LOCAL ADAPTATION PRACTICES IN RESPONSE TO A SUPER CYCLONE IN THE COASTAL REGION OF BANGLADESH

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ABSTRACT

Natural disaster is a familiar phenomenon in the coastal regions of Bangladesh. In the recent past, it has been struck by serious cyclonic storm surges like Sidr (2007) and Aila (2009). The devastating effects of those cyclones include loss of lives, livelihoods and properties. Based on field observations, Key Informant Interviews, semi-structured interviews and Focus Group Discussions, the study sought to understand the loss and damages due to Aila and post-Aila consequences in agricultural sector in Dacope upazila of Khulna district. Primary and secondary information were collected through several field visits to study area and relevant organizations. A crop model, named FAO AquaCrop, was used to analyze the future prospects of recently practiced dry season crops to support the rationality of the recent practices. The results show that in the study area, the embankments were severely damaged causing little or no crop production for three years immediately after Aila. In response to the adverse impacts of the cyclones, affected communities have adopted a variety of adaptation measures which will help them to better prepare for attenuating the losses due to future cyclones. Strategies include switching from shrimp farming to crop production, changes in cropping pattern and crop types, for instance, the introduction of salt tolerant and short period cash crops like sunflower, sesame, watermelon, etc., along with small scale cultivation of boro rice. It was found that almost 80% of the farmers completely abandoned shrimp farming and 30% of the shrimp farmers are already engaged in dry season crop production and the rate is increasing. To provide suitable irrigation water during the dry season, people are practicing storage of fresh water in the existing canals and on-farm reservoirs. Simulation of crop yield using AquaCrop model shows that the future prospects of these dry season crops are positive which will ensure the success of these local adaptation practices.

Keywords: *Cyclone, Aila, AquaCrop, inundation, adaptation, Bangladesh*

1. INTRODUCTION

The coastal region of Bangladesh has a relatively low and flat terrain. The average height of the coastal lands are less than three metres (UNDP, 2010). But the range of astronomical tide is comparatively high. So the intrusion of sea induced surges into the coastal lands are quite familiar. Historical statistics show that since 1970, Bangladesh has experienced 36 cyclonic storm surges resulting in over 450,000 deaths and immeasurable economic losses (UNDP, 2010). In the recent past the coastal region has been struck by serious cyclonic storm surges like *Sidr* (2007) and *Aila* (2009). The devastating effects of those cyclones include loss of lives, livelihoods and properties. The cyclone Sidr was stronger in consideration of wind force than the Aila, but in context of long term sufferings, the impacts of Aila outweighs those of Sidr. About 2.3 million people were affected by Aila throughout the country (Kumar, Baten, Masud, Osman & Rahman, 2010). Along with the human casualties, thousands of hectares of agricultural lands, innumerable livestock, household assets, etc., were the worst victims of this super cyclone. Scientific literatures strongly support that failure of the embankments during Aila was more responsible for the extended level of damages rather than the cyclonic wind action. Surge water intruded into the polder and then got arrested within the enclosed areas. The cyclical inundation of the inland areas during daily high tides and low tides resulted in the prolonged continuation of the immediate aftermaths. Throughout the coastal region, the agriculture was fully or partially stopped for a longer period even a few years after the event. Due to the intrusion of saline water, the soil and water salinity rose to a damaging extent that hindered any kind of agricultural activities in the coastal areas. Until the receding of the surge water and leaching out of the soil salinity, the farmers could not get back to regular agricultural activities.

This long term unproductivity caused a huge economic loss in the affected areas. The living standard, social status and income opportunities dropped sharply after the event.

