Executive Summary

Background of the Dissertation

Being exposed to nearly 7% of the world's deadly tropical storms and associated surges, disaster and climate vulnerability of the Indian Sundarban delta is well known. Especially, the rampage caused by Cyclone 'Aila' in 2009 left an indelible memory to the affected communities living in the small, isolated deltaic islands of the region. Further, with the rapid onset of climate change and depleting mangrove ecosystem services, researchers from all around the world as well as several international developmental agencies predict that the prevailing risks of coastal disasters in the delta are most likely to intensify in these extremely low-lying deltaic islands. This includes more intensified tropical storms and surges, an escalated sea level rise, severe coastal erosion and wide array of hydro-morphological changes that are expected to massively disrupt community's lives and well-being in this eco-fragile delta. In fact, it is not probably an overstatement that the very survival of the delta remains at a critical juncture and it is imperative to formulate an ameliorative disaster and climate risk reduction strategy in order to improve community's resilience against the prevailing and expected adversities.

Under this backdrop, this particular action research, mainly conducted between 2012-2014, principally attempts to provide research-driven appropriate policy guidelines to the related stakeholders, with an intention to improve the coastal community's disaster and climate resilience through participatory socio-ecological planning, collection and analysis of primary data and methodical screening of wide array of secondary data. The research, conducted against the backdrop of cyclone Aila, primarily used the devastation caused by the storm as the principal reference point for all the participatory exercises and further, hypothesized that the probability of such events or even a stronger storm (along with coastal flooding) remains much likely in the near future. Thereafter, this research characteristically aims to identify the key attributing factors that resulted in massive social and economic disruption of the communities' aftermath the 'Aila', through a bottom-up intensive assessment (both indicator and perception based) - especially focusing at the local government (block level) and the community level. Hence, the term 'resilience', as have been used in this research, principally depict the capacities of the local communities to adapt and/or embrace the adverse impacts of future disasters.

Research Concepts, Objectives and Questions

As have been hypothesized over the last decade, resilience of the coastal communities is inextricably linked with their surrounding environment. This coupled system of human and nature, often referred as 'socio-ecological' system, serves as the theoretical basis of the current study. In particular, the study recognizes coastal areas as typical examples of highly dynamic 'socio-ecological systems' bounded by its human and environmental limits, and resilience of such systems depend on multitude of complexly interlinked social, economic and ecological factors. Needless to say, the performance of coastal ecosystems such as mangroves remains seeming important to enhance community's resilience against coastal hazards. In addition, the study also recognizes various other aspects such as societal structure, resource-dependency and governance as impounding factors of community resilience in coastal areas, and thereby, envisages on correlative management of both the social and ecological systems in order to foster community resilience.

Being the largest mangrove habitat in the country and hosting nearly 4.37 million resource dependent coastal communities, the complexity of the Indian Sundarban Delta is unmatched. Additionally, dire poverty and isolation are the impeding factors that continues to exert tremendous pressure on the existing mangrove resources leading to this high complexity and erosion of resilience in the observed socio-ecological system. Given such complexities, this particular action research aims to achieve four objectives as mentioned below:

- Quantification of Community Resilience, i.e. to develop an integrated framework and indicators and to assess coastal community's disaster resilience in the backdrop of the study area.
- To identify and prioritize specific indicators, relevant tasks and corrective actions capable for enhancing communities' resilience against hydro-meteorological hazards and/or climate change.
- To develop community led sectorial plans on the prioritized indicators.
- To recommend an ameliorative disaster, climate and ecological risk reduction strategy for the Indian Sundarban Delta in order to enhance community resilience.

Specifically, the study targets to answer the following research questions

- To what extent are the communities resilient to coastal hazards and/or the possible impacts of climate change?
- Which are the key attributing factors that are impeding communities' resilience?

- Which are the precise tasks and actions required to enhance the disaster and climate resilience of the communities?
- What would be the appropriate risk reduction model against the current and future ecological, disaster and climate risk of the delta?

