D E C C M A

POLICY BRIEF

June 2018

Mapping Current and Future Salinity Risks: A Pre-requisite for Defining Adaptation Requirements

While salinity hazard maps are useful in analyzing the impacts of climatic or anthropogenic drivers (e.g. reduction of freshwater flow because of climate change and/or flow diversions, accompanied by sea level rise) on changes in salinity, salinity risk maps are specifically useful in identifying salinity 'hotspots' where risks will grow and adaptations will be required, and determining adaptation options which would minimize risk via hazard mitigation and/or exposure/vulnerability reduction. In coastal Bangladesh, salinity risks will grow differently at different rates at different locations. Dominant adaptation deficiencies and hence adaptation requirements can be determined using the risk assessment framework, which is useful for identifying investment priorities.

Background

Salinity, associated with surface water, groundwater, and soils, is a major hazard in the coastal zone of Bangladesh, which adversely impact agricultural yields, deteriorates drinking water supplies, and increases the risks of health problems. While hazard maps have been conventionally used in analyzing the impacts of climatic or anthropogenic drivers on changes in salinity, risk maps are now widely considered more useful in identifying current and future 'hotspots', the degree by which risks will grow and what types of adaptations will be required. According to IPCC AR5, risk is a non-linear function of hazard, exposure, sensitivity, and adaptive capacity.

In DECCMA study, we produce baseline salinity hazard and risk maps and investigate how risks might change in the future. We also calculate where risks will grow substantially in the future and analyze the adaptation measures that will be most effective in reducing components of risks.

Methods

To locate salinity hotspots in the delta, we followed the IPCC AR5 approach, which defines risk as the function of hazard, exposure, and vulnerability. Vulnerability is viewed as sensitivity minus adaptive capacity.

Salinity hazard was assessed by salinity magnitude in estuaries and rivers, with both sea-level rise (SLR) and changes in upstream discharges considered during salinity hazard simulation. Mid-century scenarios were constructed with a sea level rise of 26 cm accompanied by changes in climate, simulated via climate models. We used a hydrodynamical model (Delft3D), set up for the coastal zone of Bangladesh including the Bay of Bengal, to simulate salinity hazards in base condition and future scenarios. Using UK Met Office climate model data, the upstream flow boundary conditions for the model were generated by a basin-scale (Ganges-Brahmaputra-Meghna systems) hydrological model and downstream boundary conditions were generated by an oceanographic model.

Parameterisation for socio-economic vulnerability followed a number of steps. Out of a selected set of 30 indicators, the most sensitive socio-economic indicators were determined using a non-linear optimization model, with the weights for individual indicators computed by Principal Component Analysis (PCA). The exercise yielded 3 indicators for exposure, 4 indicators for sensitivity and 7 indicators for adaptive capacity (Table 1), which were all used to determine salinity hotspot in base condition.

Table 1: List of parameters for different components of salinity risk

Exposure
Cropped Land Number of Household Population Density
Sensitivity
Disabled people Dependent people Female to male ratio Poverty Rate
Adaptive Capacity
Aquaculture Growth Centre Cropping Intensity Loan Literacy Rate Polder Irrigation facilities

For future hotspots, future projections were made till mid-century (i.e. 2050) for the parameters except the adaptive capacity parameters, which were kept the same as the baseline estimates. This was done deliberately as measures to increase adaptive capacity were viewed as policy choices to be made by the government to reduce the increased salinity risk.

Among the exposure parameters, cropped land is projected by using land use land cover map projection, while population density and household numbers are projected by using projected population data from secondary sources. Among the sensitivity parameters, a linear regression model was used to project poverty rate and female to male ratio was projected by using projected population data, while the two other parameters, disabled people and dependent people, could not be projected due to lack of data and hence were kept the same as baseline estimates.

Hotspots due to salinity were determined based on: (1) Base risk; (2) Future risk; and (3) Increased risk in future.

Adaptation demands in the risk areas were determined following an optimization approach, wherein the most effective adaptations were ascertained that would minimize the salinity risk via reduction of hazard or exposure or vulnerability or combination of these. Adaptation deficiencies were computed by considering present status of adaptation (base condition) and required quantity of adaptation to minimize the future salinity risk.

