Bangl. J. Vet. Med. (2016). 14 (2): 251-255 ISSN: 1729-7893 (Print), 2308-0922 (Online)

SALINITY CHANGES IN SOUTH WEST BANGLADESH AND ITS IMPACT ON RURAL LIVELIHOODS

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ABSTRACT

Salinity intrusion greatly affects the livelihood decisions which farmers have to make. Both environmental and anthropogenic factors affect salt water intrusion within south west Bangladesh. Although climate change and sea level rise are thought to increase salinity, siltation and sedimentation of canals reduces access to surface water and prevents salt water intrusion in to farming zones. This study highlights how decreasing salinity within Khulna and Bagerhat districts is allowing farmers to diversify their agricultural practices, reducing vulnerability and improving household income and food security. By using both quantitative and qualitative data collection, semi structured interviews were held with farmers and landless people to understand how they adapt to salinity changes. The results show that whilst salinity decreases were identical across both districts, farmers adapt to the changes in a number of ways based primarily on their access to water. Whilst shrimp production struggles to improve, increases in freshwater production of prawns, fin fish and dyke crops partially confirm that salinity was decreasing within the area. Furthermore, increases in income generation were also observed confirming that diversification improved rural livelihoods. In the wider context, understanding farmer mitigation strategies towards the environment allows for future comparisons to be made on climate change and sea level rise which are widely considered to drive salt water intrusion further in land.

Key words: Aquaculture, Bangladesh, Salinity, Livelihoods.

INTRODUCTION

The South West region of Bangladesh is dominated by an extensive network of water systems forming the largest delta in the world. As the Brahmaputra, Ganges and Meghna rivers converge they generate a huge potential for the local population to engage in agricultural activities. As such, approximately 49% of the population is engaged in farming crops, livestock or aquaculture. Both environmental and anthropogenic issues have had a significant impact on local livelihood decisions. Salinity intrusion in rivers and canals has limited the access people have to freshwater bodies, reducing agricultural productivity (Afroz and Alam, 2010). Furthermore, saline intrusion is widely considered to have a negative impact on agriculture, reducing plant growth and decreasing productivity (Rahman, 2010). There is often a premise that SLR drives salt water intrusion further inland, and many studies have highlighted the reduced capacity for farmers to engage in agriculture when salinity levels are high (Deb, 1998). However, salinity levels do fluctuate between seasons and between different geographical areas along the coast. Mondal *et al.* (2001) showed that dry season soil salinity was over three times higher than during the rainy season, but through increasing crop production during this time top soil salinity levels can be lowered. The study also indicated that groundwater, although slightly saline, was still adequate for use during the dry season for agriculture and productivity levels would be adequate. However, continued use of groundwater throughout the dry season does not allow for the aquifer to reload with freshwater and the area becomes increasingly more saline and unusable for agriculture. In the wider context, conclude that future SLR will displace millions of rural people greatly affecting their livelihoods.

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MATERIALS AND METHODS

To understand how salinity changes are affecting the livelihoods of local people, the study looked at trends between 2010 and 2014. A quantitative and qualitative approach was adopted using semi-structured interviews with rural farmers and landless people. The Sustainable Ethical Aquaculture Trade project (SEAT, 2010) identified 19 villages within Khulna and Bagerhat districts where shrimp and prawn farming was the major source of income. A further 5 villages were identified by a recent field based research topic on the Golda Project (Taskov, 2014). Using PRA tools, an initial exploratory analysis of the study area was carried out within the two districts to establish current farming and salinity trends between 2010 and 2014. Three key informants (KI) from each of the 12 villages were interviewed using semi-structured questions. Each KI was interviewed using identical surveys to facilitate triangulation, providing greater accuracy of information. The salinity measurements corroborate the qualitative information provided by the key informants on salinity trends. The Key Informants were asked to participate in a simple salt test in order to understand the extent of farmer knowledge on water salinity. Participants were asked to rank the solutions in order of salinity, low to high. Furthermore, they were asked to identify which solutions they could engage in farming shrimp and prawn. The baseline information gathered from *Phase One* identified three key villages (Shobna, Badukhali and Faltita) which had experienced the highest degree of change to salinity and farming practices since 2010. In order to gain a solid perspective on the interactions between the environment and rural livelihoods there is a requirement to investigate social strata within each village (Institute of Aquaculture, 1998). Within each village, three KIs, such as a local representative, teacher or elder were asked to rank the whole village in to wealth categories as a percentage. A list of 100 farmers and 10 Landless people from each village was obtained and the KIs were asked to classify these people in to specific wealth categories based on their own parameters. All KIs identified housing type and land size as the two main categories whilst education and health were considered secondary. The dependant variable, the ICZ, is reliant on the independent variables identified in the quantitative data collection. The Independent variables in this study focus on socio-economic elements such as household income, gher lease costs, the production and cost of shrimp, prawn, finfish and dyke crops. Determining the level and intensity of these variables allows reasonably strong conclusions to be drawn in support of the hypothesis.

