# SOCIO-ECONOMIC IMPACTS AND ENVIRONMENTAL CHANGES DUE TO SHRIMP CULTIVATION IN KALIGONJ UPAZILA OF SATKHIRA DISTRICT

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## CERTIFICATE

This is to certify that the thesis entitled ***"SOCIO-ECONOMIC IMPACTS AND ENVIRONMENTAL CHANGES DUE TO SHRIMP CULTIVATION IN KALIGONJ UPAZILA OF SATKHIRA DISTRICT"*** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of ***Master of Science in Agro-forestry and Environmental Science,*** embodies the result of a piece of bonafide research work carried out by **MD. SHARIFUL ISLAM**, Registration No. **11-04352** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

**Dated:** June, 2017

**Dhaka, Bangladesh**

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# DEDICATED
# TO
# MY BELOVED PARENTS

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# CHAPTER I

# INTRODUCTION

Shrimp farming is emerged as a major cultivation product in Bangladesh. It is considered as a white gold of Bangladesh. In addition to contributing to the export earnings, the shrimp and prawn sector have created employment for a large number of people. Recent figure suggests that about 15 million people in Bangladesh are directly or indirectly depend on the shrimp and of Fisheries and Livestock (MFL, 2014). During the last few decade shrimp aquaculture, particularly the black tiger shrimp) has been a major component in the development of our national economy. Saline-water shrimp is usually known as Bagda, while the Giant Fresh Water Prawn (*Macrobrachium rosenbergii*), locally called golda in Bangladesh (DoF, 2014a).

In addition to bagda and golda, other saline waters Shrimp and freshwater prawns are also produced in Bangladesh (DoF, 2014b). Fish and fish products contributed 2.01 percent of the total export earnings of Bangladesh in 2012–2013 (DoF, 2014b). Bangladesh earned about US$ 396 million from bagda and golda exports in 2012–2013, of which about US$ 304 million (over 76 percent) came from bagda exports (DoF, 2014b). The geographic area used for saline-water bagda shrimp and freshwater golda prawn production in Bangladesh has expanded rapidly in an uncontrolled and unregulated manner (DoF, 2014a, 2014b; MFL, 2014; Environmental Justice Foundation, 2004). The areas under bagda cultivation in Bagerhat, Khulna, and Satkhira are 51,799 ha, 37,035 ha and 66,769 ha respectively (DoF, 2014b).

The environmental and ecological impacts of bagda farming are high compared to golda farming (Ahamed *et al.* 2014). Besides, the majority of environmental and ecological impacts (e.g. soil degradation, salinization of freshwater supplies, decline in freshwater fish species, and decrease in vegetation coverage and trees), the majority of socio-economic problems (e.g. agricultural production, land-use patterns, land conflicts, and negative impacts on people's health and livestock) are also linked to bagda production (EJF, 2004). Due to poor planning and management and a lack of appropriate regulations, many environmental impacts and social conflicts have occurred in the Southwestern part of the country. The loss of land previously used for agricultural crops was estimated 352 ha (0.03 percent) per year between 1976 and 2000 in Khulna division, rising to loss of 8,781 ha (0.66 percent) per annum between 2000 and 2010. Also in Khulna, the area under forest was estimated at 617 ha in 1976, and this has declined by almost 100 percent up to 2000 and no further changes observed between 2000 and 2010. The area under mangrove forest decreased annually by 0.36% during 2000–2010. The area under aquaculture increases during 1976 to 2010, which was almost from zero ha in 1976 and reached to 45,596 ha in 2000 and further, increased to 96,283 ha in 2010 (Hasan *et al.*, 2013).

The level of soil Electrical Conductivity (EC) has remarkably increased to lower depth of soil of shrimp farms affecting soil productivity. Insoluble materials from food inputs in the shrimp ponds have been prevalent causing high levels of water contamination. This has been exacerbated by the current changes in shrimp gher ownership happening all over the coast with large ghers are being converted into small ghers but without any excavation or renovation of canals and sluice gates (Hossain and Hasan, 2017). Water quality decreased in shrimp cultivation areas because of excessive feeding, presence of high biomass due to high stocking density and application of chemical fertilizer, antibiotics and chemicals, effluents etc. Higher amounts of particulate substances also exist as suspension in the water of shrimp ponds. Poor water qualities are causing diseases, higher mortality and low production and in some locations; it has become impossible to continue shrimp farming any more, due to these poor water quality conditions (Hossain and Hasan, 2017). Stagnation of saline water in the shrimp ponds allows toxic substances in the gher soil. Waterborne diseases like jaundice and diarrhoea are very common among the villagers, including women and children in gher farming areas (Masum, 2008; Khan and Azad, 2014).

Apart from the overall contribution of shrimp farming to the national economy of Bangladesh, it has been causing severe threats to local ecological systems, such as- deterioration of soil and water quality, depletion of mangrove forest, decrease of local variety of rice and fish, saline water intrusion in ground water, local water pollution and change of local hydrology (Rahman *et al.*, 1994, and Eva, 2012). Recent extensive expansion of shrimp cultivation has severely caused depletion of forest cover of the Chokoria Sundarbans and led to significant loss of biodiversity of fisheries and forest species (Alauddin and Tisdell, 1998, Shahid and Islam, 2003, Quader *et al.*, 2010). Salinization in ground water and saline water intrusion in surrounding areas have caused a serious ecological and socioeconomic damage in the coastal environment.

Salinity is being thought to be a silent poison in the southwestern part of Bangladesh due to continuous shrimp cultivation. In this region, the practices of shrimp farming have caused massive loss of crop production, loss of fruit and other indigenous floral species, fresh water crisis for drinking and so on (Wahab and Karim, 2003). The absence of national policy and strategy on sustainable shrimp aquaculture has been a fundamental problem of this sector (Environmental Justice Foundation, 2004). Gradual accumulation of toxic elements in the soil of this region is contaminating lower level soil. Products of this soil also carry these toxic substances and the potentiality to create health hazards. In addition, outsider’s control of the large shrimp farms is the primary cause of social imbalance and deteriorating law and order in the coastal areas in Bangladesh (Alauddin and Hamid, 1996). However, people of the study area also thought that water becomes more turbid, odorous and less tasty due to shrimp cultivation. High levels of turbidity over long periods can greatly diminish the health and productivity of the pond water ecosystem in the coastal area (Elmanama, 2006).

In this area, crop cannot grow properly due to high saline condition. The situation become more alarming when its effects have changed the overall ecosystem of the coastal areas and destroyed the agriculture, vegetation, livestock and poultry. But there was a little work on impacts of shrimp cultivation on environment for that reason this experiment was conducted to observe the socio economic upgrade and environmental changes due to shrimp cultivation at Kaligonj upazila of Satkhira district. However, the significance of environmental and social impacts of shrimp culture is poorly understood in Bangladesh. The objectives of the study were:

- ✓ To investigate the socio-economic condition of shrimp culture.
- ✓ To assess the impact of shrimp culture on soil and water in the study area.

# CHAPTER II

# REVIEW OF LITERATURE

## 2.1 Socio-economic and environmental impacts of shrimp farming

Saha (2017) studied that bagda shrimp farming has adversely affected the livelihoods of small and marginal farmers and landless people. It has also destroyed the mangroves and increased salinity problems and thus has negatively affected soil, water, agriculture, fishery, the ecosystem, and the livelihoods of communities in the south-western coastal region of Bangladesh. Although bagda shrimp farming under the present situation benefits a small group of people, the benefit to society is minimal, or even negative, as a small group of people appropriate the profits at a cost to the livelihoods of the majority and to the environment. Thus, any economic analysis of bagda shrimp farming needs to take into account its negative impacts on the livelihoods of small and marginal farmers and landless people, and on the environment.

Successful agriculture depends on healthy soil and water. The present study based on laboratory analysis for soil and water quality like particle size analysis, pH, Electrical Conductivity (EC), salinity, heavy metal test, turbidity, Dissolved Oxygen (DO) and Total Dissolved Solids (TDS). Results reveal that pH and EC level of both soil and water of shrimp gher are increasing (8.2 and 18.72 respectively). Moreover, turbidity and DO of soil and water has been found in a very fragile condition. Except TDS and temperature other physico-chemical parameters of shrimp gher water were not suitable for shrimp cultivation and the nutrient (ammonia and phosphate) concentrations were higher than the optimum limit. Different types of heavy and toxic metals such as Pb, Cd, Cr, Ni, Co, Fe, Cu and Mn have been detected in gher soils. The present research suggesting that an immediate step is essential to stop the further degradation of soil and water quality in shrimp gher (Shamim *et al*., 2015).