Key findings

Hazard and risk maps are not necessarily similar

Dissimilarity between hazard and risk maps stems from the fact that risk depends not only on hazard, but also on exposure and vulnerability. High salinity hazard areas may represent low risk if exposure is less or adaptive capacity is high, while moderate hazard areas with high exposure and/or vulnerability may represent high risk areas.

The salinity hazard in the western region (Satkhira, Jessore, Khulna and Bagerhat districts) varies from medium to very high (Figure 1). However, with high to very low exposure and vulnerability, the region has salinity risk varying from high to very low. But with a similar pattern in hazard as in western region, the eastern region (Feni, Noakhali, Cox's Bazar and Chittagong districts) has higher risk, varying from medium to very high, because of higher vulnerability. Both salinity hazard and salinity risk in the central region (Barisal, Patuakhali, Jhalokathi, Pirojpur, Shariatpur, Gopalganj, Chandpur, Laskmipur districts) remain as low to very low because of low hazard, even though vulnerability in this region is high.

In the western region, high exposure is contributed by higher concentration of cropped land and low exposure is contributed by lower concentration of both cropped land and population density. In the eastern region, high population density and higher number of households result in high exposure, while low exposure is contributed by low concentration of cropped land. In general, vulnerability is relatively high in the eastern region because of low adaptive capacity and relatively low in the western region because of high adaptive capacity because of higher concentration of aquaculture, better irrigation facilities, and better coverage by polders.

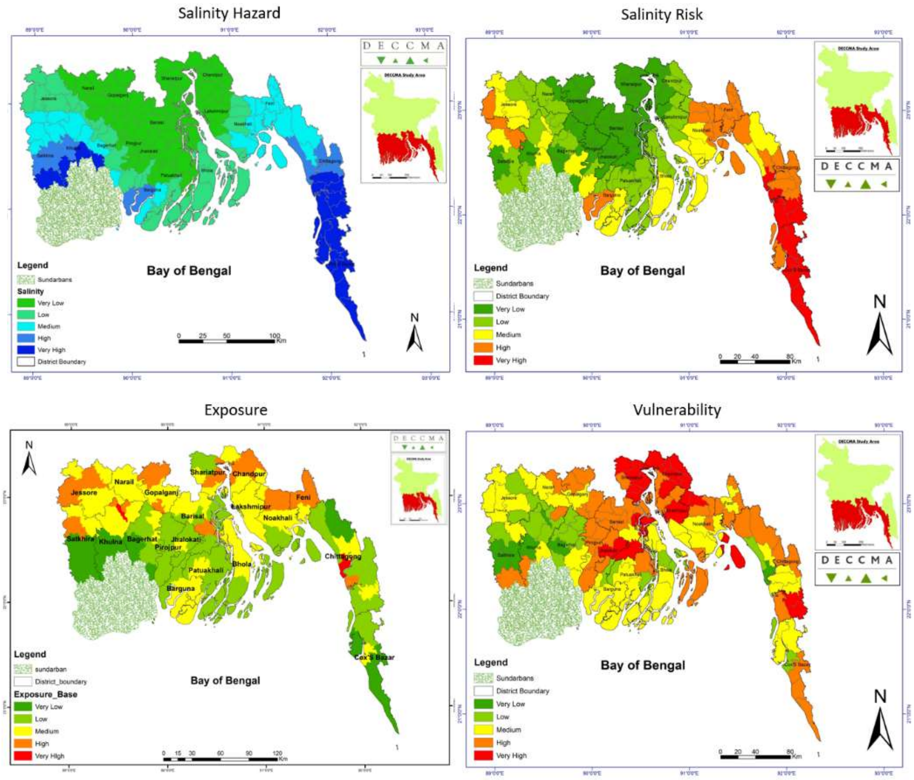

Figure 1: Distribution of salinity risk parameters in coastal Bangladesh in base condition

Salinity risks will grow differently at different rates at different locations

Most of the hotspots of salinity are distributed in the western and eastern regions (Figure 2). Few hotspots are in the exposed coast of the central region. Due to increased salinity hazard and changing exposure and sensitivity parameters in future scenario, hotspot locations are not the same in base condition and in future. In some locations of both western and eastern regions, risk remains high both in base and future conditions. These are locations where risk increases at a faster rate in future. A total of 21 baseline risk hotspots and 20 future risk hotspots are identified. There are 17 hotspots where salinity risk will grow in the future.