RESULTS AND DISCUSSION

There is a noticeable distinction between the improved livelihoods of the rich compared to those of the poorer wealth classes since 2010. Tables and graphs on income, aquaculture income, fish consumption and land rent have been arranged in a specific order to allow for comparative analysis between the villages, whereas production levels of aquaculture and agriculture have been arranged within each of the villages, to show how each village is adapting to environmental and social change. Three villages were all classified in to four wealth classes: Rich, Upper Middle Class, Lower Middle Class and Poor. Land Size and Income were the primary factors which classified an individual. All three study villages showed decreasing salinity levels over the four year period. Shobna is the only village of the three to utilize ground water for farming practices. Badukhali and Faltita also had large salinity decreases from 12ppt to 2ppt. Income generation between 2010 and 2014 indicated that the trend shows that 76% of the households were able to increase their income generation. The 24% who were unable to increase their income over the 4 years was partly due to a factor of age, and in two cases health. Similar to Shobna, Badukhali shows a decreasing trend in income between the wealth classes from rich to poor with 70% of the sample group increasing their income over the last four years. Again comparisons can be drawn between aquaculture contributions towards income, with the richest wealth groups making the highest gains in income generation and where the poorer farmers can still improve their livelihoods, their lack of investment over the four years is clear. Faltita shows a clear divide between income and wealth classes. Although income increased through all wealth classes, farmers in classes 1 and 2 have an average 40% increase in monthly income compared to an average 30% with the lower classes. Similarly, the wealthier groups have an average 60% increase in their aquaculture income compared to 37.5% seen in the lower classes, although these increases still remain relatively small. In Shobna, 83% of people ranked in classes 1 and 2 were able to increase their fish consumption between 2010 and 2014, compared to groups 3 and 4 who were unable to improve their fish consumption, 69% of remained the same, 23% lowered their consumption and the remainder were unable to recount their consumption. In Badukhali unlike Shobna, all wealth classes were able to show an increase in fish consumption by a similar amount with no clear distinctions between the wealth classes. 75% of the total sample group improved their fish