Michele (2015) studied that current shrimp farming methods remove mangroves and alter waterways to construct ponds to rear shrimp. The development and runoff of waste and chemicals from ponds negatively impacts mangrove forest ecosystems, which results in loss of mangrove resources and services. Traditional communities that depend on mangroves for sustenance suffer from these activities and become marginalized into heavily degraded environments. Turmoil arises between local peoples and shrimp farmers, which leads to protests, bombs, and killings. Policies, laws, and sustainable farming methods are needed to regulate shrimp farm development in mangrove forests and reduce negative impacts to the system. Local communities need to be involved in the regulatory process and benefit from the industry.

The present study based on primary investigations (focus group discussion, field observation, household interviews etc.), laboratory analysis for soil and water quality (heavy metal test, pH, salinity, electricity conductivity, particle size analysis etc.) and secondary materials (remote sensing data, satellite images analysis etc.) reveals that due to poor drainage system and continuous shrimp farming at Chandipur Village under Debhata Upazila of Satkhira District, salinity level of both soil and water are increasing (1.6 ppt and 13.4 ppt respectively). In adition PH, salinity, electrical conductivity of soil and water have been found in a very fragile condition. Different types of heavy and toxic metals such as Na, Fe, Cr, Zn, Ni and Pd have been detected in ghers' soil (Humayun and Jahan, 2014).

Ahamed *et al.* (2014) observed that the environmental and ecological impacts of bagda farming are high compared to golda farming. In addition to the majority of environmental and ecological impacts (e.g. soil degradation, salinisation of freshwater supplies, decline in freshwater fish species, and decrease in vegetation coverage and trees), the majority of socioeconomic problems (e.g. agricultural production, land-use patterns, land conflicts, and negative impacts on people's health and livestock) are also linked to bagda production.

Department of Fisheries (DoF 2014b) revealed that the shrimp and prawn sector (which includes bagda, golda and other shrimp and prawn species) contributed to about 81 percent of the total export earnings from the fisheries sector in 2012–2013, which about (US$396 million, US$304 million respectively) with bagda and golda making up about 74 percent of the total export earnings from the fisheries sector in this period. It also revealed that Khulna, Satkhira and Bagerhat include about 72 percent of the total area under bagda and golda cultivation of Bangladesh. These three districts include 74 percent of the total area under bagda production in Bangladesh (155,603 ha out of 210,053 ha) and contribute 76 percent of the country's total bagda production (DoF 2014b). These three districts also include about 66 percent of the total area under golda production in the country (42,688 ha out of 65,221 ha). The areas under bagda cultivation in Bagerhat, Khulna, and Satkhira are 51,799 ha, 37,035 ha and 66,769 ha respectively (DoF 2014b). The other coastal districts of Bangladesh that have a considerable area under bagda production are Cox's Bazar (43,377 ha), Patuakhali (7,009 ha), Chittagong (2,805 ha) and Jessore (922 ha). These seven districts (Bagerhat, Khulna, Satkhira, Cox's Bazar, Patuakhali, Chittagong and Jessore) represent about 99.80 percent of the total area under bagda production in Bangladesh.

Habiba *et al*. (2013) found that Shrimp farming also increases the salinity levels of the ground and surface water as saline water from shrimp farms seeps into ground and surface water.

The study findings manifest that the continuous and unregulated shrimp farming has immense impacts on human health, ecology, environment and sustainability though few of them directly benefit the shrimp farmers and the people who live around them. The extensive farming systems negatively expedite the processes: infringement of mangroves, intrusion of salinity, degradation of land, de-stabilization of coastal ecosystems. The major socio-economic effects challenge the patterns of livelihood pattern, displacement of family and social structure, internal migration, and livestock. The coastal regions suffer from environmental degradation due to increased salinity of soil, canals and ponds within dams, reduction in grazing field and livestock, changes in the cropping calendar and its pattern, bio-diversity. Unplanned Shrimp cultivation has multifarious impact in terms of salinity increase on soil, adverse effects on population health, destroying bio-diversity and ecosystems, environmental changes, and imbalance in sustainability. Ecological aspects and sustainability are also overlooked during the shrimp cultivation. Rahman observed that shrimp farming affects soil and water quality in the cultivated areas that increase soil salinity levels (up to 500%) in non-saline area that hampers crop cultivation seriously. Peasant households lose their income due to decline in rice productivity, loss of poultry and livestock, and erosion of homestead vegetation and social forestry (Rahman *et al*., 2013)

Salinity has greatly reduced agricultural production in the coastal region through a lack of freshwater for irrigation and soil degradation. It has significantly reduced rice production – the most important agricultural crop in the coastal region and the source of food for most Bangladeshis. Key causes of the increased salinity in the coastal region of Bangladesh include a rise in the sea level, reduced flow in the Gorai River during the dry season, high tidal flooding, withdrawal of water at Farakka Barrage in India, excessive use of groundwater, faulty management of coastal polders, and the rapid expansion of shrimp farming (Abedin *et al*., 2012).

Khan *et al.* (2011) found that high levels of salinity in drinking water might cause hypertension in pregnancy, resulting in various adverse maternal and fetal outcomes in coastal Bangladesh.

Paul and Vogl (2011) revealed that the rapid expansion of shrimp farming, has caused extensive destruction of mangrove ecosystems (Ahmed et al., 2008; Chowdhury et al., 2006) as well as superseding other forms of land use like agriculture. Mangrove removal causes coastal erosion and changes in sedimentation patterns and shoreline configuration (Deb, 1998). As a result of clearance of large areas of mangroves, natural production of fish and shrimp has been reduced to a great extent and shrimp larvae are not sufficiently available for stocking. However, by destroying mangroves and agricultural land, many shrimp ponds, associated dykes and polders and access roads have changed the current land use pattern.

Swapan and Gavin (2011) conducted that the southwestern part of Bangladesh found that the shrimp cultivation had changed almost 90% of the land has been converted from agricultural uses and mangroves into shrimp farms. The effect on subsistence livelihoods is likely to be dramatic, particular when examples illustrate drastic change may be concentrated in small areas. For example, a study conducted in the village Damarpota of Satkhira district, has described the transformation of 274 ha (79%) of its prime quality rice fields into shrimp farms during the period between 1985 and 2003.Swapan and Gavin (2011) studied that prior to shrimp farming, rice was cultivated on 80% of the cultivable land and harvested twice a year (February-March and July-August). The yearly agricultural production was also supplemented by other vegetables and fruits. The increased salinity due to shrimp cultivation brought about a declined production because shrimp farms located behind mangroves causes salinization in the adjacent rice and other agricultural lands. Land inundation by saline water for long periods leads to its percolation into the surrounding soils, resulting in altered soil chemistry. Swapan and Gavin (2011) studied that A study in two unions under Koyra Upazilla of Khulna District reveals that almost 90 percent of the land previously used for rice and vegetable production has been converted into shrimp ponds The same study also revealed that agricultural employment over the same period declined from 75 percent to 38 percent among males, and from 37 percent to zero percent among females. It is worth noting that about 50 percent of total employed people in the shrimp and prawn sector in Bangladesh are fry collectors who are from the poor sections of the coastal communities.

Department of Fisheries (2009) revealed that shrimp aquaculture as a whole is the second largest export industry after readymade garments, generating US$380 million annually and 5.6% of the total value of exports in Bangladesh. Export of frozen shrimp was 15,023 tons in 1988, which tripled to about 49,907 tons two decades later in 2008. There are 1.2 million people employed in prawn and shrimp production and 4.8 million household members are associated with this sector.