Research Methodology and Steps

The present study deploys a variety of qualitative and quantitative Participatory Rural Appraisal (PRA) tools across diverse stakeholders ranging from the local government units (Community Development Blocks) to the household and individuals. In order to achieve the above mentioned objectives, the study adopts the following research steps-

- In response to the first research question, the study aimed to develop an appropriate community resilience assessment framework and a composite resilience index against coastal disasters and climate change with special reference to the coastal rural communities. Consequently, based on extensive literature review, a questionnaire was developed from the above mentioned framework that consisted of 125 variables under 25 relevant indicators and 5 dimensions. In the present research, 'community resilience' of 19 coastal administrative blocks (Community Development Blocks or CDBs) of Indian Sundarban delta were assessed through an institutional questionnaire survey at the Block Development Offices. The administrative head of the blocks, i.e. the Block Development Officers were the primary respondents of the questionnaire. However, the collection of the data was also supported by other relevant Block officials such as Block Disaster Management Officer (BDMO), Agricultural extension officers etc. Resilience scores were calculated based on the specific inputs received in a pre-defined Five point Likert scale and a weightage average was taken to compute the final scores for each indicator and dimension. Classification and spatial mapping were conducted through an 'Equal-interval classification method' using ARCGIS™ 10.2.
- In order to attain the second and third research objectives, the research deployed the tool of 'Participatory Action Planning' or 'Community Action Planning' which includes collection of subjective feedbacks and prioritization of specific issues identified by the 'Cyclone Aila' affected communities. The four distinct locations were chosen based on the results obtained from the above indexing exercises, proximity to the mangroves and recommendations made by the respective block development officers. The research essentially relied on four intensive Focus group discussions (FGDs) with Cyclone Aila affected communities. The results of the FGDs were summarized in 18 relevant 'Tasks' (corresponding to 25 main

indicators used earlier) and 54 corrective actions based on a directed content and problem-tree analysis of the proceedings. The identified 'Tasks' and actions thereunder, were later subjected to a prioritization survey in the worst affected villages in the same four blocks (*n=268*). Based on the ranking, three of the community prioritized tasks (i.e. Improve livelihood resilience, enhancing the participatory mangrove conservation and embankment protection) were later taken up for the detailed investigation and planning.

- In order to advance and risk proofing the current livelihood scenario, the research principally aimed to conduct participatory adaptation planning for the coastal agriculture and estuarine fishing communities. This study was specifically designed against the backdrop of reported crop damage (especially loss of agricultural land in Cyclone Aila) and high residual soil salinity aftermath the 'Cyclone Aila' that led to massive loss of livelihood in the delta. A total of twelve FGDs were conducted with farmers and estuarine fishermen in order to identify their perceived threats and adaptation/coping options associated with their existing livelihood. In a follow up process, individual survey, aimed at three groups of farmers, i.e. small, marginal and agricultural labor was conducted to understand the nature of crop damage, yield loss and intended adaptation/coping options (*n=126*). The similar research methodology was also followed for the estuarine fishers *(n=46)*.
- With respect to the second component (mangrove conservation), the research typically examined the existing incentive design and extent of community participation in the prevailing participatory mangrove management (Joint Forest Management). The research steps include (a) interviews with forest officials (enquiry on incentive design, forest production trends etc.), (b) focus group discussions with 10 Joint Forest Management Committees (JFMCs) (enquiry related to their respective roles in the distribution and delivery mechanism of the incentives) and (c) semi-structured interviews with 119 forest beneficiaries (enquiries on perceived benefits and threats from the JFM arrangements). In order to identify the existing incentives under the JFM arrangements, the interview reports with forest officials were subjected to summative content analysis. The transcript of the FGDs and semi-structured interviews with 119 forest beneficiaries were subjected to directed content analysis and identification of potential issues were done with coding and frequency count method.
- In relevance with the third prioritized component (embankment protection), the study primarily examined the ongoing 'Sundarban Embankment Reconstruction Project' through the lens of a 'socio-technical framework' for long term embankment sustainability. The

study was conducted by interviewing the concerned government officials from the Irrigation and Waterways Department. Specific enquires were made on the design parameters, construction methods, fund availability, operation and maintenance etc. A wide array of design data, including the engineering drawings of the proposed embankments were also collected. The information obtained from the interviews were later validated in terms of their long-term sustainability through interview of local experts, including persons from hydrogeological, social and administrative background with extensive working experience in the delta.

