POST GRADUATE PROGRAMS IN DISASTER MANAGEMENT (PPDM), BRAC UNIVERSITY
INSTITUTE OF WATER AND FLOOD MANAGEMENT (IWFM), BUET

Climate Change Risk Assessment Toolkit for Secondary Cities in Bangladesh

Draft Report

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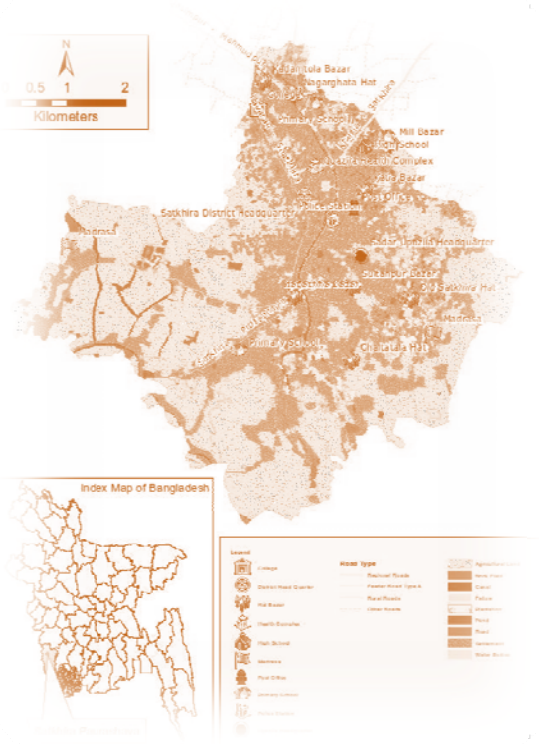


CONTENTS

1 INTRODUCTION

The Postgraduate Programs in Disaster Management (PPDM) at BRAC University and the Institute of Flood and Water Management (IWFM) of the Bangladesh University of Engineering and Technology (BUET) carried out the risk assessment task in Satkhira, Bangladesh.

2 RISK ASSESSMENT PROCESS

The Risk Assessment Process started with the collection and synthesis of secondary information in early January, 2012. The core research team in Bangladesh held a number of meetings to discuss issues regarding the toolkit and the mode of carrying out the field testing before taking it to field.

The first field visit to Satkhira was made in late February (25-29) to identify the local stakeholders. Two researchers from the core research team and two from the local partner NGO (LEDARS) carried out this task.

The assessment task was carried out from 23 through 31 March, 2012. The first meeting with the civil society was facilitated by the Vice Chancellor BRAC University, Professor Ainun Nishat. The local partner NGO, LEDARS, collaborated with the core research team and also significant support from local BRAC offices was received.

The overall risk assessment process is divided into two major components:

- Local assessment and context setting
- Future risk analysis and evaluation

This draft report elaborates the local assessment and context setting component which has been carried out in three stages:

- Pre-assessment;
- Assessment; and
- Consolidation.

In the following sections each of the above-mentioned stages are elaborated.

3 PRE-ASSESSMENT STAGE

3.1 REVIEW OF SECONDARY INFORMATION

3.1.1 PHYSICAL SETTING

AREA AND ADMINISTRATIVE BOUNDARY

Satkhira District (khulna division) with an area of 3858.33 sq km, is a south west bordered district of Bangladesh. It is bounded by jessore district on the north, the bay of bengal on the south, khulna district on the east, Pargana district of west bengal on the west. Satkhira Sadar Upazila (satkhira district) with an area of 400.82 sq km, is bounded by kalaroa upazila on the north, debhata and assasuni upazilas on the south, tala upazila on the east and west bengal of India on the west. Main rivers are ichamati, Betua, Labangabati, and Kholpatua; Pansayar canal and Dadbhanga Beel are notable.

Our area of interest, Satkhira (Town) a municipal town, consists of 9 wards and 31 mahallas. The area of the town is 27.84 sq km. The main business centre of the town is Sultanpur Bazar (old name Pransayar Bazar).

DEMOGRAPHY

The average area of the surveyed wards was 990.3 acres, with the average number of households being 2160.1 per ward and total population is estimated as 95181. Ward 9 had the most households, with 2426 households, and ward 4 had the least number of households, with 390. The average population size was 10575.7 people, and the maximum population was seen in ward 2, with 13743, and the minimum population was seen in ward 4, with 8952 people. The average population density is 3282.8 people per square kilometer, and the highest density was observed in ward 4, with 5672.0 people per square kilometer, while the minimum density was seen in ward 9, with 1278.8 people per square kilometer.

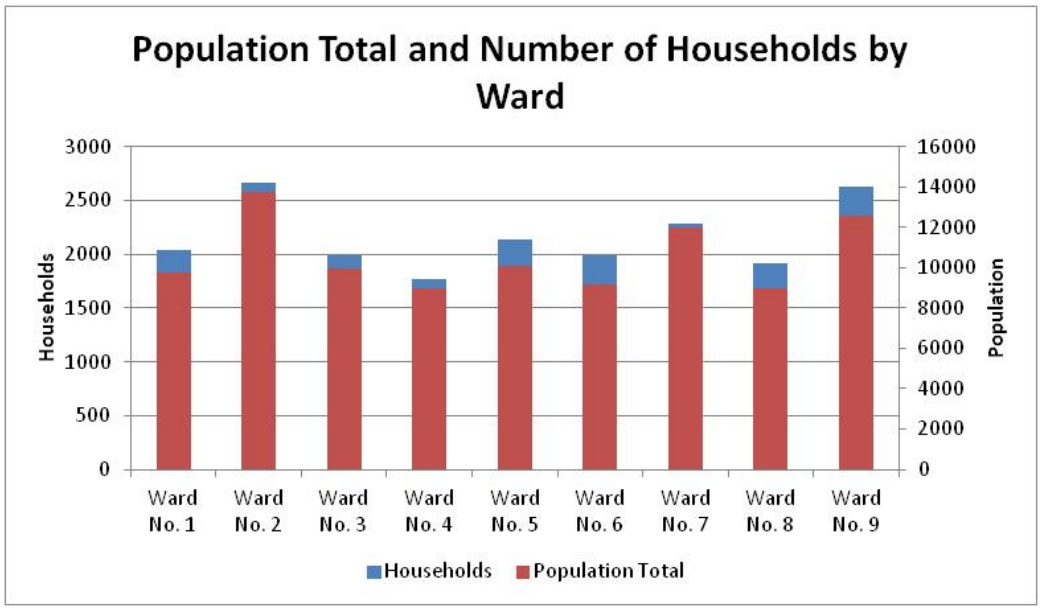


Figure 1: Population and household distribution

The average number of males is 5587.11, with the max number of males being 7343, from ward 2, and the minimum number of males being 4685, from ward 8. The average number of females is 4988.6, with the maximum number of females being 6400, from ward 2, and the minimum number of females being 4235, from ward 4.

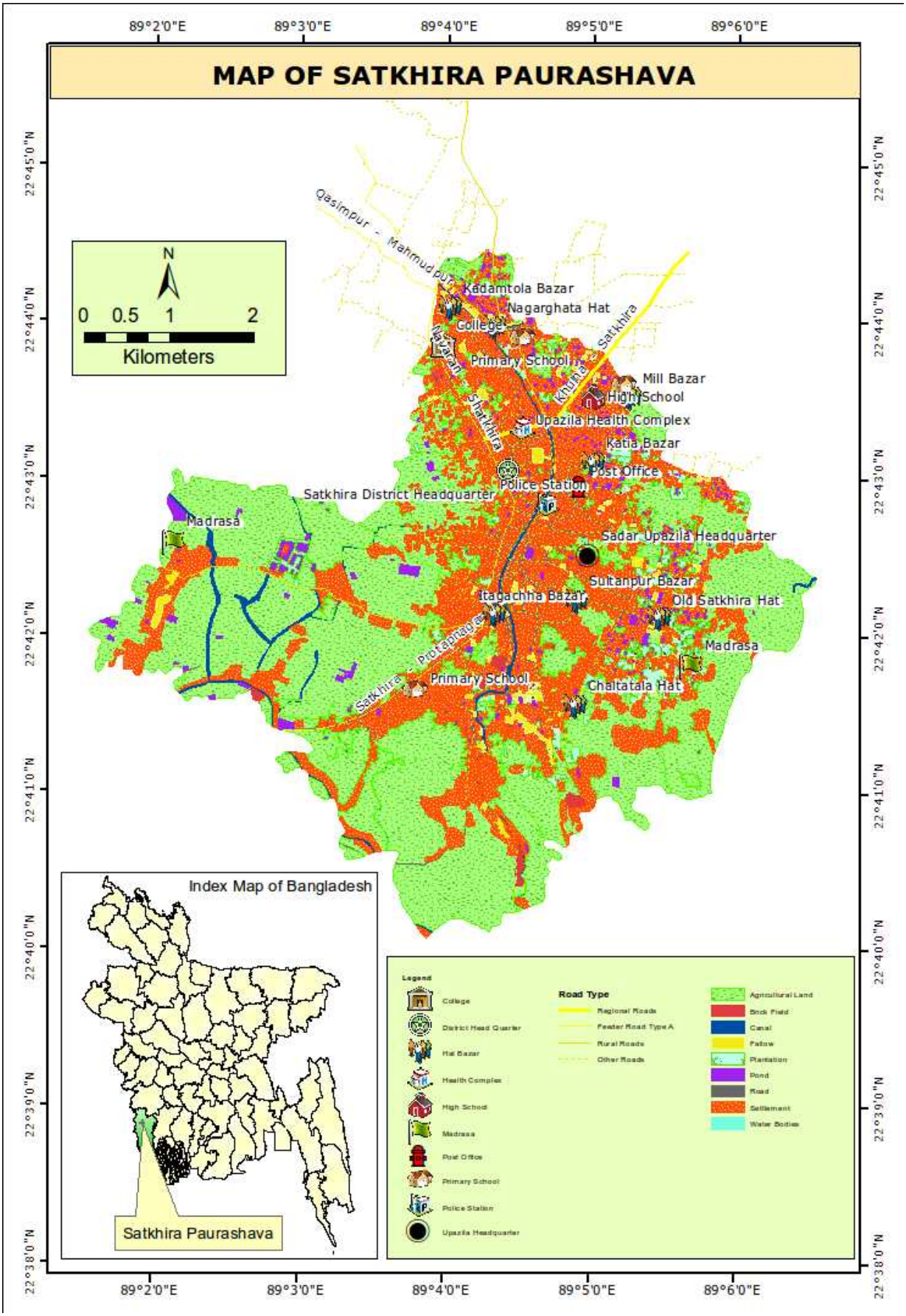


Figure 2: Base map of Satkhira Municipaility

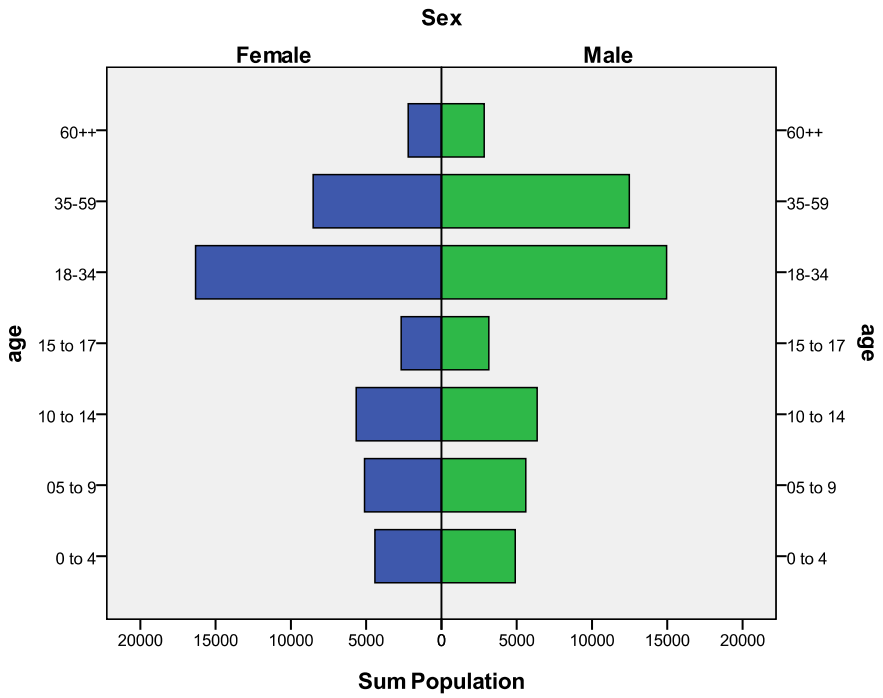


Figure 3: Population pyramid showing the distribution of male and female over different age category

The male to female ratio is 1.1 on average, with the highest male to female ratio being observed in ward 7 as 1.3 males per female, and the lowest ratio being observed in ward 9 as 1.05. It is to be noted that the overall average is higher than the national statistics (1.08).