Sadika *et al.* (2008) found that shrimp cultivation is no doubt economically beneficial for a selected group of people as well as for Bangladesh, but it has negatively affected the livelihoods of landless and marginal farmers, making difficulties for them to survive in the area. The shrimp culture development has caused serious environmental impacts e.g.; deforestation, cutting of mangrove forests, intrusion of saline water, decreased crop diversity and fisheries, water pollution and changing hydrological characteristics. These ecological imbalances again create negative impact on socioeconomic environment at surrounding areas like as lower production from crops and vegetables, loss of valuable fruit trees, fresh water crisis for drinking and related diseases like diarrhoea and dysentery, loss of grazing lands as well as livestock and poultry resources, lack of fuel wood, decline in household incomes from both on farm and off-farm sources, extra burden on women and children for collecting drinking water and fuel wood from far places.

The conversion of the mangrove forests into shrimp farms has destroyed the breeding habitat of many fishes and increased the erosion of the shorelines. This conversion also has serious adverse impacts on the traditional livelihood practices of the local communities in the Bagerhat, Khulna and Satkhira districts, as a considerable number of people from local communities are directly or indirectly dependent on various forest resources (Masum, 2008).

Ahmed (2008) stated that women and girls need to walk three to four hours a day to collect drinking water from distant sources as all nearby water sources are affected by high salinity, and thus, they lack enough time or energy to manage other household activities and to concentrate on their physical and mental health.

Chowdhury *et al*. (2006) revealed that rapid expansion of shrimp farm during the last two decades, along with the poor production technology, has leads to a growing concern because of its adverse effect on the coastal environment and socio-economic condition as well as sustainability of this sector. This farming system requires large land areas and has encroached most of agriculture land. It has also been one of the driving forces responsible for mangrove clearance. As a result, saline intrusion has caused serious degradation of land and de-stabilization of coastal ecosystems in many areas. Many scholars have already addressed these environmental issues and therefore, a question is being raised about the sustainability of coastal shrimp aquaculture.

Department of Fisheries in Bangladesh estimates that there are approximately 203071 ha of coastal shrimp farms producing an average of 75,167 metric tons of shrimp annually and an average of 370 kg/ha/year. Among this, approximately 35000 metric tonnes of shrimp are exported annually worldwide. Earning foreign exchange, this sector employs a significant numbers of rural workers as well (Gammage *et al*., 2006).

Ali (2006) reported that the expansion of shrimp farming has drastically reduced the area under rice cultivation particularly in Satkhira. It has remarkably changed the soil properties over time causing fertility reduction that has reduced the rice yield. Shrimp farming causes soil degradation by increasing soil salinity and acidity, and by depleting soil nutrients, and thus lowers rice production significantly. He found that rice production in a village in the Satkhira District declined 62 percent between 1985 and 2003 due to shrimp farming, although the population in the village increased from 888 to 1324 people over the same period. Thus, shrimp farming – by contributing to the drastic reduction in rice production – has increased food insecurity among the small and marginal farmers of the study village. The farming pattern of shrimp is either extensive or semi-extensive and intensive. Extensive shrimp farming rapidly depletes soil organic matter content. Intensive and semi-intensive shrimp farming delivers high volume of organic matter, inorganic effluents and toxic chemicals to the ecosystem that result in hyper nitrification and eutrophication and high soil toxicity. Prolonged saline water logging in shrimp ponds accelerates leaching base materials and increases soil acidity. Its adverse effects are also observed on aquatic environments. This study demonstrated that prolonged shrimp farming increases the soil salinity, acidity, and depletes soil Ca, K, Mg, and organic C content which leads to soil degradation.

Karim (2006) reported that although there is no doubt that bagda shrimp farming under present circumstances is beneficial for a small group of people, the benefits to society are minimal, or even negative, because a small group of people appropriate the profit at the cost of the livelihoods of the majority and damage to the environment. Any economic analysis of bagda shrimp farming should consider the cost of environmental problems and the negative social and economic impacts.

The economy of Bagerhat, Khulna and Satkhira districts is predominantly agricultural, the decline in the rice production area and the productivity of lands due to shrimp farming has negatively affected the livelihoods of those people in these three districts who are dependent on agriculture. It is worth noting that the coastal region of Bangladesh has been experiencing severe soil and water salinity in recent years (Ministry of Environment and Forests (MoEF) 2005; and the problem of soil salinity is much higher compared to water salinity. Out of 2.85 million ha of the arable coastal land in Bangladesh, about 1.2 million ha suffer from various levels of salinity and almost 20 million people in the coastal region have been affected by salinity in drinking water collected from natural sources (MoEF, 2005).

Environmental Justice Foundation (EJF, 2004) found that saline-water bagda-shrimp farming has exacerbated the salinity problem in these districts as soil salinity levels in the shrimp farming areas can be up to 500 percent higher compared to the non-shrimp farming areas and because shrimp farming increases the salinity levels of the adjacent freshwater sources through seepage.

Alam *et al.* (2004) reported that poor management of shrimp of the pond environments results in large scale disease outbreaks and hence mass production losses. More specifically, among the poor farm management practices, shallow pond depth, bad water quality, lack of food, presence of thick submerged weeds and vegetation were considered to be major factors to overall poor environmental condition which could be considered as the major driver behind bacterial diseases and stress symptoms. This appeared to be a significant contributory factor to the recurrent mortality (FAO, 1997). Effluents discharged directly from the nearby environment, are also likely to act as in diseases transfer. Unplanned and uncontrolled farming was also identified as the causes for the incidence of diseases and reduced the production (Deb, 1998). The total bagda and golda production area in Bangladesh was nearly 52,000 hectares (ha) in 1983–1984 and nearly 140,000 ha and 200,000 ha in 1995 and 2002 respectively (EJF, 2004). Out of 200,000 ha in 2002, nearly 170,000 ha (over 37,000 farms) were under bagda production and about 30,000 ha (approximately 105,000 farms) were under golda production Environmental Justice Foundation (EJF, 2004).

Three districts of Bangladesh like (Khulna, Bagerhat and Satkhira) accommodate around 80 percent of total shrimp production). In the early 1980s, shrimp farming was introduced in Khulna region turning a vast amount of arable lands into shrimp ponds. The transformation of potential high yielding variety aman and boro rice fields into shrimp ponds declined the yield of both cultivations and simultaneously reduced the total production of rice in Bangladesh (Chowdhury and Muniruzzaman, 2003).

Mazid and Banu (2002) reported that in 1996, Bangladesh lost 44.4% of its total shrimp production due to a sudden outbreak of disease. Such losses resulted largely from poor management practices.

Saha (2017) studied that the long-term benefits of bagda shrimp farming can only be achieved through the development of environmentally sustainable shrimp farming. Promoting bagda shrimp farming as a strategy for poverty alleviation and economic development necessitates fundamental changes in its management, and regulation to address serious adverse socio-economic and environmental impacts associated with it. This will only be possible when the issues of social equity and environmental sustainability become central to the management of bagda shrimp farming. Otherwise, bagda shrimp farming does not have a future role to play in poverty alleviation or the economic development of Bangladesh.

Chowdhury (2015) suggested that to overcoming the pathogenic problem, application of disinfectants and antibiotics is a common practice in shrimp culture. The drug and chemicals also used for good aquaculture practice.

Ministry of Fisheries and Livestock (MoFL,2014) suggested that sustainable development of shrimp farming demands both well-structured policy and institutional support. The National Shrimp Policy 2014 is directed toward achieving poverty alleviation and increasing export earnings by promoting environment-friendly and sustainable production of shrimp. In this regard, the policy indicated the requirements of institutional development, enforcement of technical and administrative management, innovation of sustainable technologies, and extension support. It emphasized on promotion of shrimp mixed cultivation and crop diversification.

The National Shrimp Policy (2014) mentioned about taking necessary action for the socio-economic betterment of small-scale shrimp farmers. This issue requires more emphasis since the shrimp sector of Bangladesh includes about 15 million people and majority of the shrimp farmers are small-scale farmers. However, the government is yet to establish structured institutional support (such as training, extension support, technical assistance, and credit facility) to implement the National Shrimp Policy to promote sustainable development of shrimp farming in southwest coastal Bangladesh. Research efforts should be invested toward best practices for sustainable cultivation, training needs of the farmers, and adaptation measures for climate change. This study had limitations in data collection process and design. The statistics of government agency (DoF) only had district-level data of shrimp yield since 2001–2002. Consequently, there was no alternative than constructing the shrimp yield data from the memory of the shrimp farmers to get the impression of yield for a longer time span. Although we tried to distribute the samples in various salinity levels, we did not consider other biophysical differences and differences in cultivation practice in the study area. Moreover, there are differences in the extension services and training facility through the study area, which we did not consider in the study design.