- In order to satisfy the last objective, the research findings obtained from the above exercises were shared with the relevant stakeholders in a stakeholder's interface workshop held in Kolkata on 5th December, 2014. The workshop was held in association with South 24 Parganas District Authority with participation of the BDOs from the Sundarban Region, academia and researchers from local universities, community representative and members from local NGOs. The 'Research Summary' report was published encompassing the key research findings and recommendations (Can be downloaded from http://www.filedropper.com/sundarbanresileincestakeholderbriefing). Feedbacks were gathered on the specific research findings and observation, suggestion, and recommendations from all the stakeholders were carefully noted. In the later stage, these recommendations were further refined and were translated to a 'No-regret' risk reduction strategy for the study area.

Key Finding of the Research

- The index based composite scores of community resilience in the Indian Sundarban delta were found to vary between 2.51 and 3.63 in a five-point Likert scale. Out of the existing 19 coastal blocks, only one could be classified as 'high' resilient block (Mathurapur I) and the rest were found to be in the 'low' and 'moderate' resilience categories. In general, majority of the extreme coastal blocks, that are situated against the open sea, were found to be poorly resilient. Nevertheless, this is not only a result of their 'high exposure' (i.e. poor natural resilience), but also the lack of other essential capacities such as poor socio-economic conditions, infrastructural deficits and improper and ineffective management of coastal resources. In particular, the study observes high correlation between the composite resilience scores with institutional resilience (r=0.80) leading to the realization of the importance of local institutions (*block offices and village panchayats*) to foster disaster and climate resilient communities. Nevertheless, the study also observed an unprecedented human and physical

developmental deficits such as primitive communication, lack of livelihood options, high resource dependency, lack of access to water and sanitation etc. In summary, this index based resilience assessment provided a decent starting point to methodically delineate the study area according to its existing resilience profile.

- The results obtained from the indicator based assessment of coastal community's resilience through the five dimensional 'Coastal Community Resilience Assessment Framework' provided an overall impression of the existing lacunas, especially in-terms of its socio-economic, physical, institutional, ecological and disaster risk management capacities. However, this assessment was based on the survey inputs received from the block officials, therefore, scores and specific weightage assigned to each indicator is mostly the reflection of the local institutions rather than the community in question. Additionally, some of the demographic and geographical data such as land use were significantly outdated. Considering the above, 'Participatory Action Planning' was conducted with the 'Aila' affected communities to identify the specific indicators, tasks and corrective actions.

Based on the extensive PRA exercises, the study could identify some commonly prioritized tasks across the four surveyed blocks, i.e. 'Enhancing Livelihood resilience', 'Enhancing safe mobility' (Transportation), 'Develop improved source of drinking water', 'strengthen the embankment network' and 'Conservation, Protection and Restoration of Mangroves'. Although, the study observed significant variation among the prioritized tasks and actions, and argues that disaster and climate resilience is essentially a property of place, the above mentioned tasks remains important irrespective of locations. In general, these prioritized tasks indicate the high developmental deficits that remain as the signature characteristics of the delta. On the other hand, the survey results also suggest that the communities, in general, are highly aware of the benefits of the mangrove forests. This was widely reflected from their affiliation to mangrove based corrective actions such as barrier plantation in front of embankments, mangrove plantation for flood risk reduction and erosion control in open areas. In addition, the study observed a close nexus between livelihood, embankment and mangrove conservation in the backdrop of the devastation caused by the cyclone Aila. This nexus arises from the failure of the unprotected earthen embankments and consequently saline water flooding of low-lying agricultural lands. As have been revealed by the communities, massive disruption of coastal agriculture for consecutive years led to significant stress on the mangrove ecosystems since communities were impelled to violate forest laws and penetrate the restricted areas. This, in turn, results in further degradation of the mangroves, limiting its

role in embankment protection, flood control and livelihood sustainability. Hence, considering this close nexus, these three indicators were further chosen for detailed action planning.