consumption with the remaining 25% decreasing fish consumption. The decrease was seen in even amounts throughout the wealth classes. In Faltita, fish consumption increases over 4 years between all wealth groups. There is an 88% increase within higher wealth groups (1 and 2), and a 72% increase within poorer groups (3 and 4) which suggests that finfish farming is increasing within the area as this is where local people source their fish. In Shobna, lease costs can be a good predictor of increasing competition within the market. With 34% of the sample owning their farming land outright, the remaining 66% of farmers were subjected to price rises across all wealth rankings. In Badukhali, with 47% of the sample group owning their land outright, the remaining 53% all saw a considerable price rise in comparison to Shobna. With the exception of Farmer 17 who downgraded his leased land size over the 4 years resulting in smaller lease expenditure. A significant proportion of land is owned in Faltita. Only 30% of the sample group leased land and costs were varied. Interestingly, the highest lease costs came from the poorest wealth group which questions the validity of the results. Over the last 4 years, shrimp production in Shobna has varied between farmers. 43% of shrimp farmers had decreased production over the last 4 years whereas 38% had increased their production and the remaining 19% sustained their production. Between the wealth classes, there was a greater decrease between Classes 1 and 2, 45%, compared to 3 and 4 at 22%. In contrast to Shobna, Badukhali shows a significant decline in shrimp production over the last 4 years. 63% of the sample group decreased their production whereas only 37% increased their production. There was an even divide between the wealth classes with the increased production however the 18.5% from the poorer classes had no production in 2010. Whereas both Badukhali and Shobna saw a relatively low increase in shrimp over the last 4 years, Faltita has seen a 57% increase in shrimp production across all wealth classes. The increase in shrimp production is consistent between the wealth groups with the richer classes having a 50% increase and the poor having a 55% increase across their respective classes. Prawn production has seen a much wider participation since 2010, with 63% of sampled farmers increasing their production, 27% of farmers sustaining production and 9% of farmers decreasing production. Comparatively, prawn production has increased in larger quantities over the last 4 years compared to shrimp farming. The average increase in production over the last 4 years is approximately 60% compared to just 38% increases in shrimp production. Prawn production is dominated by the wealthier classes in Badukhali, with 80% of the total production controlled by the first 5 richer farmers. Furthermore, over the last 4 years there has been little change to this figure with 82% of the wealthier classes carrying the total production output. Similar to Badukhali, prawn production is highest amongst the wealthier farmers; however poorer farmers still have a reasonable share of the market with 18%, as opposed to 4% in Badukhali. These figures again have minimal fluctuation between 2010 and 2014 with the richer farmers having 52% of the market share in 2010 to 46% in 2014. 82% of the sample group has increased both forms of freshwater production with staggering increases amongst the dyke crop production. In 2010, only 26% of all farmers were engaged in dyke crop production whereas by 2014 this has risen to 78%. Furthermore, 78% of the sample group improved their fish production. Whereas Badukhali was a significant drop in prawn production amongst the poorer classes, white fish production is much higher than the richer classes with 90% of wealth class 3 improving their production. On the other hand the richer people have also seen 100% increase in production over the last 4 years however this is more of a by-product to their more productive shrimp and prawn farming and not as significant as the wealth class 3. White fish production within this village is larger in terms of quantity than shrimp and prawn. Increases are seen across all wealth classes with larger production increases seen in the richer wealth classes. 84% of farmers were able to increase their production often over doubling since 2010. Salinity intrusion within Bangladesh is varied due to the country having several different physiographical regions. Contrary to another study in a similar geographical location (Paul and Røskaft, 2013), salinity in this particular region is decreasing due to siltation of local and regional rivers and canals limiting surface water access. Islam *et al.* (1999) studied the amount of sediment load within the Ganges basin and concluded that of the 1037 million tonnes carried annually by the Ganges and Brahmaputra rivers, only 517 million tonnes reached the coastline. Research by Taskov (2014), and corroborated in this study, indicates a major silted river in the lower basin. The Mongla River was once the first major branch of the Passur, carrying saline water further inland to Badukhali and Faltita. Currently, siltation and sedimentation loading has resulted in its almost complete death. This regional effect has significant impacts on villages almost 100km northwards (Halder, Pers comm, 2014). As the results show, income has increased in all three study villages over the last four years. Findings were similar to that which has been found elsewhere in the literature, where the richer classes were able to improve their financial situation much more successfully than the marginalized poor (Afroz and Alam, 2012). This relates to the availability the richer classes have to taking more