Rabhi *et al*. (2009) found that the expansion of aquaculture ponds leads to the clearance of mangroves. This clearance results in loss of essential ecosystem services generated by mangroves, including fish nurseries, wildlife habitat, coastal protection, flood control, sediment trapping, water treatment, salinity intrusion in to the nearby agricultural field and freshwater sources. Since, mangrove vegetation plays a significant role as buffer, it may be possible to utilize them to protect adjacent freshwater and agricultural fields. This would involve the deliberate planting of salt accumulator mangrove species between production ponds and adjacent freshwater and agricultural fields. This is only one aspect of coastal aquaculture farm management using the understanding of mangrove halophytes function as ecosystem properties is illustrative of the implementation of the second principle of eco hydrology. Application of this technology is currently absent in coastal aquaculture practice and such ideas currently still in experimental phase or implemented on a small scale specifically to protect agricultural land and soil without considering aquaculture issues.

Jackson *et al*. (2003) revealed that aquaculture pollution caused by excessive use of anti-biotic and chemicals may manifest as nutrients which precipitate to benthic lays at the pond bottom. This can also come from adjacent inlet as well and later act asa source of diseases. For this problem as different solution required, it would be possible to install a sequential pond system to trap sediments and nutrients and thus improve water quality. These nutrients can be used as fertilizers in the agricultural field. Hence, implementation of this measure focuses on the importance of the third principle of eco hydrology. Application of this principle aquaculture is quite promising.

Coastal communities including women got increased opportunities to improve their socioeconomic condition through their direct and indirect involvement with the coastal aquaculture. The study revealed that the unplanned expansion of shrimp culture adversely affected the production of cereal crops and vegetables, trees and plantation, poultry and livestock in the shrimp growing areas. Shrimp farming also had negative effects on coastal environment and agro-ecosystem, which significantly changed the bio-diversity in the study areas. However, due to social intervention, natural and social environments in the coastal areas have been gradually improving. He suggested that the coastal areas should be categorized into several zones on the basis of salinity and agro-ecosystem to ensure proper use of valuable land resources and accordingly, eco-friendly shrimp culture and improved management should be introduced to increase both private and social benefits (Islam *et al*., 2002).

Ahmed *et al*. (1999) revealed that water quality parameters such as dissolve oxygen (DO), pH, salinity, water temperature, transparency, un-ionized ammonia, hydrogen sulphide and alkalinity content were monitored weekly basis. Based on the prevailing soil-water condition and as per need, fortnight water exchange was done by tidal flushing during new and full moons followed by application of chemical fertilizers at a rate of 15kg/h (TSP: U = 1: 3). To keep the pH and alkalinity of water at a standard level, lime in the form of $CaC0_3$ was applied as per requirement (150-150 kg/ha).

Debapriya *et al*. (1999) suggested that a plethora of public agencies are involved in one way or another in regulating shrimp culture in Bangladesh. These include the Ministry of Fisheries, the Ministry of Land, and the Ministry of Forests and Environment. While the Ministry of Industries is involved in the shrimp processing phase, the Ministry of

Commerce deals with exports of shrimp. Scientific and technological support with respect to shrimp cultivation is supposed to be forthcoming from Fisheries Research Institute (FRI), Bangladesh Agricultural University (BAU), and Khulna University. Law enforcement agencies are quite often involved in mitigating shrimp cultivation related violence. Besides public institutions, a host of private bodies and NGOs are actively engaged in the industry. The Bangladesh Frozen Food Exporters Association (BFFEA) is the most representative trade body of industry entrepreneurs. The NGOs (e.g. Nejera Kori) and the political parties are involved in mobilizing the small and marginal cultivators, as well as landless laborers, to protect land rights, and limit growth of the shrimp cultivation industry.

Panayotou (1998) found that the challenge of integrating environmental and economic (sectoral) policies in the con- text of sustainable shrimp culture may be largely addressed by economic instruments for environ- mental management. Such instruments motivate behavioral change, inducing differential response by economic agents and allowing them to adjust flexibly to evolving circumstances. Use of economic instruments may also generate financial resources.

The National Fisheries Policy (1998) has emphasized on promotion of shrimp mixed cultivation in the coastal region of Bangladesh. Both of these policies identified the requirement of BL and Zoning for shrimp cultivation.

Paul *et al*. (1996) revealed that management of water quality is vitally important for two basic reasons, such as, it will help to direct the farmer to maintain optimum environmental condition within the water body that will help to maximize growth and survival and the other is the maintenance of a good water quality that will eliminate most of the disease related problems of the particular water body.

# CHAPTER III

# METHODOLOGY

In the study data were collected from shrimp farmers through questionnaire and soil and water dada were collected from shrimp gher. The methods and procedures that were followed in conducting this study had been described in this Chapter.

## 3.1 Study area

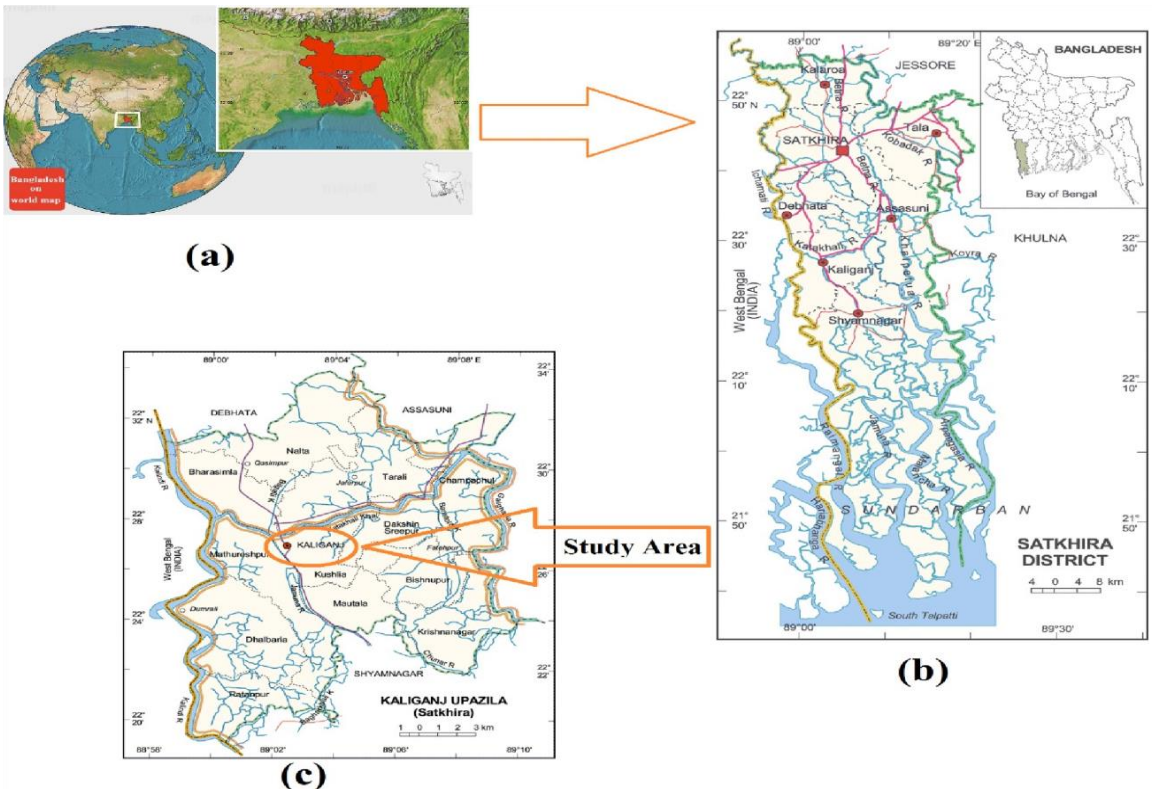


**Figure 1.** Pointing out the study area in context of the world. (a) World Map with Bangladesh. (b) Map of Satkhira (c) Map of Kaligonj Upazila (Source: Google Earth)

### 3.1.1 Geographical location of the study area

Kaliganj upazila (Satkhira District) area 333.79 sq km, located in between 22°19' and 22°33' north latitudes and in between 88°58' and 89°10' east longitudes. It is bounded by Debhata and Assasuni upazila on the north, Shymnagor upazila on the south, Assasuni upazila on the east, West Bengal state of India on the west it is on the bank of the Arpangachhia river. It is bordered to the north by Jessore district, on the south by the Bay of Bengal, to the east by Satkhira district, and to the west by 24 Pargana district of West Bengal, India. The annual average maximum temperature reaches 35.5°C (95.9°F); minimum temperature is 12.5°C (54.5°F). The annual rainfall is 1710 mm (67 inch) (source: Google) The main rivers are the Kopotakhi river across dorgapur union of Assasuni upazila, Morichap river, Kholpetua river, Betna river, Raimangal river, Hariabhanga river, Ichamati river, Betrabati river and Kalindi-Jamuna river etc.