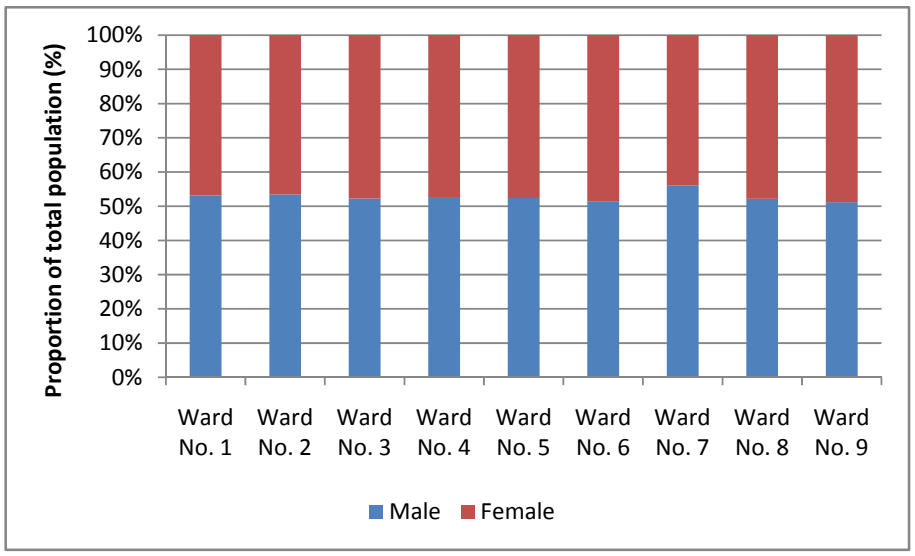


Figure 4: Ward wise distribution of male female proportion

The above chart gives us population density (people per square kilometer) per ward. 29545.27 is the average population density per ward, compared to Bangladesh's total population density, which is 883.25 (including water area and forest area). Counting only land area, Bangladesh's population density as of 2001 was 3559.5 people per square km.

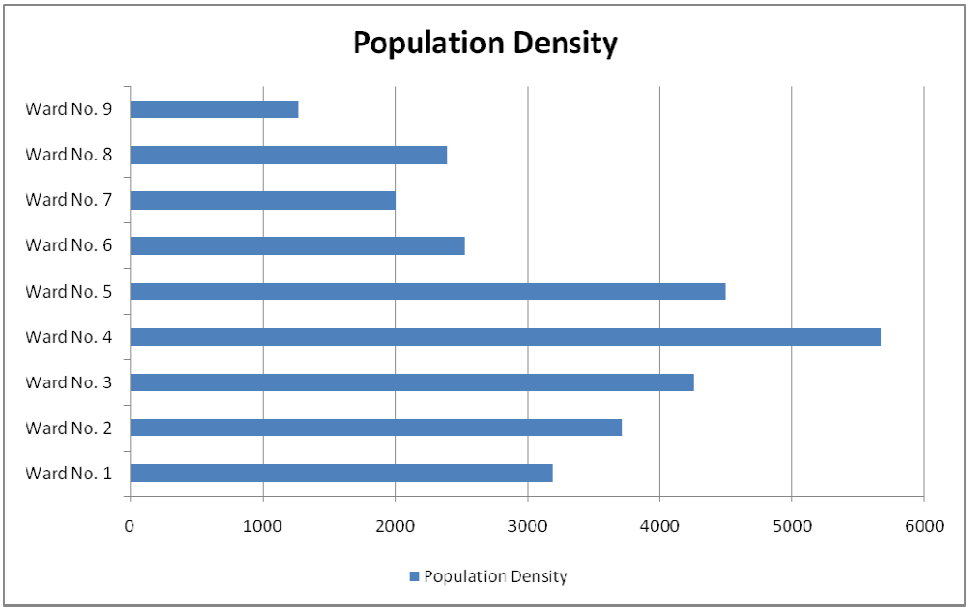


Figure 5 Ward wise distribution of population density

LIVELIHOOD AND INCOME

On an average 51% of the population is somewhat involved in some kind of livelihood options while around one third of the population is not working. Among those who are involved in some kind of livelihood options, maximum proportion of population is involved in household works followed by 9% are involved in business, 7% in agriculture and 11% in other livelihood options. A total of 8% are involved in construction, industry and transport sectors and only 1% is involved in service sector.

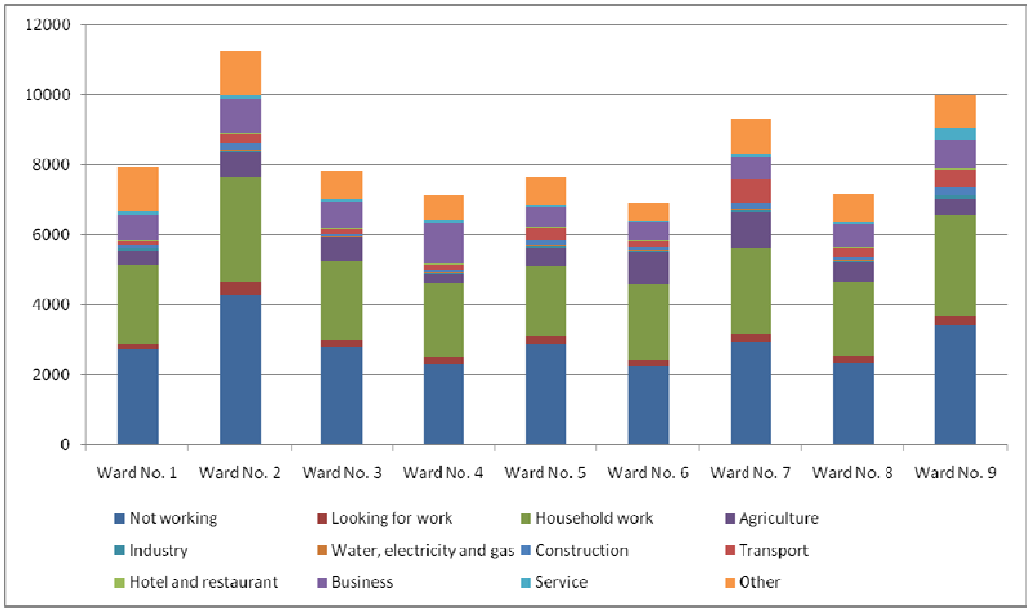


Figure 6 Ward wise distribution of livelihood options

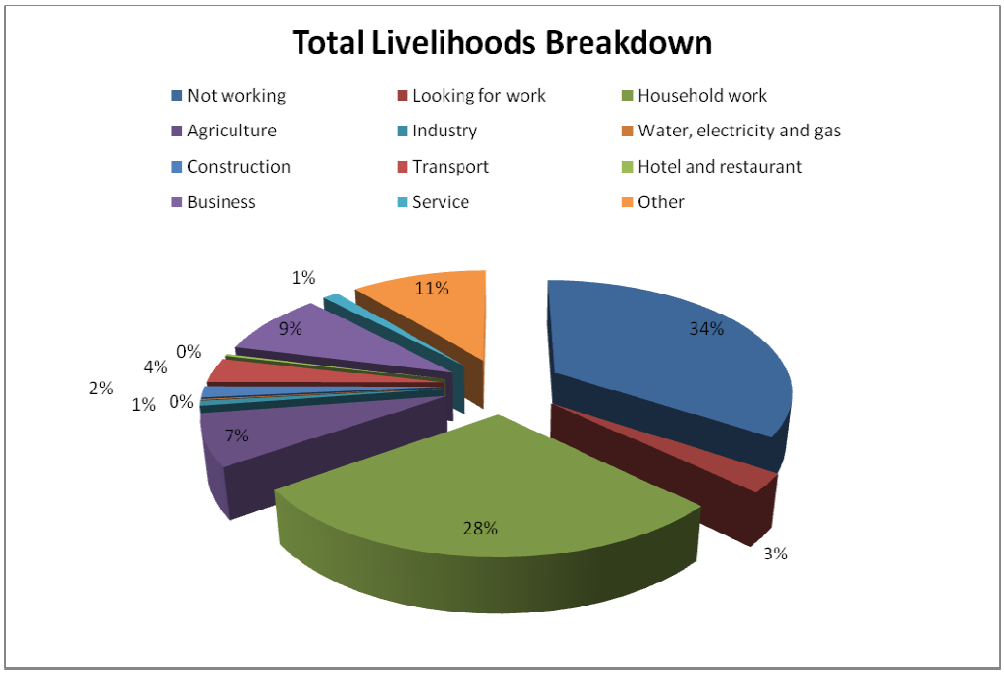


Figure 7 Overall livelihood distribution

LITERACY RATE

Average literacy is observed as being 62.9%, with average male literacy rates being 67.6% and female literacy being 57.66%. Observed literacy rate lies above the national average, where male and female literacy rate is 49.6 and 40.8 respectively. Highest total literacy is observed in ward 1, with 75.8%. Ward 1 had the highest number of literate males, at 81.5%, and literate females, at 69.4%. Likewise, Ward 5 had the lowest total literacy, at 46.4%, lowest male literacy, at 51.6%, and lowest female literacy at 40.8%. The highest male to female literacy rates were observed in Ward 6, with a ratio of 1.4, and the lowest were observed in ward 7, with 1.1.

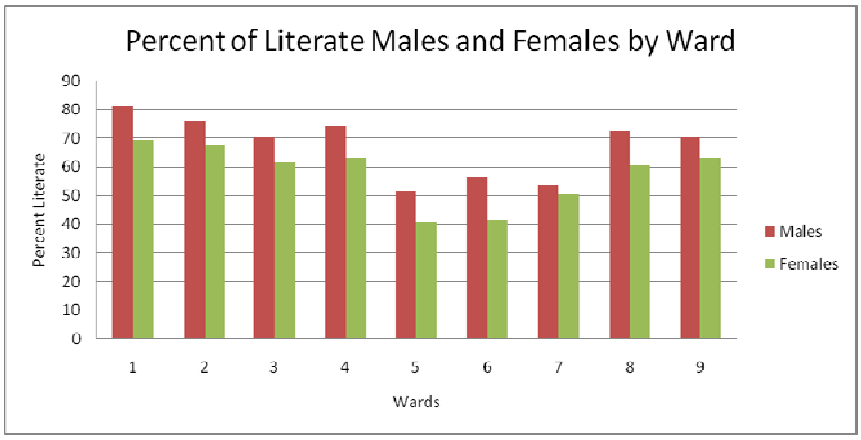


Figure 8: Ward wise distribution of literacy rate

ACCESS TO WATER SUPPLY AND SANITATION

Households out of all wards total used tubewells the most as their source of water, except for ward 4, which used tap water more. All wards used ponds the least. Wards 4 and 7 used Ponds more than any other ward.

Ward 3 used “other” the most out of all other wards. Ward 6 used wells the most out of all other wards, ward 9 used tubewells the most out of all other wards, and ward 2 used tap water the most out of all other wards.

In Bangladesh as a whole, According to BBS, Rural areas had 83.7% using tubewell sources, 5% using deep tube well, 4% using ponds, and 6.7% using “other”. Only .63% used tap as their water source. This can be compared to urban households, where 24.9% used tap, 66% used tube wells, 4.7% used deep tube wells, 1% used ponds, and 3.4% used other sources, as of 2001.

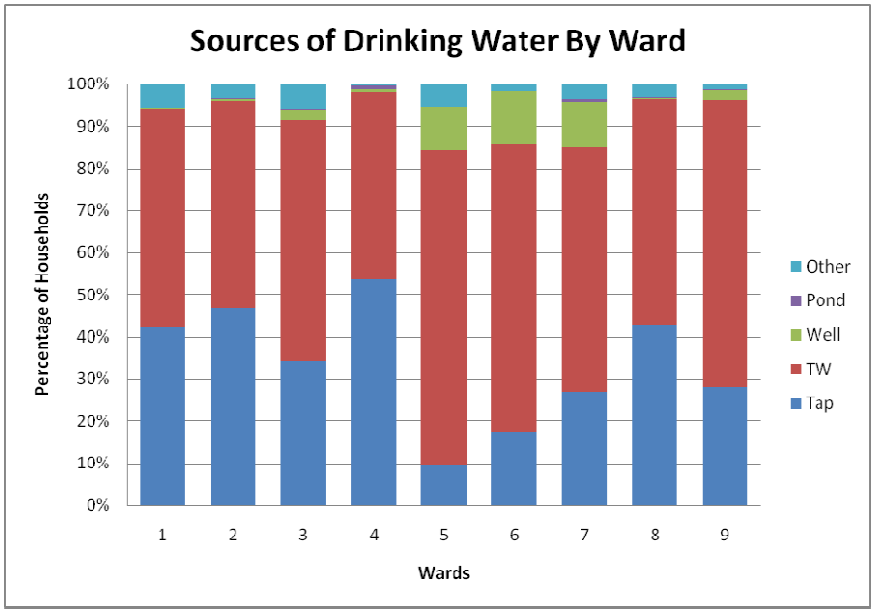


Figure 9 Ward wise distribution of access to water supply facilities

CLIMATIC PROFILE

GENERAL CHARACTERISTICS

Climate characteristics of Satkhira is influenced by the Bay of Bengal located in it’s south and also by the vast tract of Gangetic land in the north and west side. Unlike other areas of Bangladesh, this region is located in the tropical monsoon region and its climate is characterised by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations.