Agriculture is the major livelihood option throughout the coastal region of Bangladesh (GoB & UNDP, 2009). According to BBS (2011), about 40 million people of the coastal region of Bangladesh directly or indirectly depend on agriculture. The traditional cropping pattern was aman-fallow-fallow in the past. But in some areas during the dry season, agricultural crops including boro rice, vegetables, pulses, spices, etc., were practiced though in a very small scale. The mostly practiced crop was aman rice during the monsoon. As a complementary agricultural option along with the crop agriculture, in 1970s, people started shrimp farming to make an additional profit (Karim, 1986). In the 1980s, the shrimp cultivation created a substantial contribution to the coastal economy. So people engaged more focus on this lucrative livelihood option. However, shrimp farming was subjected to criticism for the damage to the coastal infrastructures, degradation of soil, water and ecology (Haque, 2004). In 2007, people started to abandon shrimp farming for improvement of the environment and enhancement of aman production (which was hampered by saline water shrimp practices). The shrimp practices faced mass criticism after the cyclone Aila as coastal people held this practice responsible for polder damages. The lesson of the event made the coastal people rethink about the traditional livelihood practices eventually. They came out of the conventional practices and started to follow new strategies to adapt with any further cyclone like disasters (Islam, 2006). To cope up with the detrimental impacts of the frequent natural disasters in the area, and to improve the socio-economic condition, the local people have taken several adaptation practices. This study was conducted to enquire the adaptation strategies of the coastal people and to assess the sustainability and rationality of these practices under future climatic conditions.

2. STUDY AREA

There are 139 polders in the coastal areas of Bangladesh (Khan & Awal, 2009). In Dacope upazila, located at 22.5722°N latitude and 89.5111°E longitude in Khulna district, there are three polders, namely polder 31, 32, and 33. The losses and damages in polders 31 and 32 had been very significant after Alia. The post Aila consequences were also more dynamic in these two polders. So for this study, these two polders were selected (Figure 1). An extensive study was conducted from January, 2014 to May, 2015 in Pankhali, Chalna, and Tildanga unions of polder 31, and Kamarkhola and Sutarkhali unions of polder 32. The area is surrounded by the Rupsa river on the east, the Sutarkhali (Bhadra) on the south and the Sibsa on the north and the west. The largest mangrove forest, the Sundarbans is situated on the south of Dacope upazila. The area has a population of 91,493 covering 143.37 square kilometres (BBS, 2011). The area is situated in a sub-tropical monsoon climate with high temperature and moderate to low rainfall. The soil salinity of the area ranges from 8-25 dS/m. Most of the lands are medium-high (inundation depth 0.30-0.90 m) (BARC, 1999). The occupation pattern consisted of shrimp farming, crop production, and wage labour. Common agricultural crops in this area were aman, boro (dry season rice), sunflower, sesame, watermelon, and some homestead vegetables. The cropping intensity in the area is 104-110%.

3. METHODOLOGY AND DATA COLLECTION

Based on field observations and different Participatory Rural Appraisal (PRA) tools including Key Informant Interviews (KIIs), semi-structured interviews and Focus Group Discussions (FGDs), the study sought to understand the loss and damages due to Aila and post Aila consequences in agricultural sector in Dacope upazila of Khulna district, an Aila affected area of greater south western coastal region of Bangladesh. FGDs were conducted with diverse livelihood groups to understand their perceptions about the damages caused by Aila. The information from the local people were interpreted to explore the local adaptation practices to cope with the loss and damages of any natural disaster. FAO AquaCrop model was used to analyze the future prospects of recently practiced dry season crops to support the rationality of the recent adaptation practices. The model was calibrated and validated using the data of different experimental fields for two dry season crops. Then, the parameterized model was used to simulate persent and predict future crop yields as well (Steduto, Hsiao, Raes & Fereres, 2009; Steduto et al., 2011).

For the study, primary and secondary data were collected through several field visits to the study area and relevant organizations. Damage information were collected from different scienfic literature in context of Bangladesh. Data on land use and crop pattern were collected through interviews with local people and different officials from Dacope agriculture office and Dacope fisheries office. Information on polder damage and rehabilitation were collected from the officials of Bangladesh Water Development Board (BWDB). The required climate data for both present and future climatic conditions included daily maximum and minimum air temperature, relative humidity, sunshine hour, wind speed and rainfall. Present climatic data were collected from local climate station of Bangladesh Meteorological Department (BMD). Future climatic data were collected from the outputs of PRECIS (Providing Regional Climates for Impact Studies) model from the Met Office, Hadley Centre, UK. Among the 17 ensemble members of IPCC-SRES scenario A1B, the data for 2015-2050 (36 years) of three future climatic scenarios, QUMP-00 (wet condition), QUMP-08 (average condition) and QUMP-16 (dry condition) have been used in this study for future prediction of dry season crop yields under local conditions.