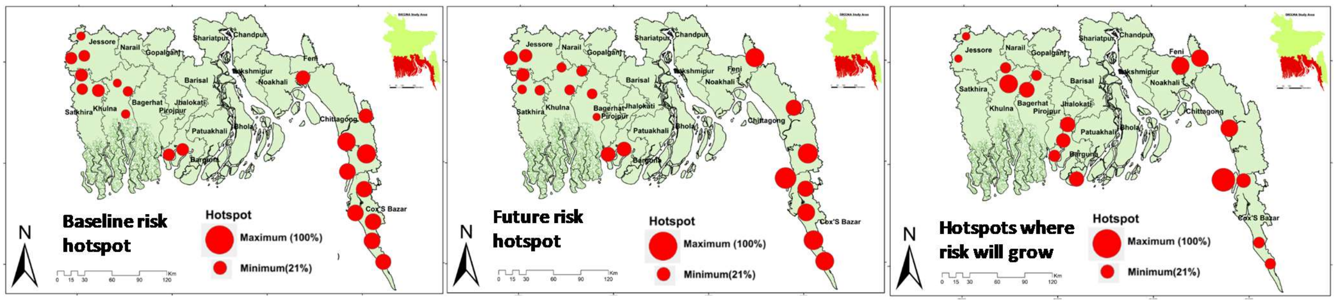

Figure 2: Salinity risk hotspots: (a) base condition; (b) future condition; (c) where risk will grow

Adaptations required to minimize future salinity risk

Adaptation deficiencies, computed by considering present status of adaptation (base condition) and required quantity of adaptation to minimize the future salinity risk, shows spatial variability (Table 2). Dominant adaptation requirement includes ‘aquaculture’ in the eastern region (Cox’s Bazar and Chittagong districts), and ‘irrigation facilities’ in the western region (Jessore, Bagerhat, Khulna and Satkhira districts). These are consistent with the baseline adaptive capacities in the coastal region (Figure 3). Table 2 provides the top three investment priorities which will minimize future salinity risks in the region.

Table 2: Adaptation deficiencies in future salinity risk hotspot locations

District	Upazilla	Adaptation Deficiency
Cox'S Bazar	Kutubdia	1. Aquaculture (65%); 2. Growth center (59%); 3. Irrigation facilities(46%)
Cox'S Bazar	Ukhia	1. Aquaculture (93%); 2. Irrigation Facilities(92%); 3. Polder(91%)
Cox'S Bazar	Teknaf	1. Aquaculture (75%); 2. Irrigation Facilities(74%); 3. Literacy Rate(62%)
Cox'S Bazar	Chakaria	1. Irrigation Facilities (87%); 2. Cropping Intensity(84%); 3. Irrigation Facilities(87%)
Cox'S Bazar	Cox'S Bazar Sadar	1. Aquaculture(59%); 2. Irrigation Facilities(56%); 3. Cropping Intensity(36%)
Chittagong	Satkania	1. Loan(92%); 2. Aquaculture(92%); 3. Irrigation Facilities(89%)
Chittagong	Raozan	1. Aquaculture (89%); 2. Irrigation Facilities (81%); 3. Cropping Intensity(77%)
Feni	Chhagalnaiya	1. Irrigation Facilities (91%); 2. Aquaculture(82%); 3. Cropping Intensity(65%)
Barguna	Patharghata	1. Aquaculture (89%); 2. Irrigation Facilities(89%); 3. Cropping Intensity(86%)
Barguna	Barguna Sadar	1. Aquaculture (69%); 2. Irrigation Facilities(64%); 3. Cropping Intensity(51%)
Jessore	Sharsha	1. Aquaculture (59%); 2. Irrigation Facilities(43%); 3. Cropping Intensity(42%)
Jessore	Jhikargachha	1. Aquaculture (59%); 2. Loan(47%); 3. Irrigation Facilities(47%)
Bagerhat	Bagerhat Sadar	1. Irrigation Facilities (86%); 2. Aquaculture(73%); 3. Cropping Intensity(61%)
Bagerhat	Morrelganj	1. Irrigation Facilities (93%); 2. Aquaculture(74%); 3. Cropping Intensity(64%)
Satkhira	Kalaroa	1. Aquaculture (76%); 2. Irrigation Facilities(70%); 3. Cropping Intensity(42%)
Satkhira	Satkhira Sadar	1. Irrigation Facilities (58%); 2. Cropping Intensity(48%); 3. Aquaculture(46%)
Satkhira	Tala	1. Irrigation Facilities (62%); 2. Cropping Intensity(63%); 3. Loan(41%)
Khulna	Batiaghata	1. Irrigation Facilities (65%); 2. Aquaculture(57%); 3. Cropping Intensity(43%)
Khulna	Phultala	1. Aquaculture (87%); 2. Irrigation Facilities(85%); 3. Growth Center(62%)
Khulna	Terokhada	1. Aquaculture (58%); 2. Irrigation Facilities(49%); 3. Loan(45%)