The most striking feature of its climate is the reversal of the wind circulation between summer and winter, which is an integral part of the circulation system of the South Asian subcontinent. During the early part of the pre-monsoon season, a narrow zone of air mass discontinuity lies across Satkhira that extends from the southwestern part to the northeastern part. This narrow zone of discontinuity lies between the hot dry air coming from the upper Gangetic plain and the warm moist air coming from the Bay of Bengal. As this season progresses, this discontinuity weakens and retreats toward northwest, and finally disappears by the end of the season, making room for the onset of the summer monsoon. The rainy season, which coincides with the summer monsoon, is characterised by southerly or southwesterly winds, very high humidity, heavy rainfall, and long consecutive days of rainfall which are separated by short spells of dry days. Rainfall in this season is caused by the tropical depressions that enter the country from the Bay of Bengal.From the climatic point of view, three distinct seasons can be recognised in Bangladesh - the cool dry season from December through February (**DJF**), the pre-monsoon hot season from March through May (**MAM**), and the rainy monsoon season which lasts from

June through September (**JJAS**). The month of March may also be considered as the spring season, and the period from October through November (**ON**) may be called the autumn season.

ATMOSPHERIC PRESSURE AND WINDS

These are characterised by seasonal reversals between summer and winter in Bangladesh. During the winter season, a centre of high pressure lies over the northwestern part of India. A stream of cold air flows eastward from this high pressure and enters the country through its northeast corner by changing its course clockwise, almost right-angle. This wind is the part of the winter monsoon circulation of the South Asian subcontinent. During this season, wind inside the country generally has a northerly component (flowing from north or northwest). Thus Satkhira region is affected by cold usually at a later date than that of other regions.

On the other hand, during the summer season, a centre of low pressure develops over the west-central part of India because of intense surface heat. As a result, a stream of warm and moist air from the Bay of Bengal flows toward the above-mentioned low pressure through Bangladesh (similar flow prevails from the Arabian Sea toward India). This wind is the part of the summer monsoon circulation of the sub-continent. So, the prevailing wind direction in Bangladesh during the summer season has generally a southerly component, flowing from the south, southwest or southeast region covering Satkhira. However, wind directions during the transition seasons (in spring and autumn) are variable. Generally, winds are stronger in summer (8-16 km/hr) than in winter (3-6 km/hr). The mean pressure is 1,020 millibars in January and 1,005 millibars during March through September.

TEMPERATURE

January is the coldest month in Satkhira. However, the cold winter air that moves into the country from the northwestern part of India loses much of its intensity by the time it reaches the southwestern corner of the country. Average temperatures in January vary from about 11°C to 25 °C and minimum temperature ranges from 4.9°C to 22.8°C . In most of the time temperature stays at minimum during the month of January and February. As the winter season progresses into the pre-monsoon hot season, temperature rises, reaching the maximum in April, which is the middle of the pre-monsoon hot season. Average temperatures in April vary from about 18°C in the northeast to 37°C. In some years, maximum temperature in summer season rises up to 40°C or more. After April, temperature decreases slightly during the summer months, which coincides with the rainy season. Widespread cloud covers causes dampening of temperature during the later part of the pre-monsoon season. Average temperatures during the rainy season vary from about 18°C in the southeast to 33°C.

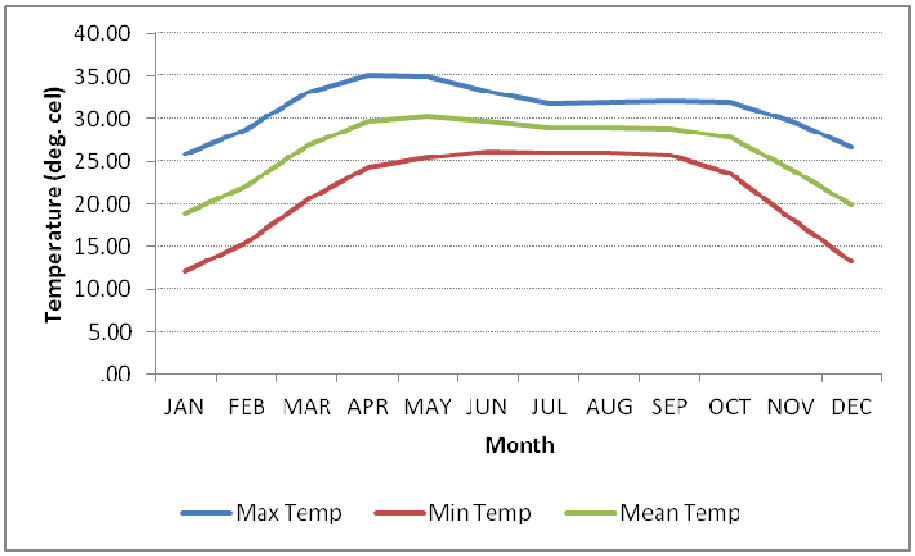


Figure 10: Monthly distribution of temperature statistics

HUMIDITY

February and March are the least humid months in Satkhira. The lowest average relative humidity (67%) has been recorded in the month of March. Here the lowest monthly average of 29% has been recorded in March. The relative humidity is everywhere over 80% during June through October. The average relative humidity for the whole year ranges from 77.6%.

RAINFALL

The single most dominant element of the climate of Satkhira is the rainfall. Though the monsoon wind start travelling to the North East side over Satkhira, but as rain starts from the foothill of Meghalaya and re-travel to the South the amount of rainfall is relatively lower than that of the national average. However, there is a distinct seasonal pattern in the annual cycle of rainfall, which is much more pronounced than the annual cycle of temperature. The winter season (DJF) is very dry, and accounts for only 2%-3% of the total annual rainfall. Average rainfall during this season is 44 mm which varies within the range of 0 to 184 mm historically. As the winter season progresses into the pre-monsoon hot season (MAM), rainfall increases due to intense surface heat and the influx of moisture from the Bay of Bengal. Rainfall during this season accounts for around 15% of the total annual rainfall which is caused by the thunderstorms or nor'wester (locally called Kalbaishakhi [Kalbaishakhi]). During the rainy season (JJAS), around 74% of the total rainfall occurs, which accounts on an average of 1205 mm and varies within the range of 452mm to 1733mm. Typically, July is the month of highest rainfall when average rainfall is 348mm. Till the end of September monthly rainfall accounts more than 250 mm, and till the mid of October monthly rainfall accounts around 137 mm.

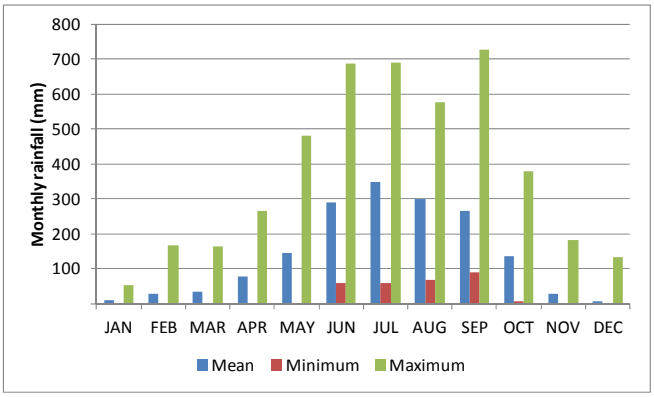


Figure 11: Monthly distribution of rainfall

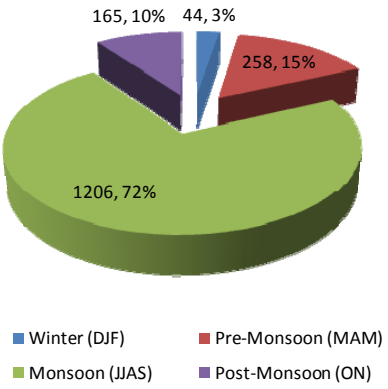


Figure 12: Seasonal distribution of rainfall

CLIMATE CHANGE AND VARIABILITY

Although any climatic change in Bangladesh will, of course, be a part of worldwide climatic changes, but Satkhira is obviously one of the worst victims of climate change and variability.

Observed changes in the mean, maximum and minimum temperature is showing a positive trend, both in terms of mean annual statistics as well as in the seasonal statistics. Mean annual temperature is showing a statistically significant (at 90% confidence interval) increasing trend of .0073° C/year, whereas seasonal temperature during the winter season (DJF) and pre-monsoon (MAM) is also showing a statistically significant (at 90% confidence interval) increasing trend of .0014° C/year and .0014° C/year respectively.

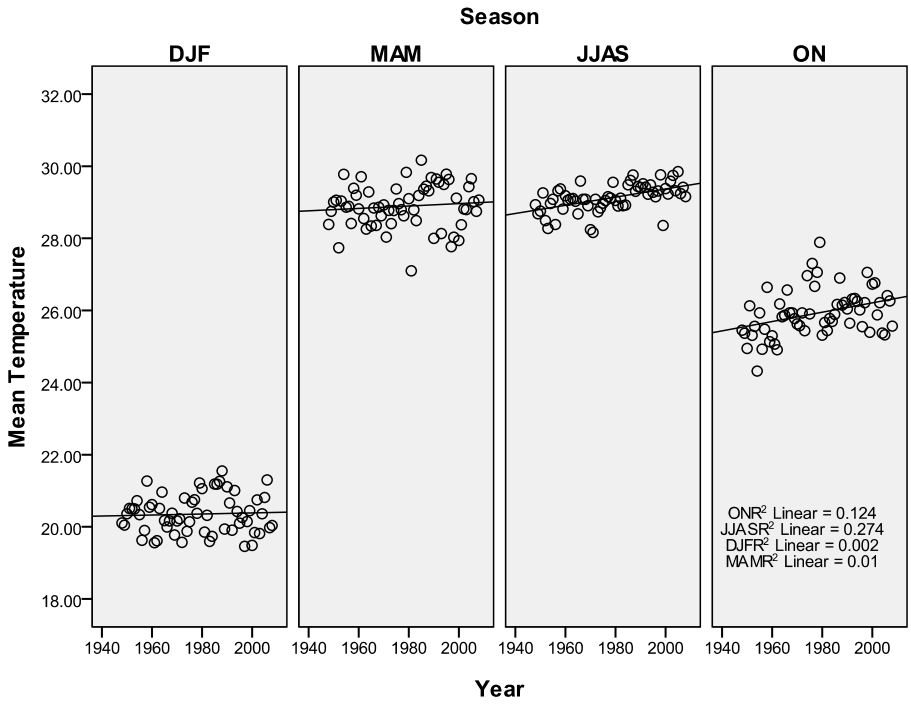


Figure 13: Trend in seasonal temperature

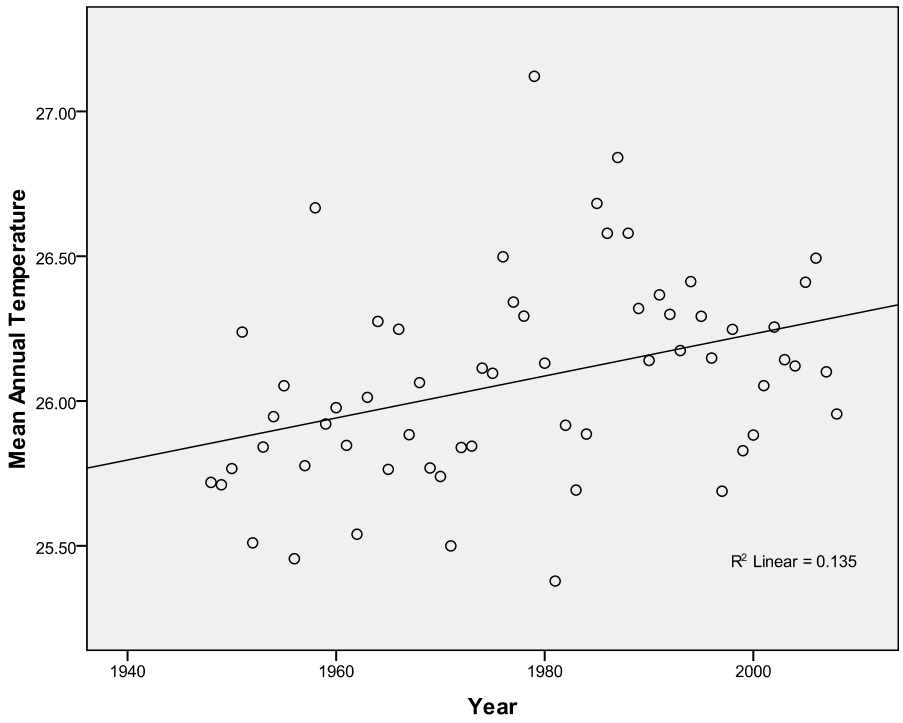


Figure 14 Trend in annual temperature

But no significant trend has been found in the mean annual rainfall. Though trend in the seasonal rainfall is showing an increase, but statistically significant trend has only been found in the case of winter seasonal rainfall which is estimated around 0.695 mm/year.