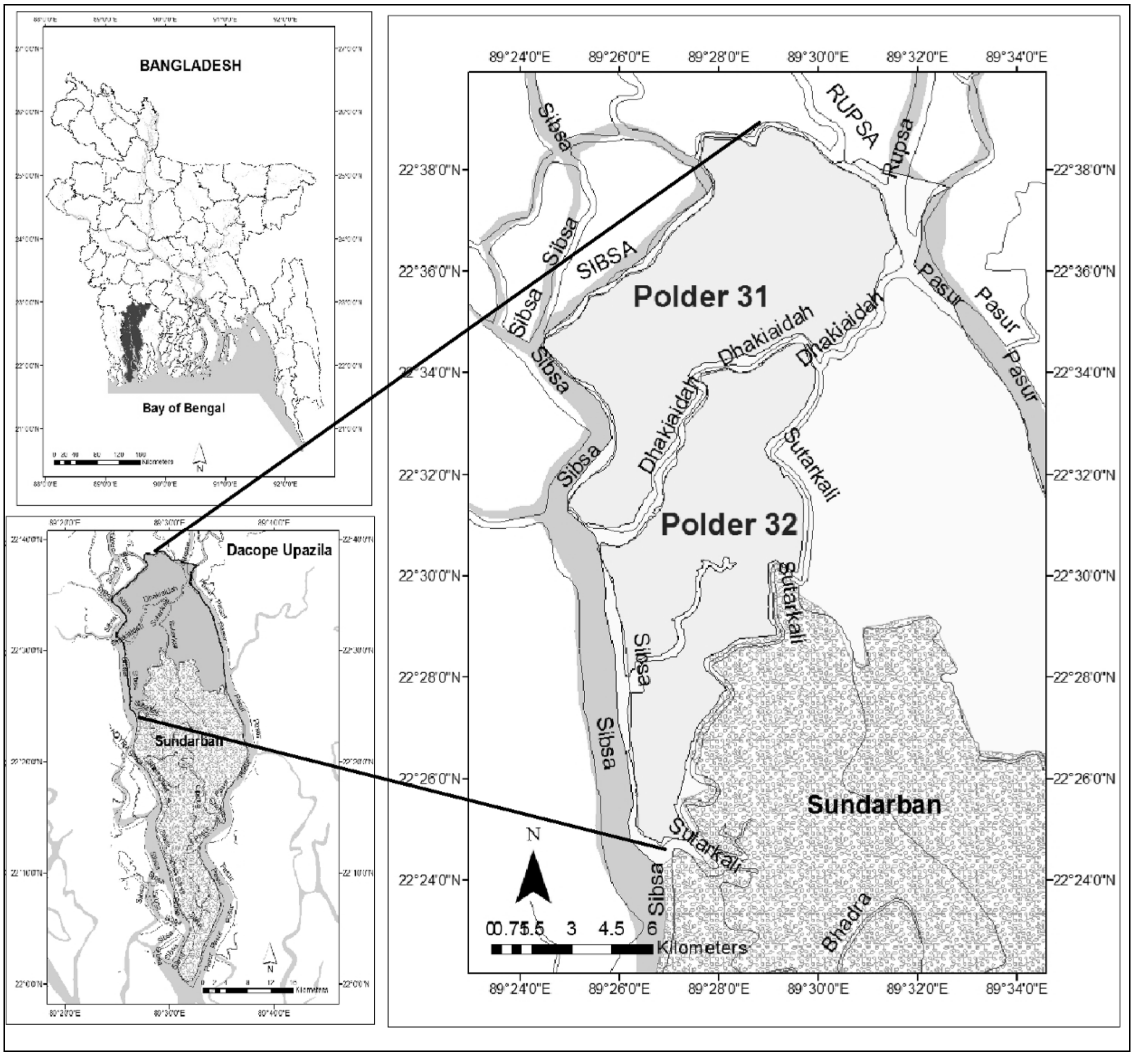


Figure 1: Study Area Location

4. RESULTS AND DISCUSSION

4.1 Impacts of Aila in Dacope Upazila

Seven out of nine unions of Dacope Upazila had been severely affected by Alia (Kumar et al., 2010). Thousands of people of Kamarkhola and Sutarkhali unions, enclosed by polder 32, were the worst victims. Pankhali, Chalna, and Tildanga unions of polder 31 experienced comparatively less damages, as surge water had entered into this polder only through breaching at some points. Respondents of polder 31 reported that water had been stagnant inside the polder for 17 days. On the other hand, people of polder 32 informed that the area had been under water for more than two years and they had been deprived of agricultural production for three years. Although, many had been relocated immediately to a nearby cyclone shelter as well as elevated roads and embankments, many others had been stranded in the affected areas finding no other alternatives. Almost all agricultural lands had been submerged by surge water for different durations of time, depending on the land type. A previous study (Kumar et al., 2010) showed that, 1080 hectares (ha) of crop land had been initially damaged in the upazila, but almost all agricultural lands in polder 32 and most of the lands in many other locations of the upazila proved unsuitable for production even two years after Aila. Other sectors like households, shrimp ghers, livestock, etc., also experienced huge losses and damages. Table 1 illustrates a summary of damages in the upazila.

Table 1. Summary of damages in Dacope upazila caused by cyclone Aila

Affected union	**Affected villages**	**Affected people**	**Displaced people**	**Destroyed household**	**Crop damage (ha)**	**Dead or missing livestock**	**Damaged shrimp gher**
Tildanga	All	26,000	10,000	2,000	200	400	300
Dacope	All	25,000	9,000	1,500	160	300	200
Bajua	All	25,000	9,000	1,800	180	400	250
Sutarkhali	All	21,000	8,000	2,000	200	400	300
Banishanta	All	15,000	6,000	1,300	140	300	300
Pankhali	All	15,000	6,000	1,200	120	250	150
Kamarkhola	All	10,000	4,000	950	80	200	150
Total		1,37,000	52,000	10,750	1,080	2,250	1,650

Source: Cyclone Aila Situation Report (USS, 2009)

Officials from BWDB informed that in the study area, surge water during Aila intruded into the poldered area through three major breaching points namely Nalian, Jaliakhali and Vitevanga. In those points, a good amount of agricultural lands were permanently converted into river portions which resulted in a huge long term economic loss. Analysis based on the field information is mentioned in the Table 2.

Table 2: Agricultural loss in three major breaching points

<table>