### 3.1.2 Selection of the study area

The survey work was carried out at Kaligonj Upazilla under Satkhira district from August to December 2016.The main objectives of the study was to find out the impacts of shrimp farming on human life and environment. The study was conducted in 5 selected unions (Tarali, Nalta, Baro-Shimla, Moutala and Dakhin Shreepur) of Kaligonj Upazilla under Satkhira district.

The unions were selected on the basis of certain sets of criteria such as:

- These areas were very promising for brackish water prawn.
- The areas having extensive shrimp culture.
- Shrimp farming had been going on for at least 15 years in the areas.

- Shrimp was the main and major source of income of the farmers.

Information was collected from 100 respondents. Information on land use pattern, socioeconomic conditions and environmental impacts of the shrimp gher were collected.

### 3.2 Preparation of the Survey Design

There are several methods of collecting necessary data and information. According to Dilion and Haradaker (1993) there are three main methods by which survey data can be collected, these are:

1. Direct observation
2. Interviewing respondent
3. Records kept by respondent

The study was based on field survey where primary data were collected from individual farmers who practice shrimp culture in gher. Though there are various methods of collecting field level data. To overcome the shortcoming, repetitive visits were made to collect data in study area and the questions were asked in such manner that the farmers could answer. The design of the survey for the present study involved some necessary steps which were outlined in this section.

Primary data were collected depending upon the nature of the study and its objectives. The design of the present study involved some necessary steps which were presented in figure. ……...

Site selection

↓

Identify target groups

↓

Design and testing of questionnaire

↓

Data collection

↓

Questionnaire interviews

↓

Data processing and analysis

**Figure 2.** Steps of research design

According to the objectives, a survey schedule was prepared to collect the expected data from shrimp producers. At first, a drift schedule was prepared in accordance with the objectives of the study. Then the schedule was pre-tested to the relevance of the questions and the nature of response of the sample producers. After pre-testing and necessary adjustment, a final survey schedule was developed.

### 3.3 Target groups: Shrimp farmers

Shrimp farming is a very common practice in Kaligonj upazila under Satkhira district. It is reported that most of the shrimp farmers are small and marginal. According to Kendrick (1994) small and marginal farmers were those who have less than0.7 ha land including pond, while Rultherford (1994) small farmers are those who have less than 0.5 ha land.

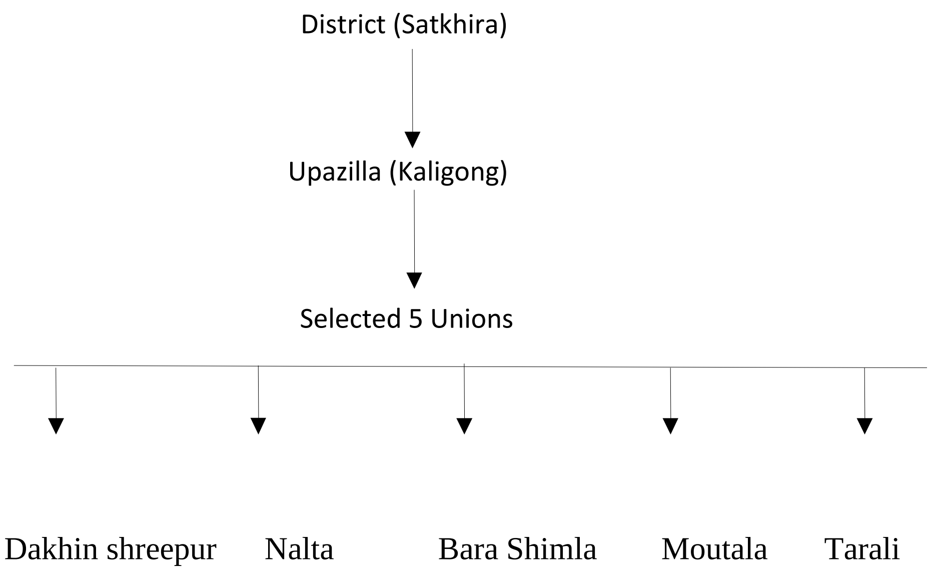


**Figure 3.** Selected 5 unions in the study area

Plate: 1 Data collection in tarali

Plate: 2 Data collection in Moutala

Plate: 3 Data collection in Nalta

### 3.4 Sample number and sampling procedure

The main objective of the study was to find the effects of shrimp culture on soil and water in Satkhira districts. Primary data were collected according to the prepared questionnaire. Data were collected with the help of local extension service agents and Upazila Agriculture Officer prepared an updated list of farmers of the selected five unions viz. Taraly, Moutala, Dakhin Sripur, Boro-Shimlan and Nalta. A total number of 650 farmers were listed. According to Yamane's (1967) formula, the sample size was determined as 100.

In calculating sample size 9% precision level, 50% degree of variability and value of Z= 1.96 at 95% confidence level were chosen from the following formula:

$$n= Z^2p(1-P)N/Z^2p(1-P)+Ne^2$$

Where;

n=Population size

N= Sample Size

e= The Level of Precision

Z= The value of standard normal variable at the chosen confidence level

P= The proportion or degree of variability

Then 100 shrimp farmers were selected from the population following random purposive sampling method. The distribution of the sample farmers and those in the reserved list from the villages was shown in Table 1.

**Table 1.** Distribution of the population, sample and number of shrimp farmers

| **Name of village** | **Population** | **Sample** |
|---|---|---|
| Tarali | 137 | 21 |
| Nalta | 130 | 20 |
| Moutala | 150 | 23 |
| Boro-shimla | 98 | 15 |
| Dakhin shreepur | 135 | 21 |
| Total | 650 | 100 |

It was not possible to include all the ghers under the study area, because of limitation of time and resources. Two things need to be taken into considerations for the selection of samples for a study. One was the sample size the sample size should be as large as to allow for adequate degrees of freedom in the statistical analysis. On the other hand, administration of field research, processing and analyzing of data should be manageable within the limits imposed by physical, human and financial resources. Considering all these aspects 100 shrimp farmers of the selected five unions viz. Tarli, Moutala, Dakhin-Sripur, Boro-Shimla and Nalta under Kaliganj upazila of Satkhira district were selected for data collection. Farmers were selected through purposive sampling method.

Age, education, farm size etc. were considered as independent variable and the dependent variable was the level of shrimp farming environmental knowledge of the respondents. These data were converted into international units. The proposed data were transferred to a master sheet from which classified tables were prepared revealing the finding of the study. Then the data were tabulated into computer. Preliminary data sheets were compared with computer spread sheets to ensure the accuracy of the data.