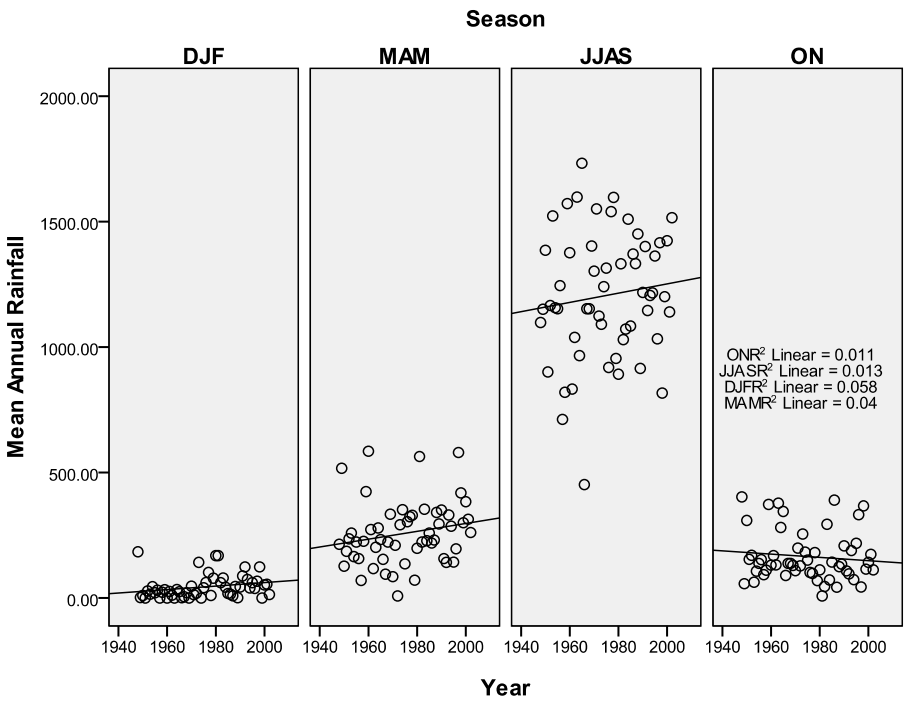


Figure 15 Trend in seasonal rainfall

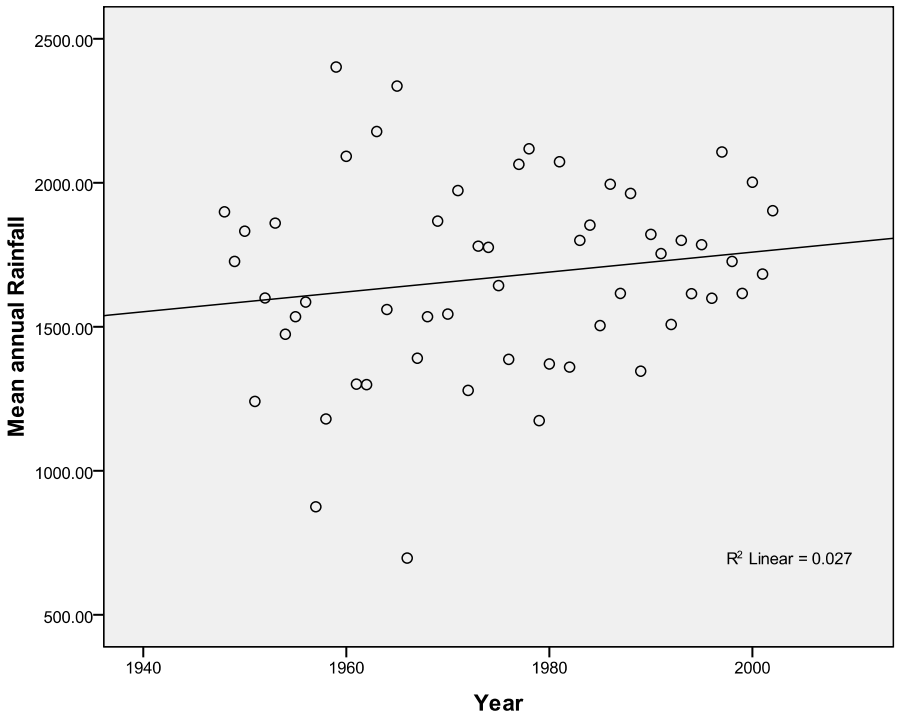


Figure 16 Trend in annual rainfall

RClimDex (1.0) software package is used in this analysis to assess the variability of different climatic extremes related to temperature and rainfall. It computes all 27 core indices recommended by the CCl/CLIVAR Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) as well as some other temperature and precipitation indices with user defined thresholds. Following are key findings of statistically significant trend on extreme climatic indices:

- Statistically significant increasing trend is observed in the annual total wet-day precipitation where the indices shows that amount of rainfall is increasing at a rate of 4.05mm per year
- Statistically significant increasing trend is observed in the annual count of daily maximum temperature above 31.25 ºC where the indices shows that maximum temperature is increasing at a rate of 0.316°C per year
- Statistically significant increasing trend is observed in the annual count of days when rainfall>=10mm and rainfall>=20mm where the indices show that amount of extreme rainfall is increasing at a rate of 0.108 mm per year and 0.141 mm per year respectively
- Statistically significant increasing trend is observed in the monthly maximum value of daily minimum temperature where the indices shows that temperature is increasing at a rate of 0.014°C per year.

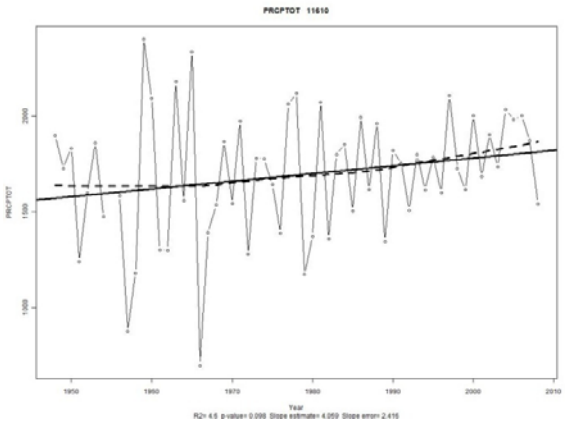


Figure 17: Trend in Annual total wet-day precipitation

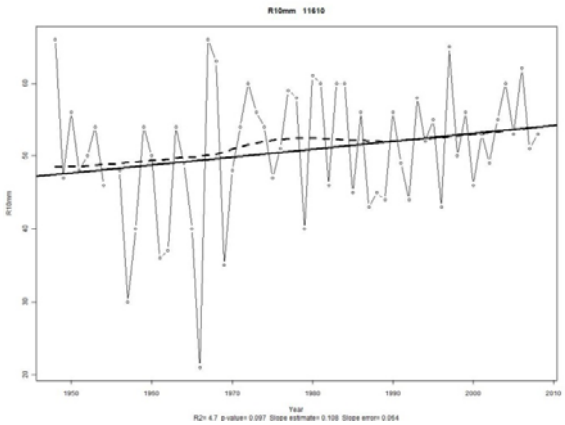


Figure 18: Trend in Number of heavy precipitation days of more than 10 mm rainfall/day

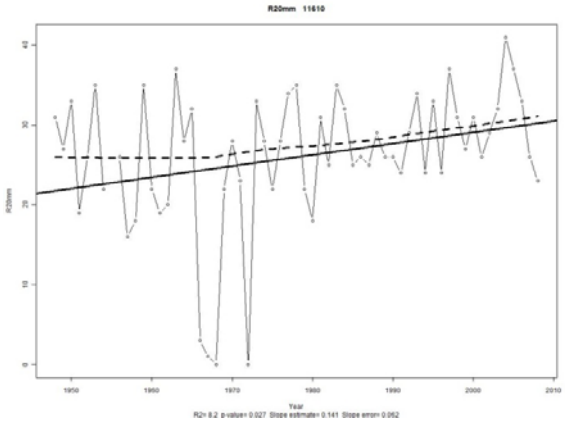


Figure 19: Trend in Number of heavy precipitation days of more than 20 mm rainfall/day

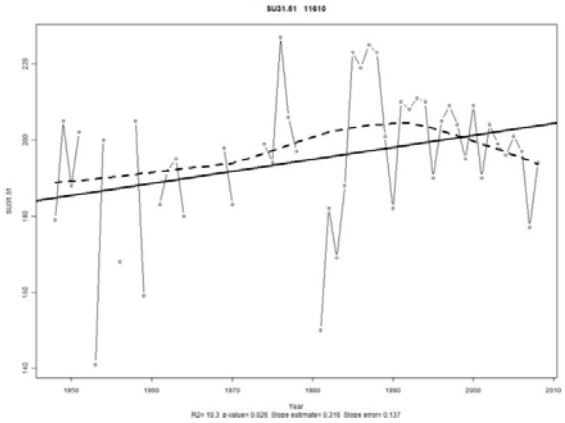


Figure 20: Trend in annual count when daily maximum temperature >31.25°C

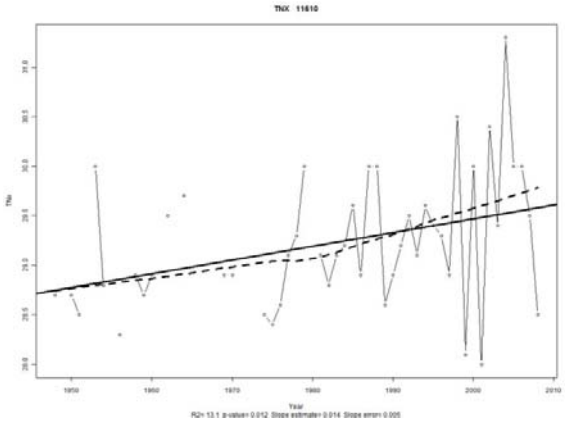


Figure 21: Trend in monthly maximum value of daily minimum temp

According to the widely used thematic map produced by FAO in 1988 on different agro-ecological regions in Bangladesh, Satkhira region falls under the central and southern sub region (11a). This region is a part of the High Ganges River Floodplain that includes the western part of the Ganges river floodplain which is predominantly highland and medium highland. Most areas have a complex relief of broad and narrow ridges and inter-ridge depressions. The upper parts of high ridges stand above normal flood level. Lower parts of ridges and basin margins are seasonally shallowly flooded. General soil types predominantly include calcareous dark grey floodplain soils and calcareous brown floodplain soils. Organic matter content in the brown ridge soils is low but higher in the dark grey soils. Soils are slightly alkaline in reaction. General fertility level is low.

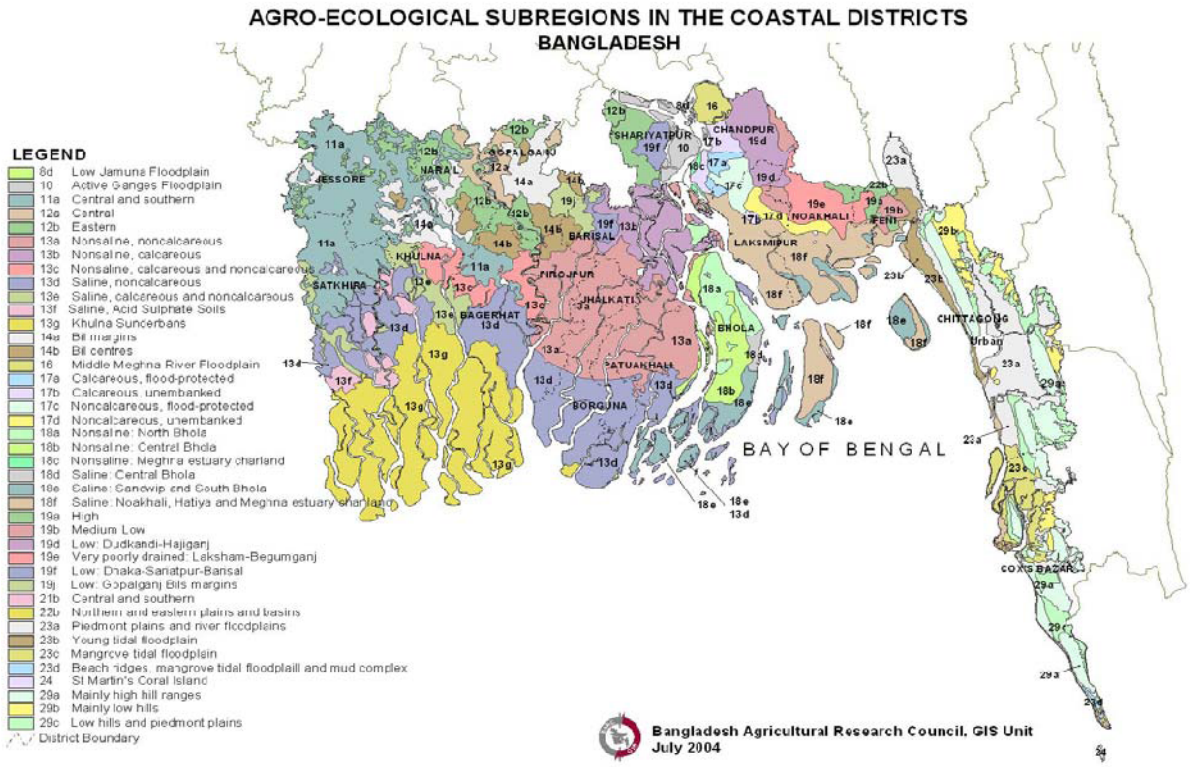


Figure 22: Agro-Ecological Sub-regions in the Coastal Districts

Later Water Resources Planning Organization (2005) provided a detail classification of coastal region based on existing land use characteristics. In this classification Satkhira sadar falls under the Shrimp (Brakish water) zone. The bagda cultivation is becoming more intensive in areas where saline water is available and land type is suitable for its cultivation. Bagda cultivation is done alone or with white fish or in rotation with paddy crops depending on land type classification and intensification of water salinity of the area. This zone lies under Gangetic tidal floodplain having mostly high to medium highlands and is almost flat and tidally flooded. The soils are mainly non-calcareous and saline which have severe limitations to crop cultivation especially in dry season. The zone is characterized by interconnected tidal rivers and khals (Creeks). In addition to bagda cultivation the upazilas are also used for agriculture (transplanted/broadcasted Aus - T. Aman- Fallow, Fallow - T. Aman- Fallow are the major cropping patterns). There are many fish processing centers and hatcheries exist in Satkhira Sadar.