<tr><th>Point</th><th>Initial width (m)</th><th>Width during repairing (m)</th><th>Area lost (ha)</th><th>Production lost (mound/year)</th><th>Loss (taka in thousands/year)</th></tr>
<tr><td>Vitevanga</td><td>20</td><td>120</td><td>50</td><td>210</td><td>3920</td></tr>
<tr><td>Jaliakhali</td><td>60</td><td>80</td><td>1.62</td><td>7</td><td>126</td></tr>
<tr><td rowspan="3">Nalian</td><td>10</td><td>60</td><td rowspan="3">16.85</td><td rowspan="3">71</td><td rowspan="3">1330</td></tr>
<tr><td>2</td><td>40</td></tr>
<tr><td>1.5</td><td>20</td></tr>
</table>

4.2 Post-Aila Consequences

In the post-Aila situation, the salinity in soil and water incresed resulting in the long term agricultural unproductivity. Aman production in the monsoon, dry season crops and other homestead vegetables production was not possible for one or two years depending on the land types. During field visits, key informants informed that the agriculture was hampered due to the increased soil salinity after the events (Table 3).

Table 3: Soil salinity (dS/m) before and after Aila in the study area

Union	**Soil salinity before Aila (2001)**	**Soil salinity after Aila (2011)**
Kamarkhola	14-30	21-49
Sutarkhali	14-30	17-34
Chalna	8-22	12-29
Tildanga	8-22	10-25
Pankhali	2.5-8	8-14

Source: Dacope Agriculture Office, Khulna, Bangladesh

Soil and water salinity in the area rose sharply immediately after cyclone Aila as mentioned in Table 3. Increased salinity hindered monsoon season aman production for a long period along with other dry season crop production. Farmers could manage to come back to agriculture after two to three years of the event depending on the land types. But the production in the consecutive years decreased. Typical local farmers informed that before Aila they used to get 4.0-4.5 t/ha aman rice during monsoon. For the first two years after Aila, the loss was 100%, and in the third year they were able to cultivate some lands which were relatively high and got 3.75-4.0 t/ha only after reduced salinity in the agricultural land. High salinity level caused soil crusting which made it brittle and unsuitable for the sustainability of the earthen houses. As a result, the houses which survived the immediate impacts of Aila, could not stand tall longer. Our analysis shows that 75% of the household damages occurred immediately after the event and 25% of the damages occurred in the long-term period. Field consultations also show that income and livelihood options decreased in the wake of Aila. Wage labourers who used to earn BDT 150 to 300 daily before Aila, could manage to earn only BDT 100 to 150 if they could find any work at all. Other sources (UNDP, 2010) report that casual labourers found only 7-10 days of work per month compared to 20-25 days in a normal year. Out- migration in search of jobs incresed sharply after Aila.