### 3.5 SOIL DATA COLLECTION AND ANALYSIS

**Laboratory Experiments:** To investigate the impact of shrimp culture on soil, 30 Soil samples were collected from five Union of Kaliganj upazila (top soil- up to 10 cm from the surface, 10-20 cm depth and then at 20-30 cm depth) and brought to the laboratory for physical and chemical analysis. Each soil sample was kept separately on a brown paper and mixed thoroughly making a composite sample. About 1kg of soil was collected from each place to give a representative sample. Samples were placed in sealed polythene bags that were labeled to avoid any damage. The level contained the name of the places, date of collection and code number of soil sample. Soil texture i.e. % of sand, silt and clay determinations were carried out by hydrometer method as outlined by Bouyoucos (1927). Organic matter (OM) was done by wet oxidation method. The percent organic carbon of the collected soil samples was determined by wet oxidation method developed by Weakley and Black (1996). Total nitrogen in the soil was determined by micro Kjeldahl method. For both soil and water sample: pH was determined by glass electrode pH meter; electrical conductivity (EC) was measured electrometrically; phosphorous (P) was determined calorimetrically by Olsen's method; exchangeable potassium (K) was determined by Ammonium acetate extraction method;

sodium (Na) was determined by flame emission spectrophotometer; calcium (Ca) was determined by titration method using $Na_2EDTA$ and Sulphur (S) was determined by turbid metric method with the help of a spectrophotometer. Soil samples were experimented in the Department of soil science under University of Sher-e Bangla Agricultural University and Bangladesh Council for Scientific and Industrial Research (BCSIR), Dhaka.

### 3.6 WATER DATA COLLECTION AND ANALYSIS

**Laboratory Experiments:** To investigate the impact of shrimp culture on water there were 20 water sample were collected from the selected gher using 500 ml plastic bottles between 09-11 AM. After collection of the samples dissolved oxygen (DO) was measured immediately in the sampling site.  Collected samples were analyzed in laboratory for particle size, hydrogen ion concentration (pH) by pH - glass electrode pH meter, electrical conductivity (EC) by electrometrically, total dissolved solids (TDS) by TDS meter, salinity, dissolved oxygen (DO) using DO meter, turbidity was measuring by Portable Turbid meter.

**3.7 Data analysis:** The data obtained from interview schedule was coded and tabulated in a data sheet. All personal traits were categorized and arranged in simple tables for descriptions. Statistical tools such as number, percent, rank order, range, mean and standard deviation were used to interpret data. Data analysis was done using the concerned software Microsoft Excel and Statistical Package for Social Science (SPSS) Version 16.

**Plate: 4 Collection of soil  sample**

**Plate: 5 Collection of soil  sample and bagining**

**Plate 6 Discussion about the impacts of Lime in shrimp culture**

**Plate 7 Discussion about the impacts of shrimp culture**

# CHAPTER IV

# RESULTS AND DISCUSSION

The findings of the study and interpretation of results with necessary discussion have been presented in this chapter. The socio-economic characteristics of the respondents, the environmental impacts of shrimp culture, chemical properties of soil and water are discussed below.

## 4.1 **Socio-economic characteristics of the respondents**

### 4.1.1 **Age of the respondents in the study area**

The distribution of respondents according to age were markedly varied showed in table 2.

**Table 2.** Distribution of the respondents according to age

| Categories | Score(Year) | Respondent (N=100) | | Range | Mean | Sd |
|---|---|---|---|---|---|---|
| | | Number | Percent | | | |
| Young<br>Medium<br>Old | ≤ 35<br>36-50<br>>50 | 21<br>52<br>27 | 21<br>52<br>27 | 16-77 | 41.93 | 11.68 |
| Total | | 100 | 100 | | | |

Most of the respondents belonged to medium to old aged categories and only 21% respondents were in the young aged group (Table 2). It indicates that medium to old aged people are doing well in shrimp culture business and hence were engaged in shrimp cultivation in Satkhira district.

4.1.2 **Educational qualification of the respondents**

Distribution of the respondents according to educational qualification have been showed in table 3.

**Table 3.** Distribution of the respondents according to educational qualification

| Categories | Score (Year of schooling) | Respondent (N=100) | | Range | Mean | Sd |
|---|---|---|---|---|---|---|
| | | Number | Percent | | | |
| Illiteracy | 0 | 4 | 4 | 0-17 | 8.46 | 4.25 |
| Primary | 1-5 | 27 | 27 | | | |
| Secondary | 6-10 | 35 | 35 | | | |
| Higher secondary | 11-12 | 20 | 20 | | | |
| Graduate and above | >12 | 14 | 14 | | | |
| Total | | 100 | 100 | | | |

From the study we found that around 35% of the respondents were secondary education level (Table 3). Anowar (2003) observed that 38.33% farmers were illiterate, 19.16% were below secondary, 26.6% were S.S.C passed and 2.5% were bachelor or above at Paikgacha upazila in satkhira district.

**.1.3 Farm size of the respondents**

In the study area there were three different categories of shrimp farm size was observed.

a. Homestead area;

b. Gher area (own); and

c. Gher area (leased out).

**Homestead area**

From the study area the highest category farmers were minimum in number (who had >20 decimal of land) and maximum farmers had low category shrimp farm (who had ≤10) in the homestead area (Table 4).

**Table 4.** Shrimp culture at Homestead area in the studied area

| Categories | Score (decimal) | Respondent (N=100) | | Range | Mean | Sd |
|---|---|---|---|---|---|---|
| | | Number | Percent | | | |
| Low | ≤10 | 90 | 90 | 0-30 | 2.37 | 5.99 |
| Medium | 10-20 | 9 | 9 | | | |
| High | >20 | 1 | 1 | | | |
| Total | | 100 | 100 | | | |

**Gher area (own)**

The maximum farmers had lower (≤500 decimal) type gher area (own) followed by the highest category farmers were minimum gher area (≤500 decimal). It was found that 88% respondents have their own gher area and only 2% had high category gher area (Table 5).

**Table 5.** Gher area (own) of the respondents

| Categories | Score (decimal) | Respondent (N=100) | | Range | Mean | Sd |
|---|---|---|---|---|---|---|
| | | Number | Percent | | | |
| Low | ≤500 | 88 | 88 | | | |
| Medium | 500-1000 | 10 | 10 | 0-1500 | 2.48 | 288.65 |
| High | >1000 | 2 | 2 | | | |
| Total | | 100 | 100 | | | |

**Gher area (leased out)**

Medium type farmers had minimum gher area (800- 1600 decimal) and maximum farmers had lower (≤800 decimal) type gher area (leased out) and the mean was 2.65 (Table 6).

**Table 6.** Gher area (leased out) of the respondents

| Categories | Score (decimal) | Respondent (N=100) | | Range | Mean | Sd |
|---|---|---|---|---|---|---|
| | | Number | Percent | | | |
| Low | ≤800 | 96 | 96 | | | |
| Medium | 800-1600 | 1 | 1 | 0-2500 | 2.65 | 400.43 |
| High | >1600 | 3 | 3 | | | |
| Total | | 100 | 100 | | | |

### 4.1.4 Annual family income of the respondents from different sectors in the study area

In this study, annual family income was calculated from shrimps, agriculture (crops, fruits, trees, and livestock's) and others (services, day labors, business, fishes except shrimp etc.). Majority of the farmers were involved with shrimp culture and their annual income of maximum was greater (>200000 tk/year) compared to other services (Table 7). Annual income from agriculture was not so high because, the soil was not suitable for agricultural crops due to high salinity percentage. A few numbers of people (16%) were involved in other income generating activities.

**Table 7. Annual income of the respondents in the study area**

| **Source of income** | **Amount (Tk.)** | **Percent** |
|---|---|---|
| Shrimp | Low (50000-150000 | 29.8 |
| | Medium(150000-200000 ) | 22.3 |
| | High (>200000) | 47.9 |
| Agriculture | Low (50000-150000 ) | 28.26 |
| | Medium (150000-200000) | 41.30 |
| | High (>200000) | 30.43 |
| Other sources | Low (50000-150000) | 12.5 |
| | Medium (150000-200000) | 43.8 |
| | High (>200000) | 43.8 |

### 4.1.5 Cropping pattern of the study area

Environment had changed in the study area due to continuous shrimp culture. Most of the farmers were not interested in agriculture because it was less profitable than shrimp culture. In the study area, 83% farmers had changed their land use by shrimp culture, integrated rice-fish cultivation and integrated rice-fish-vegetables cultivation were 83%, 12% and 5% respectively (Table 8). Swapan and Gavin (2011) found that prior to shrimp farming, rice was cultivated on 80% of the cultivable land and harvested twice in a year (February-March and July-August) at Dmarpota of Satkhira District.