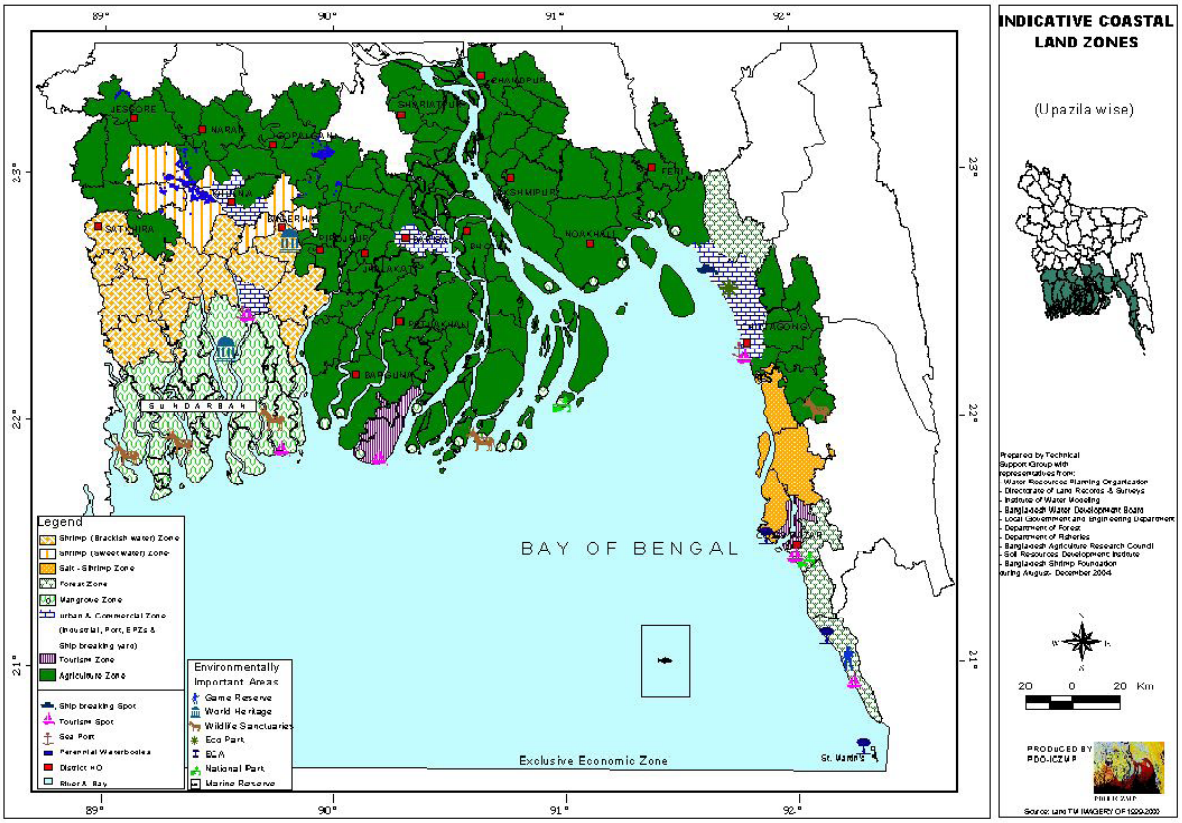
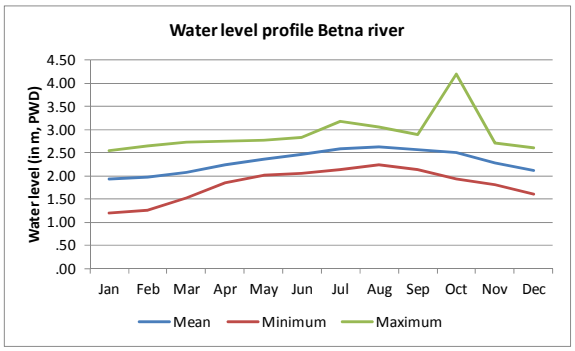
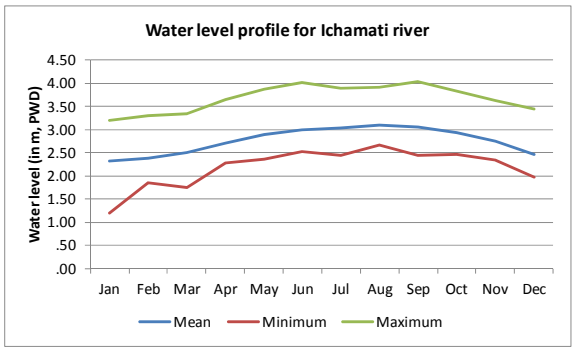


Figure 23: Indicative Coastal Land Zones

RIVER REGIME

The rivers that influences the surface water regime in the Satkhira Municipality are: Kabodak river, Morichap River, Kholpotua River, Betna River, Raimangal River, Hariabhanga River, Ichamati River, Betrabati River and Kalindi-Jamuna River. Out of these rivers, Betna flows from North to South Eastern boundary and Kholpetua flows from north to South western boundary of the municipality area. Ichamati and Kabodak play an important role in the surface water regime of the locality, though they flow through the outskirts of the locality. Moreover, Satkhira khal or Pran Shayer khal flows from north to south through the centre of the municipality and plays the most vital role in storm water drainage from the locality.





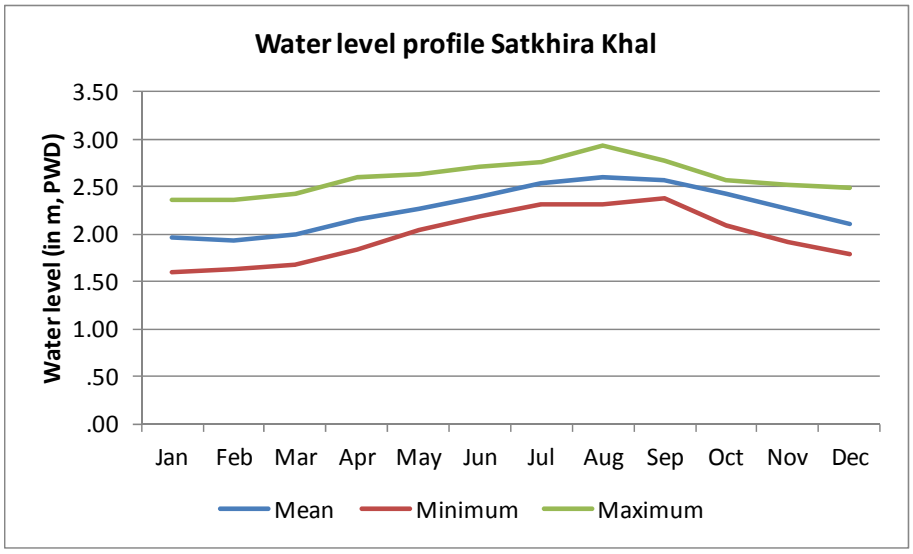


Figure 24: Water level profile of different rivers

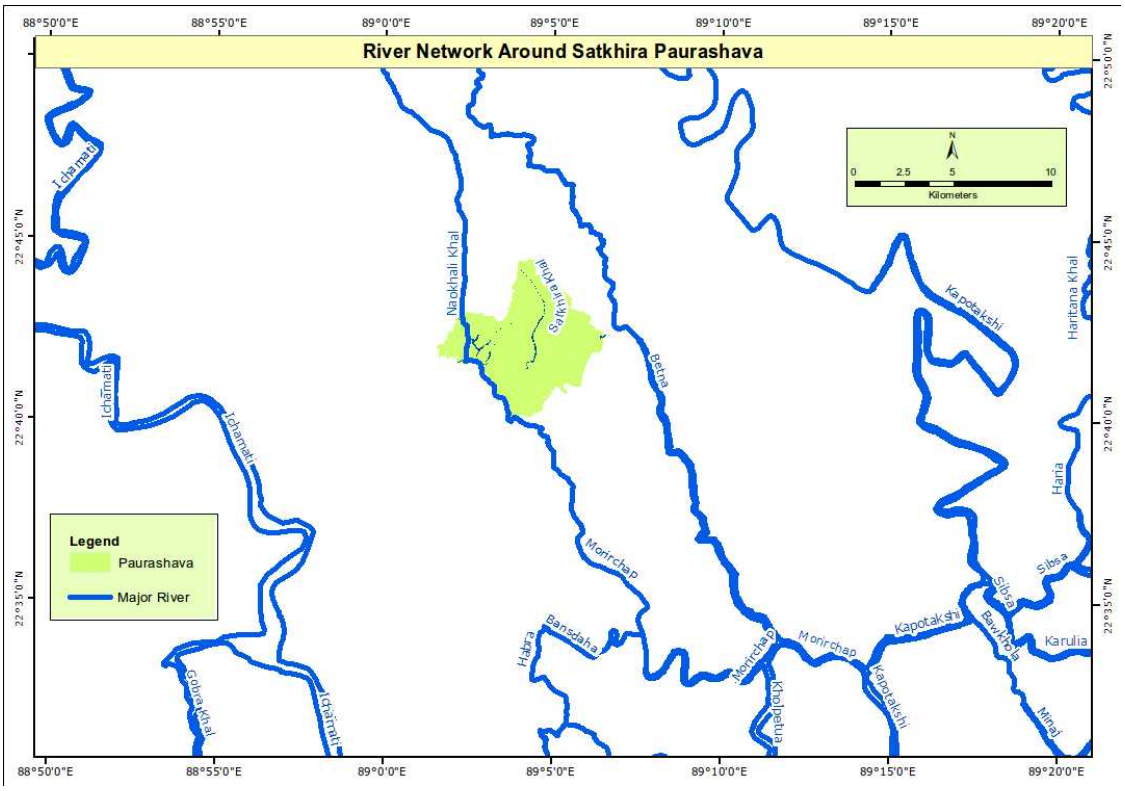


Figure 25: River network around the study area

In the Betna river, mean water level is 2.31 which varies between 1.20 to 4.21. In the month of august the mean water level reaches the maximum (2.63) and the variation ranges from 2.24 to 3.07. Mean water level in the Pran Shayer Khal (Satkhira Khal) varies between 1.59 to 2.94 with a mean of 2.28. Like Betna river, mean water level is highest in the month of august (2.60) and the variance is between 2.3 to 2.94. Ichamati plays a significant

role in the flood of year 2000, where mean water level stands at 2.76 and it varies between 1.20 to 4.04. August is the month of highest water level like others, when mean water level reaches 3.11 with the variance being between 2.67 to 3.91.

3.2 INITIATING CONTACT AND FINALISING KEY LOCAL STAKEHOLDERS

During the first visit, all relevant stakeholders were visited to identify the nature of business they are involved. Based on these visits, a number of potential stakeholders included Government agencies, Non-Government Organization, business people and civil society, political leaders, public representatives and journalists were invited to a half day workshop. Following is the outcome derived using tool no.1.