4.3 Adaptation Strategies

Local agriculture was severely affected by the super cyclone Aila. Under the future climatic conditions, the severity and frequency of the natural disasters will increase (IPCC, 2007). Taking the lessons from Aila, local people have adopted some adaptation strategies for attenuating the damage levels due to any further cyclone. The adaptation strategies are discussed in the following sections.

4.3.1 Switching from Shrimp Farming to Crop Production

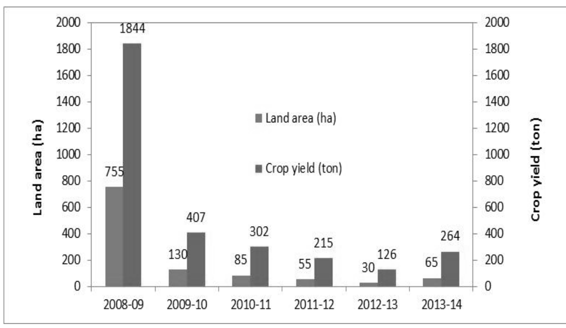
Saline water shrimp farming used to cause severe environmental degradation like deteriorated soil and water quality. Dry season shrimp farming decreased the consecutive aman production. During field visits, local farmers informed that the aman production was decreased by around 30% when the shrimp farming was followed by aman rice than that of the aman production which was not followed by any shrimp farming. They also informed that, the working opportunities in shrimp ghers were temporary. As long as the constructions of the ghers were completed, their work as labourers was done. In the shrimp ghers they found working opportunities only for the few months of the year and during the gher construction, but in crop fields they could work in both aman field in monsoon and dry season crop field. Field consultations show that the income of the small scale farmers and day labourers increases when they grow crops rather than shrimp farming. Local farmers told that, the production of shrimp was about 200-250 kg/ha/season. Economic analysis shows that, shrimp farmers used to get a benefit of 45000 tk/ha from the dry season shrimp farming and 35000 tk/ha from consecutive aman production. But, if they grow agricultural crops in the dry season then they get a benefit of around 50000 tk/ha from dry season crops and 45000 tk/ha from the consecutive aman production. Since 2007, people started to abandon shrimp farming considering the unsuitability and degradation of soil and water quality for further rice production and the decrease of aman production and livelihood options. The abandonment of the shrimp practices was accelerated after the cyclone Aila of 2009. The local people held the shrimp farming responsible for embankment breaching which caused untold miseries and sufferings to the affected areas. People used to cut the polders, insert pipes through the embankments for allowing the access of saline water into the polders for shrimp farming. This weakened the polders and as a result failed in the first phase of Aila. So people are switching from shrimp farming to crop production which will reduce the environmental degradation, prevent embankment failure in case of further natural disasters; at least minimize the breaching possibilities. Scientific literatures reveal that, a major portion of the damages in the polders were caused by embankment breaching. So the control of embankment breaching will subsequently reduce the vulnerability of the coastal people to damages due to natural disasters. During field visits, local people and other officials informed that almost 80% of the previous shrimp farmers have abandoned their shrimp farming. They also added that, 30% of the previous shrimp farmers are now engaged in crop production.