**Table 8. Cropping pattern of the study area**

| Categories | Frequency | Percent (%) |
|---|---|---|
| Shrimp culture | 83 | 83 |
| Integrated rice-fish cultivation | 12 | 12 |
| Integrated rice-fish-vegetables cultivation | 5 | 5 |
| Total | 100 | 100 |

**Table 9. Grain crop varieties cultivated in the study area**

| Grain Crops | Percent |
|---|---|
| Boro rice | 52 |
| Aus rice | 32 |
| Aromatic rice | 49 |
| Wheat | 10 |
| Maize | 12 |

Around 52% fermers cultivated boro rice where as 12% cultivated in maize in the study area (Table 9). Wheat and Maize cultivation practices were decreasing day by day. The major cause of this problem was the degradation of land due to shrimp culture and saline intrusion. Jodder (2013) found that 90 percent of the respondents cultivated Aman rice, 10% cultivated Aus rice and 8 percent Boro rice in Khulna districts. In Satkhira district cultivation of Aus rice was lower than Khulna districts because salinity in satkhira districts was greater than Khulna districts.

### 4.1.6 Chemical used in shrimp culture

According to the respondent, mejority of the farmers used chemicals and antibiotics indiscriminately without knowing their mode of action, doses and appropriate procedure of application. Commonly used chemicals found in the study area were lime, urea, Triple super phosphate (TSP), Potassium permanganate, Vitamins, Antibiotics, rotenone, phosphate, phostoxin, sumithion, melathion, timsen, zeolite and théiden to prevent definite insect, pest and diseases.

### 4.1.7 Fertilizer use and application rate in the study areas

From the study area most of the farmers used urea and TSP as fertilizer in their gher. In the study area, the application rate of urea was 15 kg/bigha for both bagda and golda gher and the application rate of TSP was 12 kg/bigha for both bagda and golda gher. Moreover, some other fertilizer such as Zinc, MoP, DAP also used in their gher to promote the gher condition.

## 4.2 Environmental impacts of shrimp culture in the study area

### 4.2.1 Changes of the soil fertility in the studied area

Around 81% respondents told that the fertility of the land was decreased day by day in the study area (Table 10).

**Table 10. Changes of the soil fertility in the study area**

| Response of the respondents | Frequency | Percent (%) |
|---|---|---|
| Yes | 81 | 81 |
| No | 15 | 15 |
| Not Notice | 4 | 4 |
| Total | 100 | 100 |

The shrimp farmers used different types of fertilizers in their gher land to improve their field condition. Due to the application of chemical fertilizer and pesticide, soil fertility was reduced. According to Islam (2003) land inundation by saline water for a long period leads to its percolation into the surrounding soils, resulting in altered soil chemical properties. Williams and Islam (1999) observed that soil fertility was decreased by 92 percent in shrimp farming areas. The major reasons of decreasing soil fertility were due to chemical fertilizer and pesticide, water logging and saline intrusion. According to Anwar (2003) the organic matter content of the soils was also reduced to 1.0–1.5 percent and nutrient deficiencies in nitrogen and phosphorus were prevalent in saline soils.

### 4.2.2 Salinity level of shrimp gher in the study areas

Among the respondents 90% gave positive opinion , 7% gave negative and 3% did not notice increased the salinity level of their shrimp gher showed in Table 11.

**Table 11. Salinity level of shrimp gher in the study area**

| Response of the respondents | Frequency | Percent (%) |
|---|---|---|
| Yes | 90 | 90 |
| No | 7 | 7 |
| Not Notice | 3 | 3 |
| Total | 100 | 100 |

Salinity was increased in the study area due to continuous cultivation of shrimp. In the study area, most of the fermers responded salinity increased two times in every 10 years. According to Habiba *et al*., (2013) found that Shrimp farming also increased the salinity levels of the ground and surface water as saline water from shrimp farms seeps into ground and surface water in the coastal region of Bangladesh (Abedin et al. 2012; EJF 2004). According to Rahman (2014) the total area of Bangladesh affected by saline water in the meantime saline affected areas had increased by 3.5 percent over 10 years, from 1.02 million ha in 2000 to 1.06 million ha in 2009.

### 4.2.3 Soil erosion increased due to shrimp culture in the study area

According to the respondents, due to continuous farming of shrimp various problems were arisen. Soil erosion problem was one of them. Among the respondents, about 64% told that soil erosion was increased due to shrimp culture in the study area (Table 12).

**Table 12. Soil erosion increased due to shrimp culture in the study area**

| Response of the respondents | Frequency | Percent (%) |
|---|---|---|
| Yes | 64 | 64 |
| No | 25 | 25 |
| Not Notice | 11 | 11 |
| Total | 100 | 100 |

### 4.2.4 Cultivated land decreased due to shrimp culture in the study area

Shrimp was cultivated in Satkhira that had created negative impacts on gher land as a result cultivated land decreased day by day, most of the farmers told that due to shrimp farming cultivated land decreased in the study area (Table 13). Ali (2006) reported that the village Damarpota of Satkhira district, 274 ha (79%) of its prime quality rice fields had transferred into shrimp farms during the period between 1985 and 2003.The expansion of shrimp farming had drastically reduced the area under rice cultivation particularly in Satkhira. According to Barraclough and Finger-Stich (1996) many shrimp ponds had been constructed on cultivated land, especially rice field because of shrimp farming was more benefited than rice farming.

**Table 13. Cultivated land decreased due to shrimp culture in the study area**

| Response of the respondents | Frequency | Percent (%) |
|---|---|---|
| Yes | 82 | 82 |
| No | 11 | 11 |
| Not Notice | 9 | 9 |
| Total | 100 | 100 |

#### 4.2.5 Biodiversity loss due to shrimp culture in the study area

Due to increase of shrimp some problems were found to arisen in relating to biodiversity loss. Among the respondents 80% responded yes, 9% no and 11% had no idea about biodiversity loss (Table 14).

**Table 14. Biodiversity loss due to shrimp culture in the study area**

| Response of the respondents | Frequency | Percent (%) |
|---|---|---|
| Yes | 80 | 80 |
| No | 9 | 9 |
| Not Notice | 11 | 11 |
| Total | 100 | 100 |

From the study it was found that trees including date, palm and coconut trees were dried due to continuous shrimp cultivation. Thus, saline water leached into fresh land degraded soil quality that adversely affected local vegetation, plants and trees, crops, fishes and livestock, changed the environment, ecology, and impacts population health and disease patterns. Many of the local varieties of large fruit trees like mango, guava, sapodilla (sofeda), palm, berry, rose apple (jamrul), jujube (kul/boroi), kadbel, wood apple, coconut and so on had markedly declined over time in the southwestern part of Bangladesh (Kabir and Iva,2014). Paul and Vogl (2011) revealed that the rapid expansion of shrimp farming caused extensive destruction of mangrove ecosystems. Gain *et al.,* (2008) also observed that fish diversity was reduced in coastal areas with increased salinity. It was observed that the conversion of the mangrove forests into shrimp farms had destroyed the breeding habitat of many fishes and increased the erosion of the shore lines (Masum 2008; Swapan and Gavin 2011).

### 4.3 Chemical properties of soil in the studied area

After the survey report it was found that salinity was a major problem at Kaligonj upazila in Satkhira District. So soil sample of that region was analysed and the findings were discussed below.

**Table 15.** Soil pH, Electrical Conductivity and Salinity in the studied area

| Sample area | pH | EC (dS/m) | Salinity (%) |
|---|---|---|---|
| Taraly | 8.7 | 11.9 | 6.9 |
| Nalta | 8.6 | 12.34 | 6.8 |
| Moutala | 8.1 | 11.71 | 5.9 |
| Baro Shimla | 8.6 | 10.79 | 6.5 |
| Dakhin sreepur | 8.2 | 11.09 | 6.3 |
| Optimum value for shrimp culture | 6.5-7.5(CIBA 2001) | 4.0 (CIBA, 2001) | |

**Soil pH**

Soil pH is a very important variable and it helps to know chemical, biological and indirectly physical environment including both nutrients and toxins. In most cases, apH ranged from 6.0-7.5 is optimum for the adequate availability of nutrients in the soils of Bangladesh (BARC, 2005). From the table it was found that among the selected unions the pH values ranged from 8.1 to 8.7 (Table 15). Kabir and Eva (2014) observed the pH values ranged from 7.11 to 8.23 in the Debhata upazila of Satkhira district.