Figure 26: Some snapshots at pre-assessment stage

3.2.1 TOOL 1: IDENTIFYING KEY LOCAL STAKEHOLDERS

KEY QUESTIONS	Notes
Who should be included because of their relevant formal position (e.g., government authority)	Satkhira Municipality Authority is the local government authority responsible for urban development and management. Municipality is run by a Mayor and Councilors from nine different Wards. They are elected public representatives and have an administrative pool for day to day business. Satkhira Municipality is a part of Satkhira Sadar Upazilla under the Satkhira District Administration. District administration is headed by Deputy Commissionar (DC) and Upazilla Administration led by Upazilla Nirbahi Officer (UNO). Other relevant agencies could be Bangladesh Meteorological Department (BMD), Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED), Roads and Highways Department (RHD), Department of Environment (DOE), Office of the District Relief and Rehabilitation Officer (DRRO), Department of Agricultural Extension (DAE) etc. According to the Standing Order on Disaster issued by the Government, Municipality level disaster management committee is a formal body headed by the Mayor looks after overall disaster management activities of the municipality.
Who should be included because of their experience and knowledge (e.g., local community based organizations)	Local civil society members are the representatives of the society because of their experience, knowledge and their concern about the well being about the peoples. Municipality based Non-Government Organizations (NGO) are supposed to have better understanding of the local environmental challenges due to their involvement in the development activities.
Who should be included because of they have control over relevant resources (e.g., money, expertise)	Business people and land owners can fall under this category. Among the land owners, further classification can be made among the residential land owners, agricultural land owners, shrimp farmers, etc.
Who has power to promote, hinder or block the assessment process (e.g., lobby groups, vested interested groups and individuals)	Political workers (both from the ruling and opposition party), social activists and media personnel (both print and electronic) belong to this category.

3.2.2 TOOL 2: MATRIX FOR STAKEHOLDER ANALYSIS

Using tool 1, the potential stakeholders were identified and were invited to a half-day workshop. Tool no 2 was used to assess their potential partnership in this project to get the final list of stakeholders. Outcome of the stakeholder finalization process is listed below:

- Municipality authority plays the key role in urban development and management. But during the workshop representatives from other government agencies did not show up.
- From the NGOs, BRAC, Shushilan, Uttaran, Agragati, World Vision, LEDARS and Red Criscent found as potential contributor in the assessment process. Out of which LEDARS has agreed to provide man-power support in further assessment.
- Business people, agriculturalists, fishers, teachers, health workers, day-laborers, transportation workers from each nine wards agreed to participate in the further assessment process.

Stakeholders	Description of key interest	Description of key potential contribution	Partnership assessment Is their involvement: Essential: Process will fall without involvement Important: Process may suffer without it Minor: nice to have	
			Current	Potential
Government				
Municipality	Urban development and management of utility services	Provide support for baseline data on demography and urban settings Geo-spatial data of administrative boundary and key land use features within the municipality Validation of community perception of risks with respect to specific hazards	Essential	Essential
District and Upazilla (sub-district) administration	Coordinate and manage disaster management related activities of different government and non government agencies at district level	May facilitate coordination among different stakeholders for arranging the workshops at city and community levels and help validate the findings	Important	Minor

Stakeholders	Description of key interest	Description of key potential contribution	Partnership assessment Is their involvement: Essential: Process will fall without involvement Important: Process may suffer without it Minor: nice to have	
			Current	Potential
Bangladesh Meteorological Department (BMD)	Record historical database of climatic information which may help in detecting any evidence of change in the local weather pattern (rainfall, heat, cold and extreme events)	May help in drawing the baseline climatic profile Help identify variability in the climatic pattern Validate communities perception of extreme events	Essential	Essential
Bangladesh Water Development Board (BWDB)	Record historical database of hydrographic information which may help in detecting any evidence of hydro-meteorological hazards (like flood, drought, etc.) Implementing agency for infrastructural development (embankment, dam, bank protection, silt management, etc) in water sector	May help in drawing the baseline hydrological profile Help identify evidences of extreme hydro-meteorological events like flood, drought etc. Help in identifying the vulnerability of water management infrastructure to extreme events Validate communities perception of extreme events	Essential	Important
Local Government Engineering Department	Facilitate building infrastructure for communication, and other social services	Help in identifying the vulnerability of infrastructure to extreme events	Essential	Important
Roads and Highways Department	Facilitate construction and management of national highways	Help in identifying the vulnerability of national highways to extreme events	Essential	Important

Stakeholders	Description of key interest	Description of key potential contribution	Partnership assessment Is their involvement: Essential: Process will fall without involvement Important: Process may suffer without it Minor: nice to have	
			Current	Potential
Municipality Disaster Management Committee	Coordinate pre-,during and post-disaster events among GOs, NGOs and the communities	Help in identifying the risk areas with respect to specific hazards and hence identify the most at-risk community for detail community level risk assessment	Essential	Essential
NGO and CBO				
BRAC, Shushilan, Uttaran, Agragati, World Vision, LEDARS	Involved in different post-disaster relief and response activities in ad-hoc basis at the city level	Participate on the city level risk assessment process Help identify communities with differentiated physical, social, economic and environmental vulnerability	Important	Important
Red Criscent	Post-disaster relief and response	Articulate suggestions for early response and recovery to reduce community vulnerability	Important	Important
Business				
Business people (those who are involved in secondary level economic activities, e.g., wholesalers, retailers and exporters)	Uninterrupted economic gain from business activities	Help in assessing economic vulnerability of business sector at city and community scales	Essential	Essential

Stakeholders	Description of key interest	Description of key potential contribution	Partnership assessment Is their involvement: Essential: Process will fall without involvement Important: Process may suffer without it Minor: nice to have	
			Current	Potential
Farmers	Uninterrupted primary production from crop farming activities	Help in assessing economic vulnerability of crop based agriculture sector at city and community scales	Essential	Essential
Fishers	Uninterrupted economic gain from fish/shrimp farming activities	Help in assessing economic vulnerability of fish/shrimp based agriculture sector at city and community scales	Essential	Essential
Others				
Teachers, health workers, day-laborers, transportation workers	Uninterrupted livelihood protection	Help in assessing vulnerability of livelihood at community scales	Essential	Essential
Housewives and children	Uninterrupted day to day activities	Help in assessing the vulnerability at household and individual level	Essential	Essential

4 ASSESSMENT STAGE

4.1 CITY LEVEL RISK ANALYSIS

4.1.1 TOOL NO 4: HAZARD RANKING

Following are the key findings from the risk ranking procedure as outlined in the Tool No 4:

Water logging was identified as the main climatic hazard at the city scale. All nine wards reported water logging as a hazard and seven out of nine wards categorized it as “High”. The respondents mentioned the water logging event of year 2011 as the most devastating one, and they anticipated a regular recurrence of the same type of event in the coming years.

Monsoon Flood was identified as the second most disastrous climatic events at city scale. All the nine wards in the municipality have experienced this event to some scale, out of which three wards have mentioned the risk as “high” followed by five wards which have mentioned the risk as “medium” and one ward ranked the risk as “low”. Representatives from different wards have identified the flood event of year 2000 as the most devastating one.

Extreme heat was noted as the third most disastrous event at the city scale. Six out of nine wards have ranked the risk to the scale. Two out of six wards mentioned the risk as “high”, followed by three other wards ranked the risk as “medium” and one ward perceived the risk as “low”. Respondents from different wards observed the maximum risk exposure over the last few years.

Erratic behavior in the rainfall pattern was identified as the fourth most hazardous event at the city scale. Seven out of nine wards were exposed to this event to some extent. Two wards out of seven have identified the risk as “high”, followed by another two wards identifying the risk as “medium” and three wards have identified the risk as “low”. Respondents from different wards have identified the rainfall variability in year 2011 as the most devastating one.

Drought holds the similar rank with erratic behavior in the rainfall pattern at city scale. Eight out of nine wards ranked the severity of drought to some scale. One of of eight wards ranked the risk exposure as “high”, followed by three wards identifying the risk as “medium” and four wards ranked the severity as “low”. Respondents from different locality have linked the occurrences of erratic behavior in the rainfall pattern, extreme heat and scarcity of surface and ground water resources as the key drivers of drought in the locality.

Salinity intrusion holds the sixth rank in the city level assessment process. Three out of nine wards identified the risk to some extent. One out of three ranked the hazard exposure as “high”, followed by another identifying the risk as “medium” and one has ranked the risk as “low”. Respondents from different community identified it as a rapid progression event, caused due to increasing imbalance in the fresh and brakish water flow regime.

Hazard	High risk	Medium Risk	Low Risk
Water logging	W-1 W-3 W-5 W-6 W-7 W-8 W-9	W-2 W-4	
Monsoon flood	W-2 W-6 W-8	W-1 W-3 W-5 W-7 W-9	W-4
Drought	W-5	W-3 W-6 W-9	W-1 W-2 W-4 W-8

Hazard	High risk	Medium Risk	Low Risk
Erratic rainfall pattern	W-2 W-5	W-6 W-8	W-1 W-3 W-7
Extreme heat	W-6 W-9	W-1 W-2 W-3	W-4
Salinity	W-6	W-7	W-2

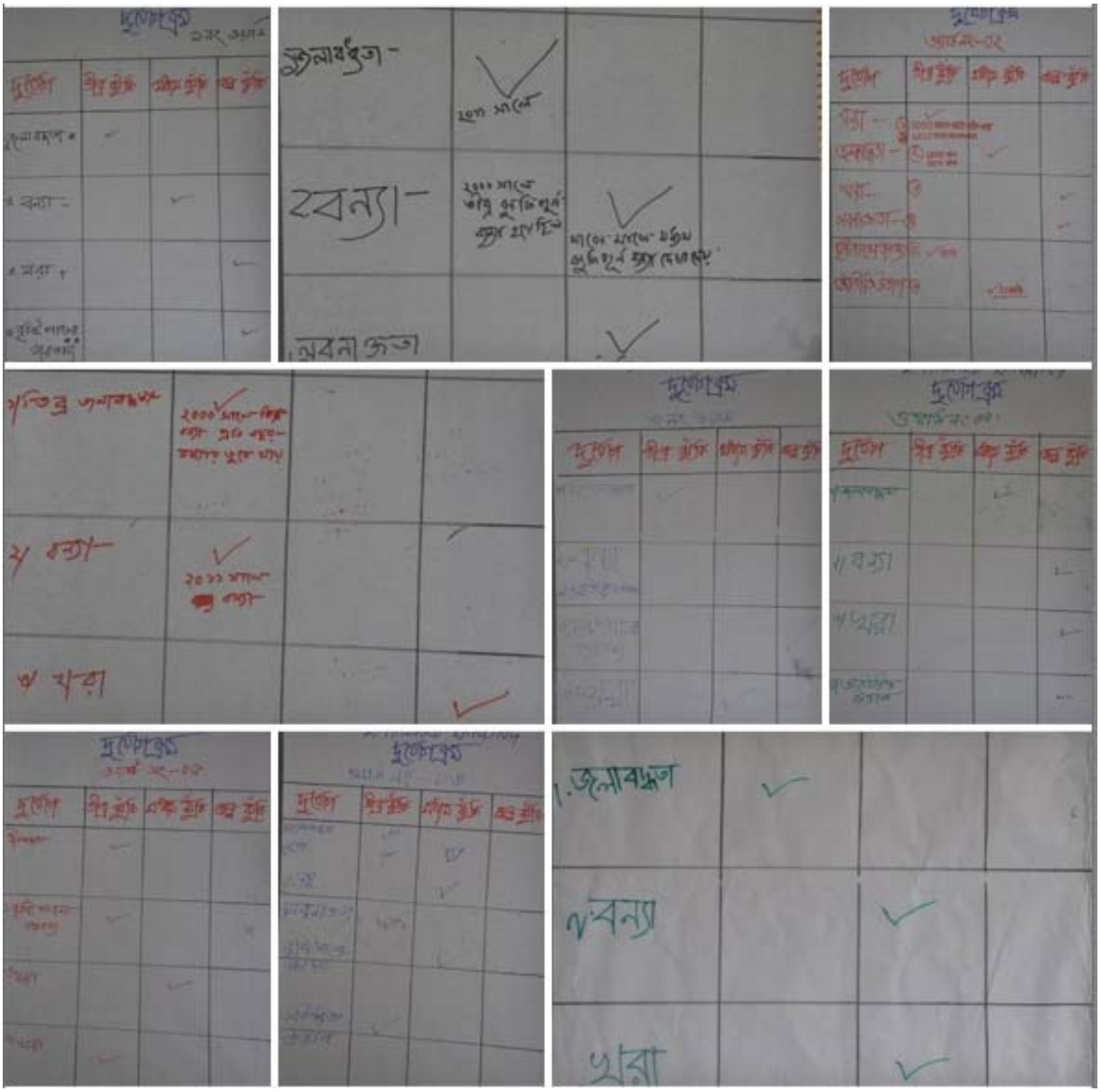


Figure 27: Hazard ranking at city level

Figure 28: Some snapshots of hazard ranking at city level

4.1.2 TOOL NO 3: HAZARD MAPPING

Participant from nine different wards were divided into nine groups. Representative samples were composed of GO, NGO and business people. Each group was given the task to portray the spatial extent of climate change induced natural hazards in their respective locality. Outcome of the hazard mapping procedure in line with the Tool No. 3 is shown below.