- With respect to the livelihood sustainability of the coastal communities, FGDs with the local farmers identified a total of eleven adaptive/coping methods that can be applicable against the current and projected agricultural adversities. These were grouped as three behavioral adaptation measures, seven technical adaptation measures and one institutional adaptation option. Among these adaptive/coping options, the follow up questionnaire survey indicated that the intentions and ability to adapt varies at individual level. Hypothesis testing through χ^2 test and Freeman Halton Extension of Fisher Exact Test reveals a statistically significant ($p<0.05$) difference among three farming groups in intention to adapt (in case of 8 out of the 11 potential adaptation/coping options). The result from the survey also suggests that small farmers largely wished to cultivate salinity resilient rice varieties, construction of irrigation facilities and dual use of agricultural lands. Similarly, marginal farmers also mentioned about construction of irrigation facilities and salinity tolerant rice varieties, however, put additional priority on dual use of agricultural land. On the other hand, most of the agricultural labors prioritized cultivation of salt tolerant species, dual use of agricultural land and migration to different places as their potential adaptation options. Nevertheless, the study also observes the lack of physical infrastructures, technical and financial capacity as the major constraint for infusing these adaptive options in the existing agricultural practices. With respect to inland and estuarine fishermen, similar participatory exercises revealed six potential corrective (adaptive) actions; of which, cultivation of fresh water aquaculture (e.g. *Telapia sp. etc.)* and diversification to non-fisheries based livelihood such as goatery etc. have been found to have major applicability in ensuring the livelihood sustainability of the fishers. Similar to the farmers, fishermen also mentioned about their technical and financial inability to incorporate the adaptive measures.

- Investigation over the existing ecosystem based incentives and extent of community participation reveled a precariously safety-margin based incentive design approach which largely restricts the overall goals and objectives of JFM. The study observes, although the existing restrictive policies are in line with the overall conservation goals of the government, it severely impairs effective participation from the communities. In general, the study observes that the forest dependent communities are bifurcated into supporters (e.g.

agricultural communities, forest product collectors, tourist operators) and criticizers (e.g. Fishermen, prawn seed collectors), and the division has strong correlation with the share of household income derived out of forest benefits. In particular, perception generally tends to be negative (anti-institutional) with greater degree of dependence on mangroves. For example, more than 70% of the household income of the fishermen and 100% of the household income of prawn seed collectors are derived from the mangrove waters. In addition, multitude of other factors, such as lack of market and poor pricing of forest products, territorial rights are identified to play a significant role in shaping user perception. Given the existing complexity of the stakeholder's interests where collective consensus is barely reached, the study argues that the long term sustainability of the existing JFM arrangement is questionable. The study recommends the need of more competitive incentives through calculation of maximum sustainable yields of fish and other products and a bottom-up, need based incentive design. Alternatively, non-forestry based provisions such as direct monetary provisions or developmental incentives (e.g. construction of sluice gates, ponds, rural infrastructure, small scale jobs, alternative livelihood etc.) can be used to complement the mangrove based incentives in order to achieve better community participation in the existing JFM arrangements.

- The evaluation of 'Sundarban Embankment Reconstruction Project' through the lens of the proposed 'socio-technical' framework reveled that the reconstruction of the earthen embankments mostly fulfills the minimum desired technical requirements. For example, safety factors/aspects considered for construction material, embankment height, width and wind speed durability, barrier plantation is within the range of 'moderate' to 'good'. However, in terms of institutional and social factors, monitoring and maintenance of these extensive earthen embankment network, emergency land acquisition and livelihood interests remain the key attributing factors for the long term sustainability of these extensive earthen embankments. In order to overcome these challenges, the study recommends to establish a participatory embankment monitoring mechanism (such as village embankment committee), formulating an appropriate land acquisition law, rerouting cargo ships and establishment of a reliable funding mechanism for the sustainable management of these extensive coastal infrastructures. In addition, it also remains imperative to extend the current embankment reconstruction program beyond the damaged embankments (778 km) in the cyclone Aila.