4.3.2 Change in Cropping Pattern

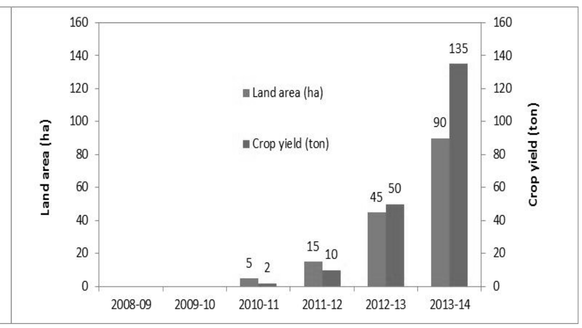
In the past, the marginal and then small scale farmers used to practice only aman rice in the monsoon and small scale vegetables during the rest of the year. The dry season crop cultivation was limited due to the unavailability of fresh water. The large farmers and so-called powerful people used to practice shrimp farming during the dry season. This shrimp practice worsened the dry season crop cultivation affecting the soil and water quality. So in the later period, they kept the land fallow during the dry season and cultivated aman during the monsoon. In this case, the monsoon time aman production increased than that of the previous production by 15%. Local people informed that during the previous single crop practice i.e., during the monsoon, they could manage their food requirement for five to six months of a year. But, now they have changed their cropping pattern from aman-fallow-fallow to aman- dry season crop- fallow. For the additional dry season crop production, now most of the people can fulfil their food requirements for the whole year. Sometimes they even get surplus, which helps them to access to other resources or opportunities. Moreover, during Aila due to their single cropping season they faced both short term and long term food scarcity. But, now they have more food sufficiency than any previous time. So in case of some Aila like disaster, now at least they will not face immediate food scarcity.

4.3.3 Cash Crop Cultivation During the Dry Season

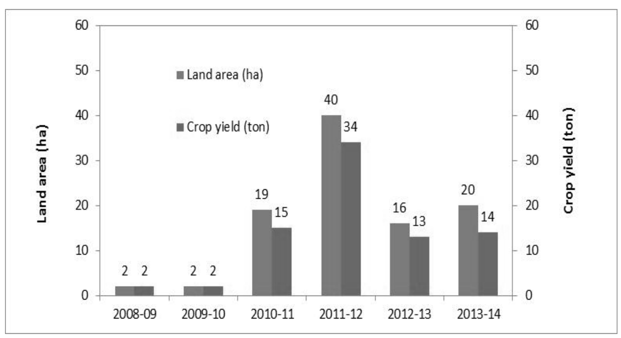
People of the study area are now practicing cash crops like sesame, watermelon, sunflower, etc., in the dry season along with some homestead vegetables. Local farmers informed that, boro rice production in the dry season requires more irrigation water. But the production of the above mentioned cash crops require less irrigation water. On the other hand, the cash crops are more saline tolerant, less labour intensive and short period. Local farmers had been gradually shifting to non-rice dry season crops from boro rice, as the former require less water and can tolerate comparatively more salinity than rice. In the recent years, the practices of cash crop cultivation during the dry season have increased which have been shown in Figure 2.



(a)



(b)



(c)

Figure 2: Dry season crop production in different years (a) boro rice (b) sunflower (c) sesame

Our analysis based on the information collected from Dacope agriculture office shows that boro rice cultivation is decreasing over the past few years (Figure 2(a)). We find the unavailability of fresh water for dry season irrigation as the reason for reduced cultivation of boro rice. But, recently as per the graph shows, the boro rice cultivation has increased due to the re-excavation of some existing canals and rainwater harvesting. Again, Figure 2(b) shows that, the practice of sunflower cultivation is increasing sharply. The local people have been interested in this cash crop cultivation as it is less water intensive and more profitable. From Figure 2(c), it is also observed that, sesame cultivation is decreasing in the recent years, as people prefer sunflower to sesame from economic point of view. Now, people find themselves economically solvent than any previous period as they are now getting additional production from agricultural fields during the dry season which they previously kept fallow. This increased economic return is decreasing their vulnerability to the impacts of any natural disasters.