In the process, ward no 9 was selected as most “at-risk” community, mainly due to relatively high exposure to hazards as well as perceived vulnerability of population and different productive sectors.

Figure 29 Some snapshots of hazard mapping at city level

Figure 30: Outputs of city level hazard mapping

4.1.3 TOOL NO 5: TRANSECTS

City level transects were supposed to be conducted using tool no 5, but sufficient participants were not found to carry it out as per the prescribed methodology. To make it up, the research team identified a technical tool using the remote sensing imagery and digital elevation model. Following are the outcome of the transects:

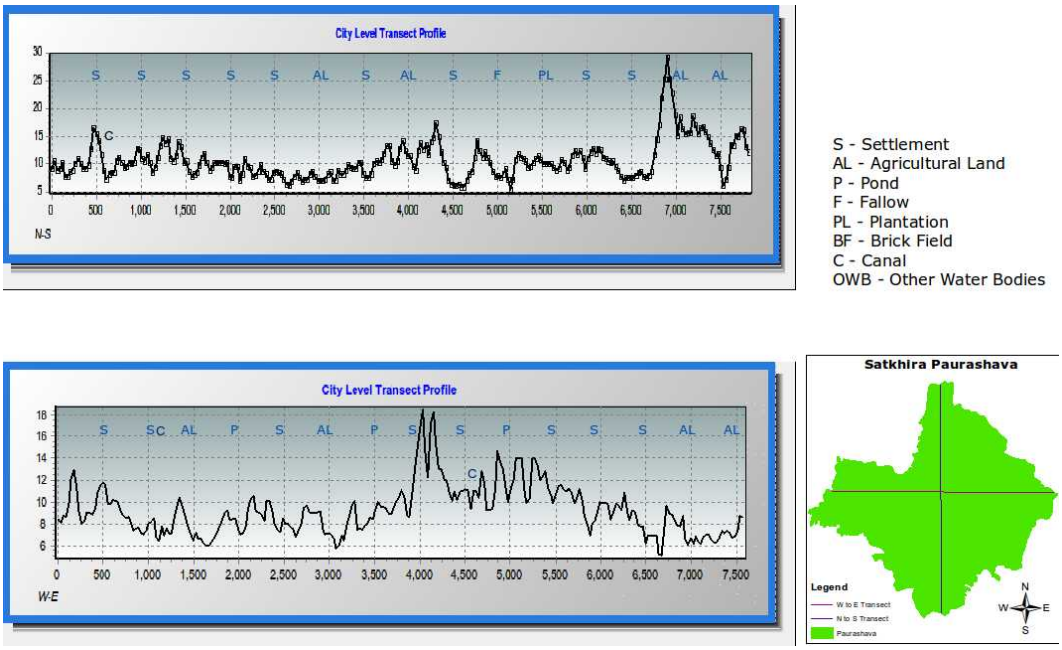


Figure 31: City level transects

4.1.4 TOOL NO 6: SCENARIO ANALYSIS

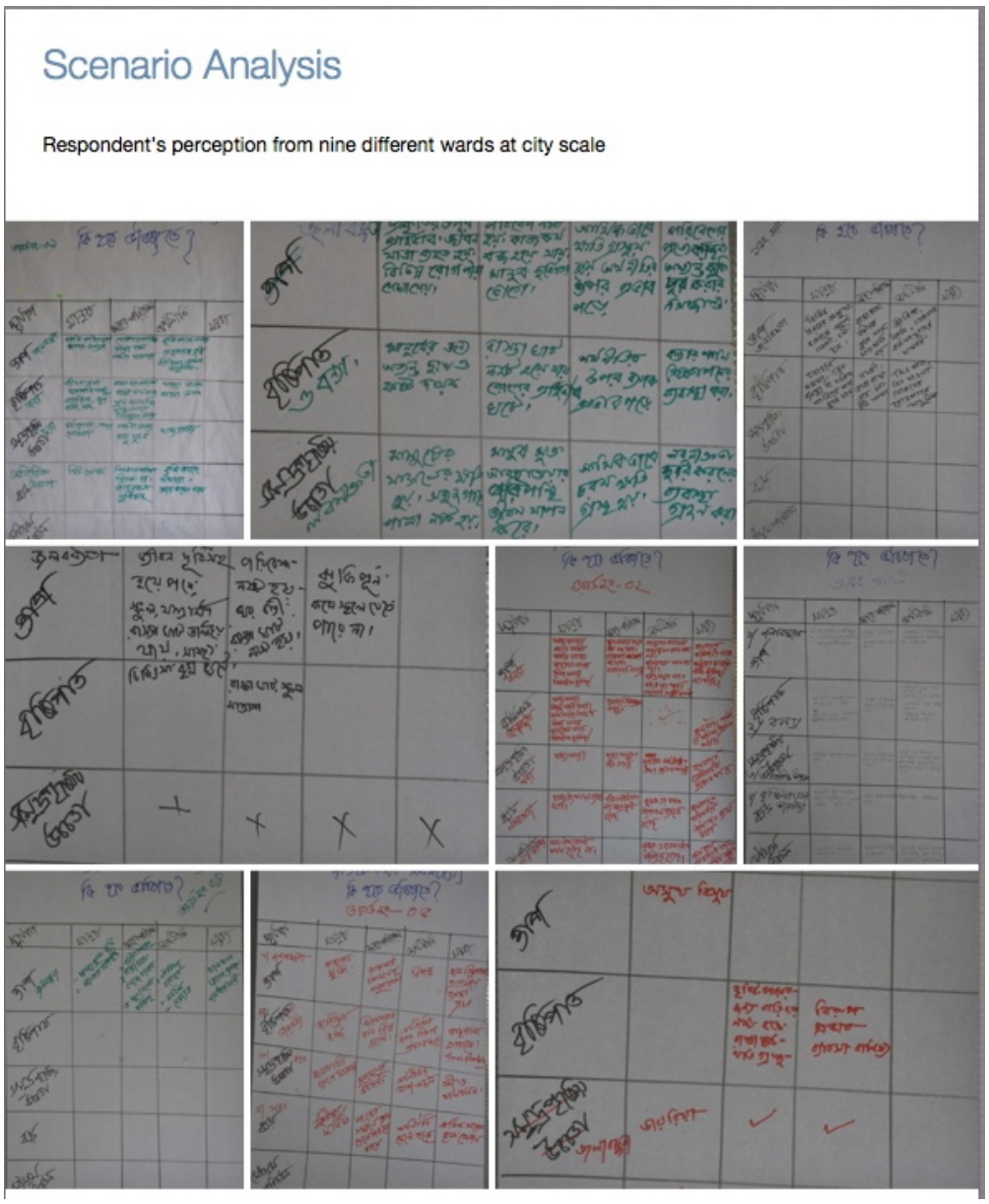
Vulnerability and capacity of three key sectors, i.e., human, built environment and economy were identified using the scenario analysis tool. At the city scale, responses from respondents from different wards are summarized below for individual hazard events:

Key projected climate change	Impacts			
	People	Built environment	Economy	Comments
Water logging	Spread of diseases, Difficulties in communication Unlivable condition Food insecurity Potable water scarcity Spread of vector borne disease due to outspread of mosquitoes and flees Spread of water borne diseases like diarrhea Threatened childhood	Inundation of roads, homesteads causes damage to physical infrastructure Damage to educational infrastructure Bio-physical environmental degradation	Insecurities in livelihoods and lack of employment opportunities arising from difficulties in communication Poor peoples are getting poorer Creates temporary unemployment People suffer financially	Climate change is altering the incidence of water logging Re-excavation of drainage canals, creation of retention ponds may help in improving the situation

Key projected climate change	Impacts			
Monsoon flood	Bring sufferings to peoples lives Food insecurity Potable water scarcity Child and adult health related problems Outbreak of water borne diseases	Damage to roads leading to difficulties in communication Peoples taking shelter in school and colleges suspending their regular activities Outbreak of diseases in the built environment due to bio-physical degradation	Insecurities in livelihoods and lack of employment opportunities arising from difficulties in communication Poor peoples are getting poorer Price hike of food commodities	Climate change is putting life and livelihood at risk Increase the conveyance capacity of rivers and canals
Drought	Food insecurity May lead to famine like situation Skin disease and blistering	Incidence of drought in the neighboring locality is pushing peoples towards the city Scarcity of potable water Air pollution arising from increasing suspended solids in the air	Economic conditions of the farmers are getting worse Price hike of agricultural commodities due to reduced supply resulting from decrease in production	Climate change is affecting the agricultural sector negatively. Afforestation might help in improving the situation

Key projected climate change	Impacts			
Erratic rainfall	Heavy rainfall causes drainage congestion leading to difficulties in communication that creates problem for inhabitants	Overflow of ditches and damage to roads cause huge communication problem Fall of living standard	Peoples who live hand to mouth faces problem in earning Increase in poverty incidence Decline in crop yield due to variability in the rainfall timing Farmers and business people are getting affected Excessive rainfall submerge crop land resulting in yield reduction Damage of perishable agricultural commodities	Afforestation might help in improving the situation
Extreme heat	Outbreak of diseases Restricted internal mobility of city dwellers Incidence of heat stroke	Sufferings in everyday life Disrupted education	Price hike of everyday commodities due to interrupted communication Hindrance in agricultural production lead to loss of income	

Key projected climate change	Impacts			
Salinity	Food insecurity	Incidence of salinity in the neighboring locality is pushing peoples towards the city Uncomfortable living condition due to salt concentration in the air	Drop in agricultural production Peoples suffers financially	Climate change is affecting the agricultural sector negatively. Measures should be taken to remove salinity



4.1.5 TOOL NO 7: KEY INFORMANT INTERVIEW

A meeting with the civil society representatives and journalists was arranged separately to carry out the Key Informant Interview (Tool 7).

Figure 32: Session for key informant interview

At first the respondents were given a briefing on the objective of the project. The interview checklist was followed thoroughly for the enquiries and the outcome was synthesized as follows:

OCCURRENCES OF EXTREME WEATHER EVENTS:

- Excessive rainfall in 2011, water logging
- Extreme river flood in 2000
- Extreme tornado in 1987, and cyclone in 2007and 2009

- Salinity intrusion
- Hail storm in 2011

EXPERIENCE OF THOSE EVENTS AND PERCEIVED CHANGES

- Most of the city lands mass were inundated due to the occurrences of heavy rainfall event during 2011. Water logging last for more than three months. Affected peoples took shelter in the local schools which had to shut down their regular academic affairs. Some NGOs arranged relief in terms of food and health care facilities and some also rendered their services for the house reconstruction. Water logging situation is further aggravated due to variability in the tidal bore. Some of the key observations in this aspects are:
    - Tide height is increasing;
    - Frequency of natural disasters is on rise
- In 2000, Satkhira locality was affected severely due to river flooding. It was not happened due to heavy rain inside the country, rather sudden intrusion of flood water came from the neighboring country due to failure of water infrastructure.
- The locality was affected by a tornado in 1987. But the effect of devastating cyclone SIDR and AILA was not much in the city area, but these two events lead to serious in migration of rural people to Satkhira town. Following are some of the key facts related to migration:
    - People from Sidr and Aila affected area are moving to the city because of loss of productivity in the rural areas; they cannot use the land for primary production purposes
    - Migrants suffered further in 2011 flood
    - 25% increase of population in town
    - Land price going up; migrants purchasing land in town
    - Some people from around the area are migrating to Khulna as well
    - Displaced men leaving wives back home; getting married to in Dhaka or other cities; leading to social crises
- Salinity intrusion is a rapid progressing event. Particularly, the city is in deep crisis of potable water and agricultural lands located at the outskirts are in danger due to salinity. Following are the key observations regarding salinity:
    - Salinity is increasing; excessive extraction of ground water is aggravating the situation;
    - Mainly water salinity and soil salinity are among the problems
    - Agricultural land and water supply in and around the city will get affected
    - Land subsidence might aggravate the salinity situation
    - Peoples experienced huge devastation of crops cause by a hail storm in 2011. They have reported unusually big size of hails in the recent years. In addition to this, peoples also reported about notable variability in the weather events. Some of their experiences are:Erratic heat-cold spells
    - Cold: mild to severe
    - Hot: mild to severe
    - Shift in seasons
    - Early bloom in mango plants; later no fruits
    - Apprehend low production of mangoes
    - Increased poverty level and less food production in rural areas lead to migration to the city

In addition this, people also reported significant increase in the health hazard, which they linked with climate change. These include:

- Heart failure: young people die
- High incidences of skin diseases
- Sudden death at45-55yrs
- Increase in diabetics and hypertension
- Increase of diarrheal diseases

PERCEIVED SOLUTIONS

- Polder system should be equipped with appropriate drainage infrastructure like sluice gates
- Catchment area and flow should be calculated and drainage canals should be re-excavated based on that capacity
- Local influential people might impede the maintenance process of natural drainage system since this might have to trade off with their interests; this should be prevented
- Dike height might require to be heightened
- Land use zoning for agriculture, fish and industry is deemed essential
- Crop diversification is necessary
- Water use policy is required
- Recycle of urban water

4.2 COMMUNITY LEVEL PARTICIPATORY RISK ANALYSIS

4.2.1 TOOL NO 8: COMMUNITY PROFILING

Key aspects	Notes
Population	30,000-40,000
Area (size of the area)	North to South: 2.0-2.5 km East to West: 1.5-2.0 km
Age of settlement (take into account stages of growth)	Typically this locality is around a hundred year old, settlement type has been upgraded over last few decades
Typical incomes	Monthly income range % of household BDT 3,000-10,000 50% BDT 10,000-15,000 33% More than BDT 15,000 17%
Typical livelihood	Agriculture (5%) Service (20%) Business (30%) Day labour (25%) Teachers (10%) Doctors (10%)
Location	The area in bounded by the Pran Shayer khal which enters from the north-west part of the locality and flows along the eastern boundary, Jessore-Satkhira highway crosses the locality from the north western part to south central region. In the south, two localities named as Bakchara and Polashpole are situated on the west and east boundary.
Environment	Mostly built environment with disperse agricultural land and water bodies.