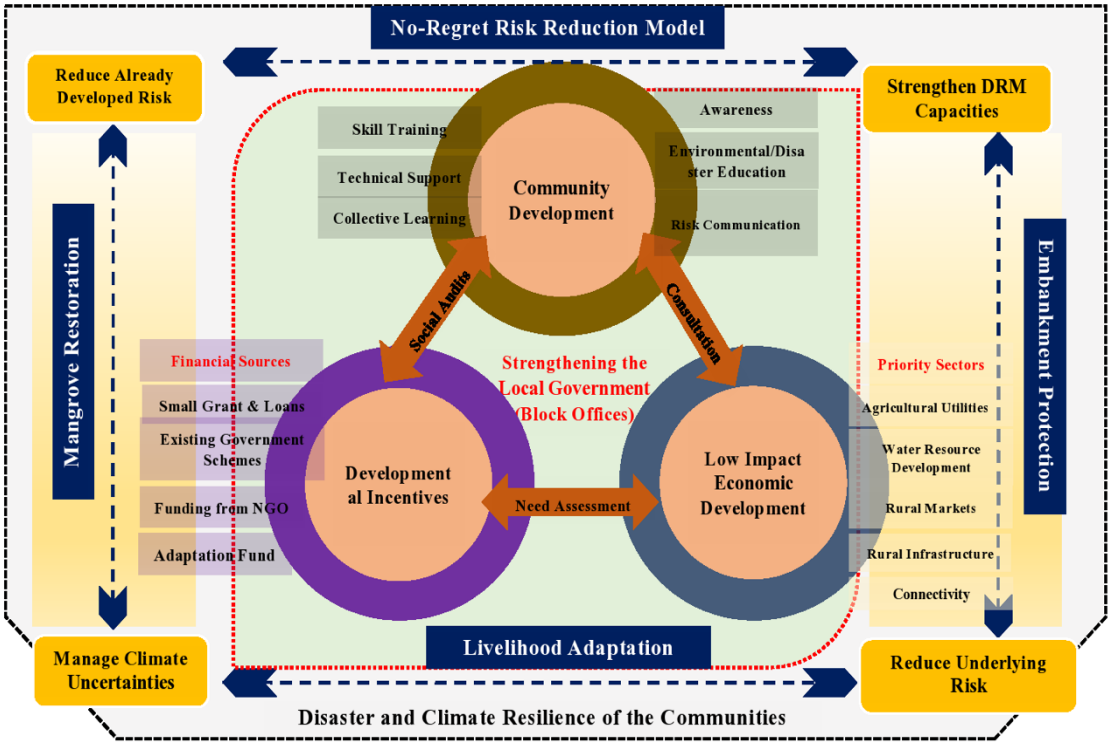

Figure E.1. 'No-Regret' Model for Disaster and Climate Risk Reduction Strategy in the Indian Sundarban Delta

- They study principally realizes that the observed poor resilience of the communities is the result of extensive human and physical developmental deficits that not only increases the susceptibility to coastal hazards and results in poor recovery from the impacts of Aila, but also exerts significant stress on the biotic and abiotic resources of the delta. In order to overcome these deficits (factors related to basic vulnerability of the communities) and to enhance community's coping capacities (capacities to minimize the impacts of future disasters), the study, essentially proposes a 'No-regret' risk reduction model for the Indian Sundarban delta. As have been hypothesized in the 'No-regret' doctrine, these model essentially rely on minimal capital investments and refrains from the major alteration of societal structures and livelihood profile. On the contrary, this model essentially advocates for implementing a risk sensitive, low impact economic development strategy which depends on combining social and ecological engineering for fulfilling the current developmental deficits as well as to minimize the existing and future risks (including ecological, disaster and climate risks). The above figure outlines a schematic flow of the suggested 'no-regret model'. Although, this model is conceptualized based on the key research findings, the study

argues, that the suggested risk reduction strategy needs to be customized at the local government level, especially at the block level in order to produce most effective results. A brief narrative of this 'no-regret' risk reduction model is provided in the following paragraphs.