4.3.4 Canal Re-excavation for Irrigation Water Storage

The cultivation of dry season crops requires suitable irrigation water. For this purpose, local people are now using the nearby canals to store rainwater during the monsoon season. There are a good number of large and medium canals in the area which have been silted up due to lack of proper management and maintenance. These canals have the potential to store a huge amount of rainwater and also the freshwater from the connecting rivers during the monsoon. If the canals are re-excavated up to a certain depth, then they will provide large amount of water storage which will not only facilitate the cash crop cultivation, but also ensure the cultivation of boro rice during the dry season, although boro rice is more water intensive than the cash crops. Some of the canals in polder 31 have previously been excavated by BWDB up to 2-3 ft than the pre-existing depth. These re-excavated portions provide additional storage facility for water which is applied to the nearby crop fields using low lift pumps. During field visits, it is found that, at or nearby the canals where fresh water is available during the dry season, people are able to cultivate dry season crops. Some typical farmers told that, as the dry season water storage in the canals increased after re-excavation, they were capable of cultivating a good amount of lands surrounding the canals (Table 4). Some individual farmers of the polder 31 informed that they were cultivating additional 35% of their total lands during the dry season with the canal water. The above amount is variable depending on the locations and availability of water. They also stated that, if more canals can be re-excavated than the dry season crop production will improve their economic conditions and provide food sufficiency. Local people stated that, with the help of local government and village level water management groups, they have taken initiatives of re-excavating some small canals, but this requires huge capital and it is very difficult for the people with their poor economic condition. So they require funding from governmental and non-governmental organizations for this purpose. In some of the areas, local people are constructing on-farm reservoirs within their agricultural lands to store rain water for dry season irrigation purposes. In those reservoirs they also culture white fishes which provide them with additional economic supports.

Table 4: Details of canal re-excavation

Canal name	Previous depth in dry season (ft)	Dry season depth after re-excavation (ft)	% Increase in storage
Moukhali-Dowani khal	5	6.5	30
Baroikhali khal	2	3.5	75
Katakhali khal	4	5.5	37

4.1 Rationality of the Adaptation Strategies

Local agriculture was severely affected by the super cyclone Aila. Under the future climatic conditions, the severity and frequency of such natural disasters are expected to increase (IPCC, 2007). Using the parameterized AquaCrop model, prediction of two dry season crop yields, rice and sunflower, under changed future climate has been performed. For each of the 36 future years, starting from 2015 to 2050, the yields of these two crops have been simulated for the crop growth periods. In this process, the future yields for each of the three ensemble members of IPCC-SRES scenario A1B, QUMP-00, 08 and 16 have been calculated and presented in graphical representations and trend lines have also been fitted. They are provided below in Figure 3, Figure 4 and Figure 5:

(a) (b)

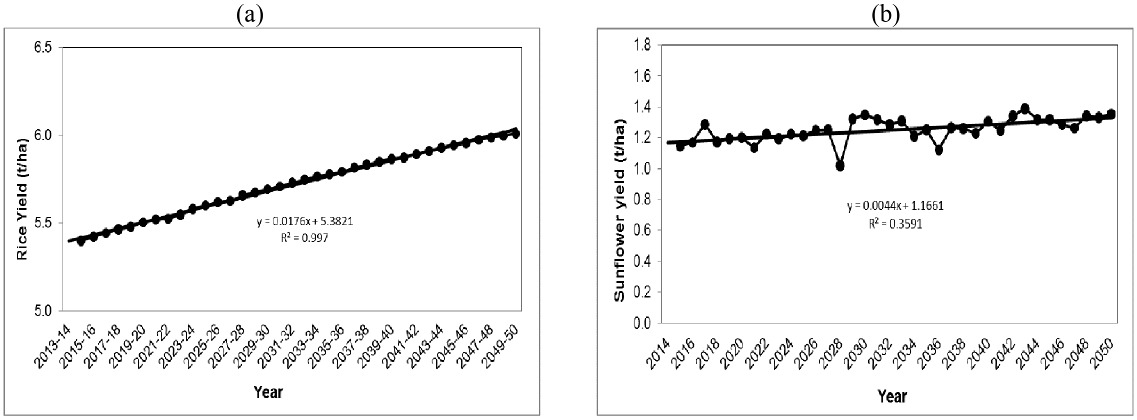


Figure 3: (a) Future rice yield and (b) sunflower yield from 2015-2050 for ensemble QUMP-00

(a) (b)