Key aspects	Notes
Settlement characteristics: Typical housing, roads, infrastructures , services etc.	Settlement and roads: 70% Offices and commercial facilities: 20% Agricultural land and water bodies: 10%

4.2.2 TOOL NO 9: HAZARD MAPPING

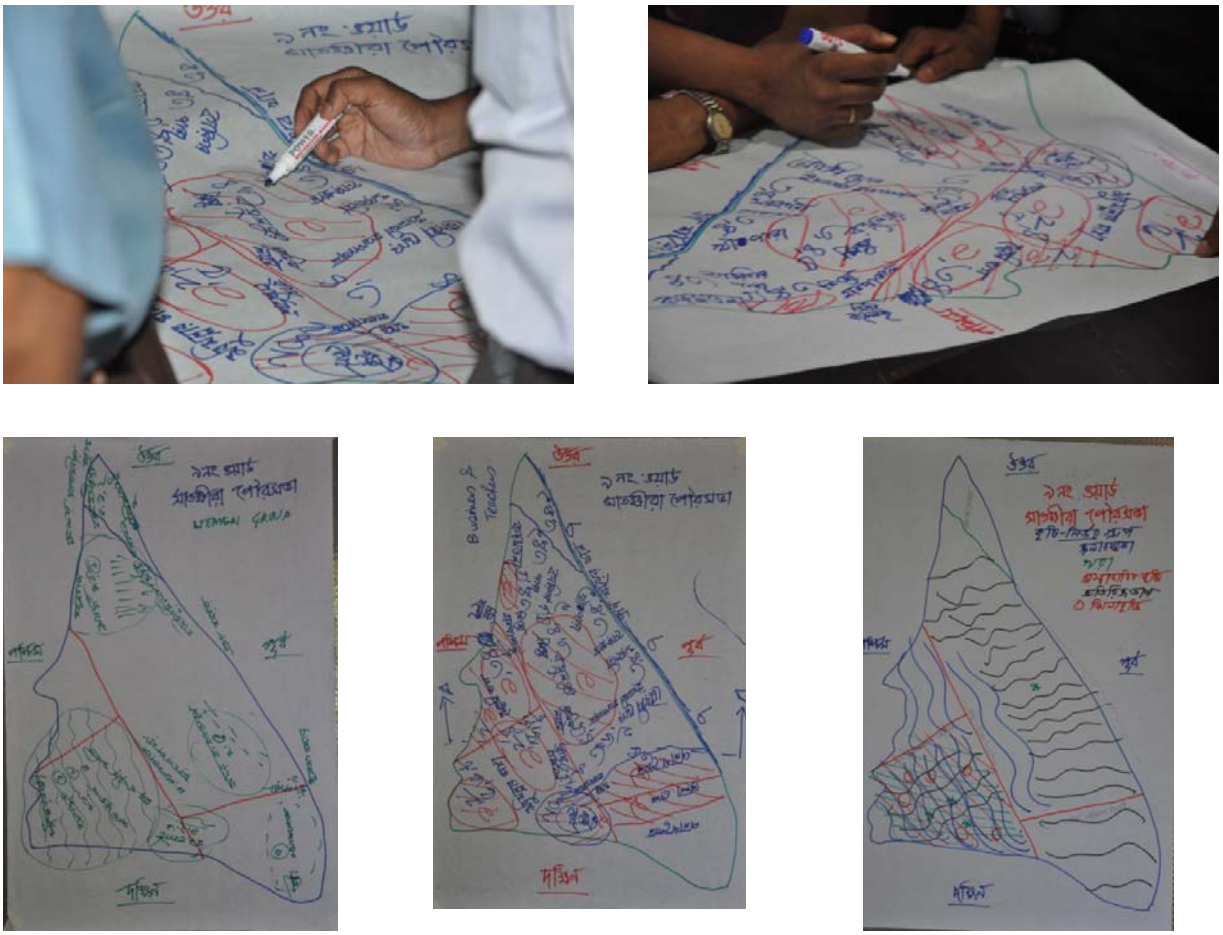


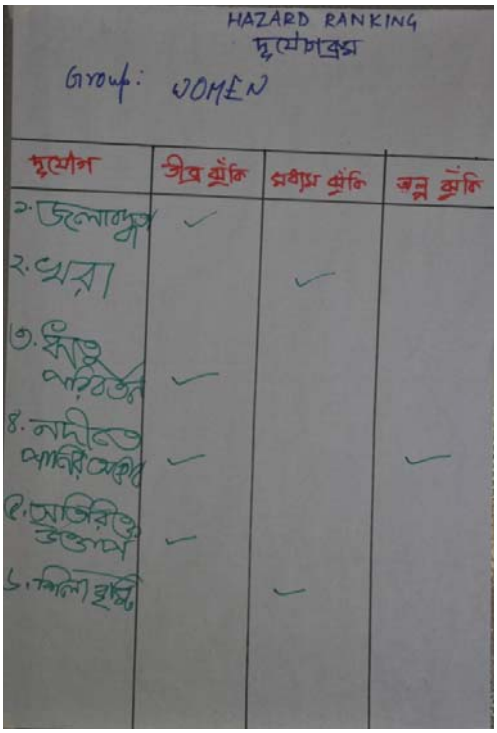
Figure 33 Community level hazard mapping for ward no 9

4.2.3 TOOL NO 10: HAZARD RANKING

Respondents were arranged into three major sub-groups:

- agriculturists and fishers,

- teachers, service holders and businessman
- women and children



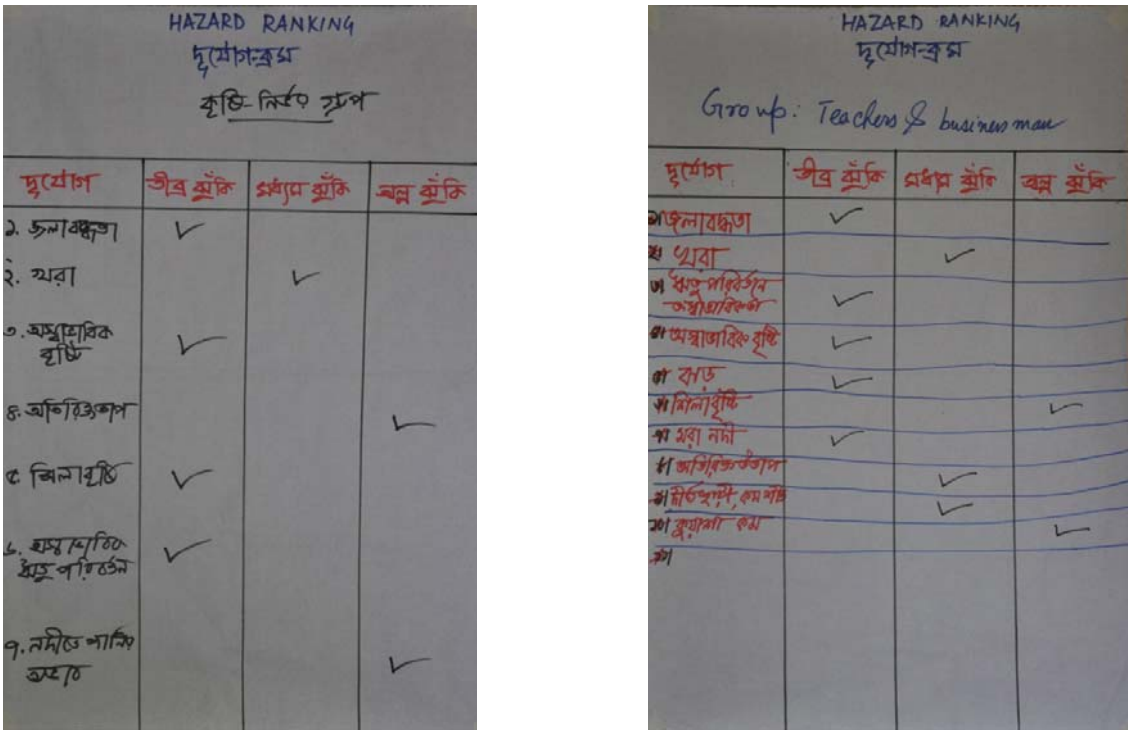


Figure 34: Hazard ranking for ward no 09

Response from each group was summarized to rank individual hazards which are stated below:

- Water Logging was identified as the top most hazards by all the sub-groups.
- Variability in seasonal characteristics has been ranked as the same severity along with water logging.
- Reduced flow in the rivers has been ranked as third risky hazard at the community scale. Agriculturists and fishers have ranked the risk as low, but other two groups ranked it as high.
- Incidence of drought has been ranked in the fourth when all the three groups ranked the risk as medium.
- Erratic rainfall has been ranked in the fifth, where women didn't recognize the risk at all and other groups identified the risk as high.
- Extreme heat holds the same rank as erratic rainfall, while women identified the risk as high followed by the group of teachers, service holders and business man's ranking as medium and low ranking by the agriculturists and fishers.
- Risk of hail storm holds the same severity rank as erratic rainfall and extreme heat. Agriculturists and fishers identified the risk as high, while women group identified the risk as medium followed by the group of teachers, service holders and businessman identifying the risk as low.
- Risk of mega storms and cyclones were only recognized by the teachers, service holders and business man as high risk category event resulting it's combined risk rank in the eighth position.
- Long duration warmer winter event was only identified as moderate risk event by the teachers, service holders and business man group and this event hold the last rank in the combined evaluation.

4.2.4 TOOL NO 11: TRANSECT WALK

Figure 35: Community level transects

4.2.5 TOOL NO 12: LONG TERM TRENDS

Year 1990 has been considered as the baseline year to analyze the long term trend in heat, rainfall, water logging and drought. Summary of trend analysis is listed below:

Surface warming or incidence of heat has been reported to be increasing progressively from 1990 through 2012 and is apprehended to further increase in the years to come

Erratic pattern in the rainfall has been observed over the years with a notable variability over last decade. This erratic behavior of the rainfall, according to the community perception, is likely to sustain in future.

In the 1990's no incidence of water logging was reported by the community. But the unprecedented flood in the year 2000 induced some water logging in the city which became more evident in the following years. The worst water logging event took place in the year 2011 when short duration heavy rainfall submerged the locality for more than three months. This was aggravated due to clogging of natural drainage channels. Since there has been no significant improvement in clearing the impediments the community feels the threat of recurrence of such event with an increased intensity in the coming years.

Drought event was not observed during the 1990's. But over the last two decades short term drought events are in increase. In the coming years, this event is anticipated to be more evident.

4.2.6 TOOL NO 13: KEY INFORMANT INTERVIEW

Three respondents were identified as key informants from the community level risk assessment workshops. These three peoples were from three different occupation groups (one from business, one from service and one from teaching). They were interviewed separately following the interview checklist in Tool 13. No significant variation with the above observation was found with the city level key informant interview findings.

5 CONCLUDING REMARKS

The major findings using the tool kit in Satkhira town are not much different from the ones already perceived and discussed in many literature. The participants in workshops almost unanimously agreed that hydrological hazards are becoming more and more evident over the past years. Though the participants were not much aware of the issues of climate change, they recognized that the extent of these hazards (Waterlogging, due to intense rainfall, etc) are increasing unusually. It is to be noted that Satkhira town, being secondary in nature, has a mixture of rural and urban characteristics. The city characteristics of Satkhira municipality are not as much distinct as in mega cities like Dhaka. Like all of the secondary cities, Satkhira municipality attains the urban characteristics progressively, as one moves from the rural fringe to the centre of the town. This is important because, when we are trying to assess climate change risk of secondary cities, we cannot eliminate generic risk issues which pertain to rural areas from consideration, at least not in the case of secondary cities in Bangladesh.

The researchers tried to follow the tool kit in every step of the assessment process; whenever the response from the participants in terms of understanding the key task was identified to be insufficient, the team tried to improvise the specific tool, keeping in mind the specific objective. This has been indicated under the tools where such modifications were necessary.