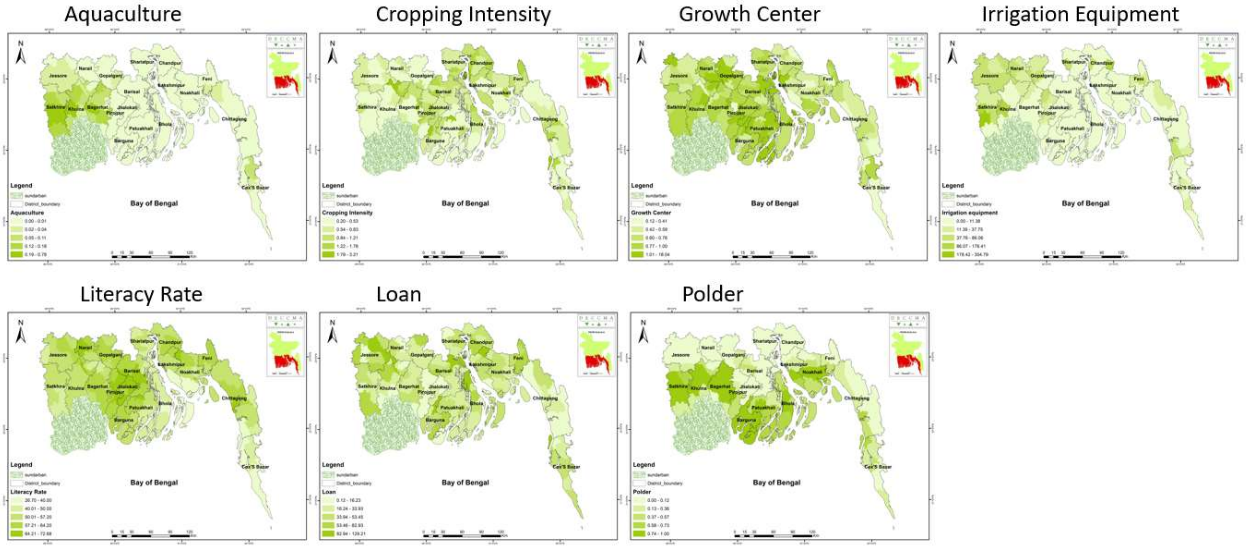

Figure 3: Variation of adaptive capacity indicators at different locations

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This work is carried out under the Deltas, Vulnerability and Climate Change: Migration and Adaptation (DECCMA) project (IDRC 107642) under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) programme with financial support from the UK Government's Department for International Development (DFID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creator and do not necessarily represent those of DFID and IDRC or its Boards of Governors.