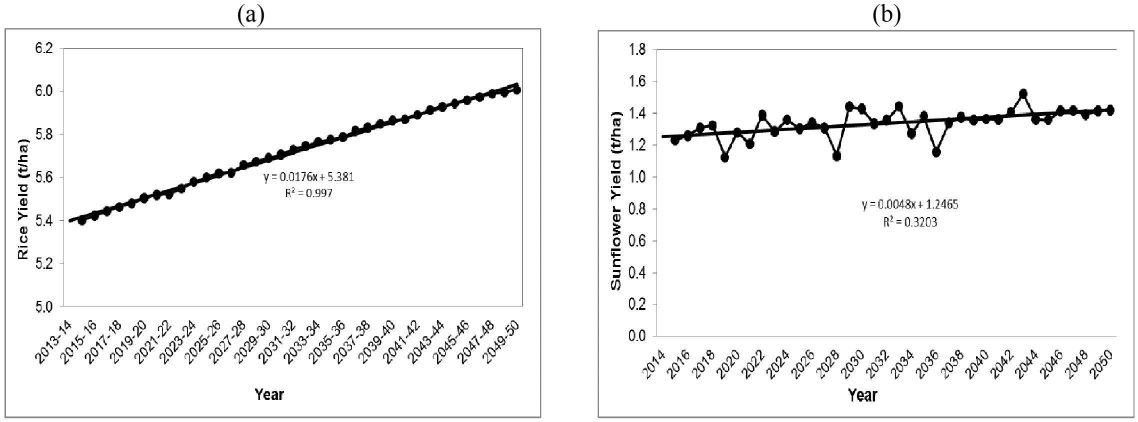


Figure 4: (a) Future rice yield and (b) sunflower yield from 2015-2050 for ensemble QUMP-08

(a) (b)

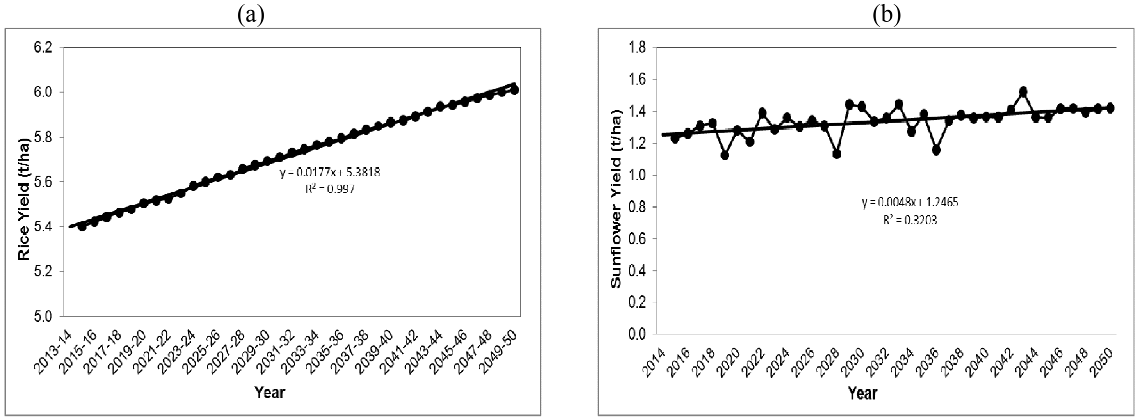


Figure 5: (a) Future rice yield and (b) sunflower yield from 2015-2050 for ensemble QUMP-16

Future rice and sunflower yields from 2015 to 2050 indicates increasing trend for each of the three scenarios. This indicates that, if the maximum temperature during the flowering duration of the crops remains within an acceptable limit, then with the increased carbon dioxide concentration in future, the yields of rice and sunflower may increase. This fact proves the rationality of boro rice and sunflower cultivation in the area during the dry season. Also, the decreasing soil and water salinity will also provide suitable condition for cultivation of these crops in future. This knowledge of increased future yield may also encourage the local farmers to bring in the cultivation of these crops in a larger scale.

5. CONCLUSIONS

The adaptation measures taken by the local people of the study area are resulting in increased crop production, improved soil and environmental conditions and food sufficiency. Improved agricultural practices are providing them with economic solvency, better access to foods and other resources which results in enhancement of their living conditions and resilience to further disasters. In future, the current practices will achieve more acceptance to the coastal people as the future predictions ensure better prospects in future climatic conditions. The increased agricultural productivity will subsequently decrease the long term vulnerability of the coastal people and will inhibit the intergenerational transfer of poverty.

ACKNOWLEDGEMENTS

This research paper is prepared based on the Master's thesis of the first and third authors under the "IDRC-SAWA Fellowship Project" funded by IDRC, Canada. The authors express their heartiest gratitude to their respective supervisors and other faculty members of the Institute of Water and Flood Management, BUET.

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