- As depicted in the figure E.1., the model is comprised of four essential risk reduction components based on the recommendation furnished in the recently concluded Sendai Framework for Disaster Risk Reduction (SFDRR), i.e. **(a)** ***Reduce already Developed Risks-*** which is mostly the current human and infrastructural developmental deficit (i.e. factors leading to poor recovery from 'Aila'), for example, reduction of poverty and improving economic alternatives and secondly, mangrove restoration in the reclaimed and degraded areas ***(b) Strengthen the Disaster Risk Management (DRM) components***, particularly the monitoring and maintenance of the the embankments and develop a culture of preparedness through appropriate community development ***(c) Reduce the underlying risk factors***, i.e. mostly controlling the risk of future embankment failure and restricting further degradation of mangrove ecosystem services and lastly, (***d) Managing the future uncertainties***, mainly focusing on implementation of planned adaptation process for sustainable livelihood, long-term management of earthen embankment systems etc. In order to implement this model, the study proposes a theoretical implementation strategy which is essentially divided into three components, i.e. **Low Impact Economic Development (LIED), Developmental Incentives and Community Development.** LIED is known to be an alternative economic development approach that is intended to reduce the adverse ecological impacts and utilize the ecosystems or environmental services for the betterment of the communities. The superiority of LIED over the conventional high investment based development approach can be broadly summarized in its low capital investments and '*building with nature'* principles. In addition, LIED, in general, has greater social acceptability, since, it does not aim to alter any massive changes in the social structures, community profile and livelihood etc. In addition, the implementation mechanism is mostly participatory and envisages active community participation. Based on the research findings, the study identifies the key sectors where small capital investment can bring about the desired changes. These sectors are (a) Strategic investments in agricultural utilities (mostly to facilitate planned adaptation process) (b) Water harvesting structures (to solve the acute water shortage for agriculture and other uses) (c) Connecting rural producers to urban markets (to enhance profitability) (d) Improvement of rural connectivity and (e) betterment of existing rural infrastructure. The second part of the model, i.e. 'Developmental Incentives' is the backbone of this model and the study argues,

that the proposed LIED should not only rely on capital investments, but also make necessary arrangement for providing developmental incentives to the community. The incentives should aim at individual or community groups in recognition to their participation in mangrove conservation, embankment protection and plethora of participatory social development projects. A social business approach may be high imperative. The incentive may include monetary and non-monetary support in form of (a) Small grants and Loans (b) Proper utilization of government schemes (c) Funding support from the NGOs (d) funding through a dedicated adaptation fund to enhance community livelihood and economic gains. The last component of this model is essentially aimed to 'community development'. This can be done through imparting environment and disaster awareness, skill training for the development of alternative livelihood, technical support for promoting research-led adaptation programs and lastly, by establishing community based risk communication and collective learning platforms. As have been mentioned, the intended implementation of this model is aimed at the local government, especially at the block level. Therefore, empowering and strengthening the local government (especially block offices and panchayats) remains highly imperative in the backdrop of the current study.

- **Research Implications and Way Forward**

The study took a participatory approach to enhance community's disaster and climate resilience in Indian Sundarban Delta, assuming that the communities are the best judge of their risks and are capable of managing their risks, given sufficient knowledge and resources are provided to them. Contrary to a hierarchical risk reduction approaches, the research steps used for this present study essentially relies on community perception and intended actions, thereby, attempts to utilize the 'no-regret' doctrine of disaster/climate risk reduction for designing a local level risk reduction strategy. In general, the research implication can be summarized as the development of an ameliorative resilience assessment framework capable for measuring coastal community's resilience, community based identification of potential tasks and corrective actions, development of a planned adaptation strategy for coastal farmers and fishermen, strategies for improving the existing participatory mangrove management mechanism and rudimentary action plan for strengthening the extensive earthen embankment network. Although, the current research finding are site specific, the research results have several implications in Indian Sundarban and beyond. In particular, the study can be used as a baseline and reference for several other vulnerable mega-deltas in Asia or across the world.

The research outcome has also highlighted a number of information gaps and potential areas for future research. For example, on the scientific front, future research should identify the possible changes of mangrove ecosystem services and its impacts on the community. Additionally, there is also a requirement to better quantify the current sea level rise and it potential impacts on the delta. On the other hand, apart from the geo-morphological changes, research should also focus on developing locally applicable high yielding, salinity tolerant rice varieties, sustainable prawn cultivation methods etc. In the policy research domain, one important aspect of future research would be assessing the effectiveness of local conservation policies including the utility and effectiveness of vast protected area network, management policies for controlling upstream pollution, developing strategies to control migration from across the international border etc. Above all, the thrust area of the policy research should remain on meaningful engagement of local communities in regional development process.

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