calculated risks, whereas the poor do not have the option to take increased risk as their lack of capital prevents increasing production (Swapan *et al*, 2011). Aquaculture income does differ significantly between the villages. The basis for the difference is a direct result of the mitigation strategies which each village has adopted for their production. Although shrimp is a much more favored product due to its economic benefits and low input costs, aquaculture income in Faltita has generally struggled to improve over the last four years, whereas Badukhali has seen greater income increases through moving towards the production of more freshwater species. Food security is a principle concern in poor underdeveloped countries, and with rice and fish considered staple foods within Bangladesh, fish consumption trends provide interesting scope when considering livelihood changes. Belton *et al* (2014) showed that within all wealth classes people are becoming more reliant on farmed fish as a source of dietary protein, and as populations put pressure on capture fisheries the reliance on farmed fish species becomes even more necessary. This reliance is further highlighted by salt water intrusion, which lowers the indigenous fish diversity that the poorer classes rely on (Gain *et al*, 2008). Belton *et al.* (2014) also highlighted the variation in results between villages and advised that seasonality differences along with geographical influences also play a part in fish consumption trends. The results from this study were similar, showing that fish consumption between wealth classes was alike, and significant differences were observed between the villages. Badukhali managed to increase fish consumption significantly more than Faltita. Finally, although increases in fish consumption were seen between all wealth quartiles, the poorer classes were still unable to increase their consumption significantly in comparison to richer classes. Land ownership and size are two of the main drivers of wealth in Bangladesh. This was indicative when undertaking the wealth ranking exercises within the study villages, as a primary indicator of wealth was land size. Farmers either lease land for agro cultivation or they outright own the land. In the context of this study, lease cost trends were aimed to provide insight in to local competition for land. The results indicate that price rises were observed between all wealth classes with a variation between overall rental costs. Another socio-economic factor which determines land rent trends is the quality of the land. Rahman (2010) showed that farmers are more willing to rent land when the land is fertile in order to increase their agricultural output. This coincides with the findings from this study, where differences can be seen between Shobna and Faltita soil quality. Qualitative analysis revealed that Faltita experiences poor soil quality with high levels of iron content. Local farmers from all wealth classes acknowledged that the land quality was particularly bad within the area due to historical salinity encroachment. As a result, of the total sample group interviewed only 30% of farmers rented land. In comparison, Shobna is a village where diversification of crops has flourished over the last four years, with all forms of aquaculture and agriculture improving to some extent. The farmers between all wealth classes confirmed that soil quality was improving in the face of declining surface and groundwater salinity. Shobna continues to have stable production of both shrimp and prawn. Although levels of shrimp have been declining in the wealthier classes, production increases can still be seen in the lower classes. A potential explanation of this shifting trend is the overall benefit of shrimp farming to generate fast income with few inputs (Deb, 1998), whereas prawn production has seen a huge increase in the wealthier classes because they are able to take on the six month production cycle with higher cost of inputs (New, 1990). The variation shown in Shobna between shrimp and prawn suggests the farmers are not governed so much by environmental changes within the localized area, and have more freedom to make decisions based on their capital investments. Both Badukhali and Faltita use surface water for their farming practices and the difference in production levels of shrimp and prawn could indicate different environmental processes. Whereas, shrimp farming was negligible in Badukhali, prawns were mainly farmed by the richer classes. On the other hand, Faltita shows a general increase in shrimp farming compared to a rather static local prawn industry. This could imply that salinity levels were increasing within Faltita. The integration of vegetable production alongside aquaculture has been shown to improve the livelihoods of those who practice such methods (Sen, 2011). Furthermore, the introduction of vegetable farming for a household reduces their vulnerability through diversification (Karim *et al*., 2011). In addition, a reduction in salinity can improve vegetable crops significantly (Shannon and Grieve, 1998). The findings from this study identified significant increases in dyke crop production in Shobna and Badukhali, interestingly, in most cases crop production has tripled since 2010, suggesting that salinity levels are decreasing and soil quality is increasing. In truth, this study did not establish the true drivers of vegetable production but one can reasonably assume increase in production is a combination of salinity decreases and market demand. There are typically four main species of farmed fish within Bangladesh; Carp, Rohu, Mrigel and Catla (Azim *et al.*, 2001). All three villages showed increasing rates of production, this could suggest salinity decreases as well as farming techniques were driving

the trends. Furthermore, by improving the yields, farmers are able to satisfy the fish consumption needs of the household as well as using the fish as a cash crop (Belton and Azad, 2012; Wandschneider, 2001).

Although different mitigation strategies are adopted by the villages to cope with changes in salinity, all three variations appear to improve livelihoods to a degree. Nevertheless, it is important to understand that this zone of salinity is actively changing. External issues such as siltation and sedimentation of local canals, which are perhaps the causes of salinity decreasing, are an issue rather than a solution. With different villages having individual physical characteristics, further research is required within each localised area of Bangladesh in order to create a clear picture of how climate change and future SLR will impact the many rural people who reside here. In short, the use of macro level concepts to address micro level situations misrepresents the true reality of the livelihood decisions which rural people face.

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