two ft permanent inundation occur. Peoples are thinking to mitigate the effect of SLR locally, which is very limited corresponding to their needs. So, development and implementation of adaptation policies and to take initiatives for mitigation measures are the right ways to respond to sea level rise impacts.

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