**Electrical Conductivity (EC)**

Electrical conductivity (EC) is the important parameter for soil salinity. From the study it was found that the electrical conductivity were 11.9 dS/m, 12.34 dS/m, 11.79 dS/m, 10.79 dS/m and 11.09 dS/m respectively at Taraly, Nalta, Moutala, Baro-Shimla and Dkhin Shreepur (Table 15). The highest EC value was observed 12.34 dS/m at Nalta union and the lowest EC value was found 10.79 dS/m at Baro Shimla union. According to Shamim *et al.*, (2015) found that the highest EC observed 11.77 dS/m and the lowest EC 10.07 dS/m in the Satkhira District of Bangladesh.

**Salinity percentage of Soil**

Salinity is the measure of all the salts dissolved in water. The reason behind the increase of soil salinity is poor drainage system, poor irrigation system, less rainfall, dumping toxic substances and others (Blaylock, 1994). From the table it was found that among the selected unions the highest salinity was observed at Tarali that was (6.9%) and the lowest salinity was observed at Moutala (5.9%) (Table 15). Shamim *et al*., (2015) found that the highest salinity value in the study area was 6.7% and the lowest was 5.1% in Satkhira District of Bangladesh. Humayun and Jahan (2014) observed that due to poor drainage system and continuous shrimp farming at Chandipur Village under Debhata Upazila of Satkhira District, salinity level of both soil and water were increased (1.6 ppt and 13.4 ppt respectively).

**Soil Organic Carbon**

Soil organic carbon is a important parameter for agriculture. It affects productivity of soil for agricultural production. From the laboratory experiment the organic carbon was found (1.96% to 0.83%) in the study area. Baten *et al*., (2014) found that the organic carbon ranged from 0.79% to 2.0% with the mean value 1.14 and standard deviation 0.44 some selected areas of Bagherhat District.

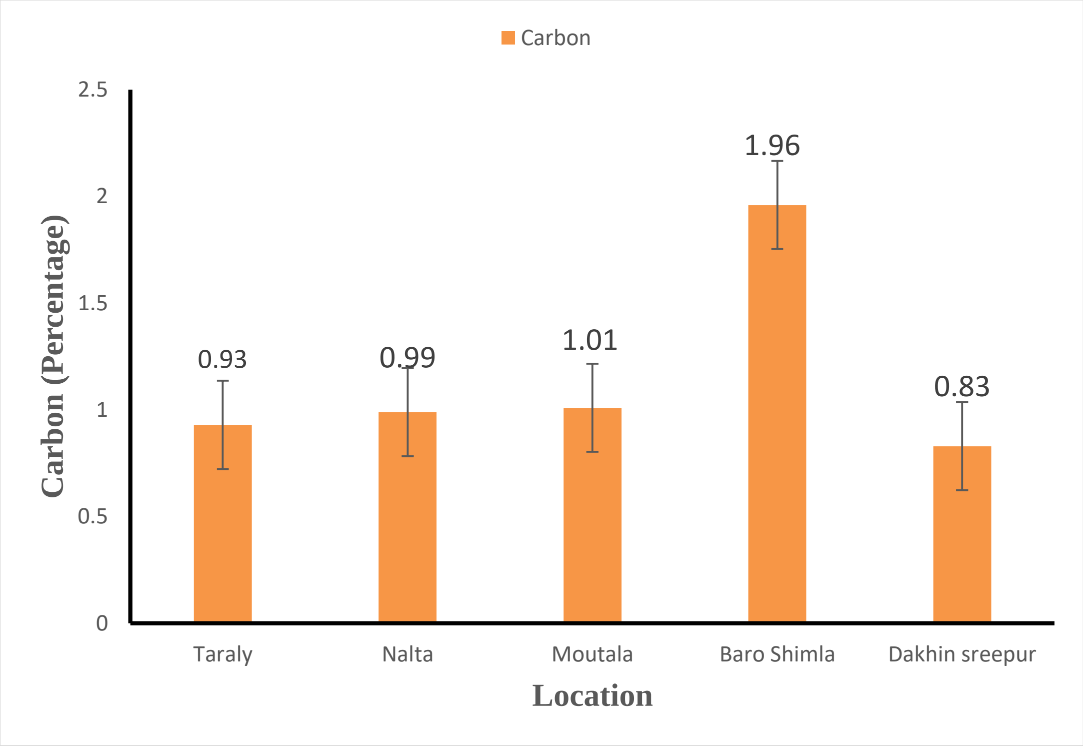


**Figure 4.** Organic carbon (%) in the studied area

**Organic Matter (OM)**

The organic matter content ranged from 1.37% to 2.11% (Fig.5, Appendix 1) in the study area. The highest and lowest value of organic matter was observed at Boro Shimla, Dkhin Shreepur respectively. The low level of organic matter in some areas might be due to higher oxidation rate of plant and animal residues by relatively high temperature. Baten *et al., (*2014) found that the organic matter content ranged from 1.37% to 3.47% with the mean value 1.98 and standard deviation 0.77 some selected areas of Bagherhat District. Islam *et al*., (1992) found that organic matter ranged from 0.6 to 1.7% in soil series from different region of Satkhira district. Organic matter in the study area decreased day by day due to cultivation of shrimp culture.

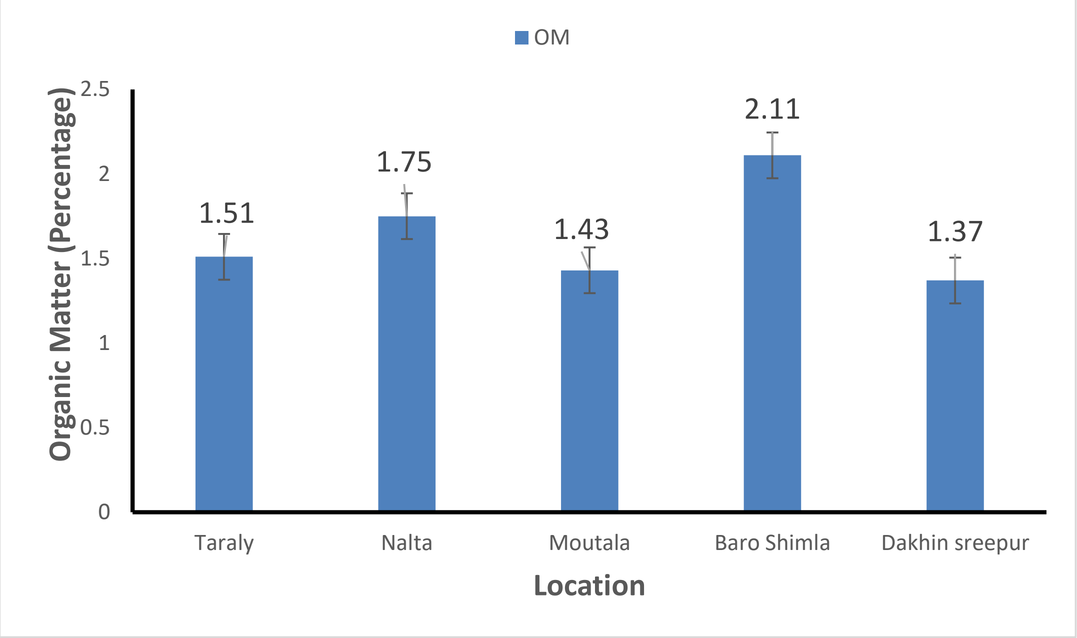


**Figure 5**. Organic matter (%) in the study area

### Exchangeable Potassium

Potassium is the third most essential elements after nitrogen and phosphorus, to limit plant productivity Brady (2004). The Potassium content ranged from 251.1 to 293 ppm (Fig. 6, Appendix 1) in the study area. The highest value of exchangeable K was found in soils of Baro Shimla (293 ppm) and the lowest was at Dkhin Shreepur (251.1 ppm). SRDI (1999) reported that the available potassium value ranged from 0.20 to 1.02 meq/100g soil in salt affected Satkhira district of Bangladesh.

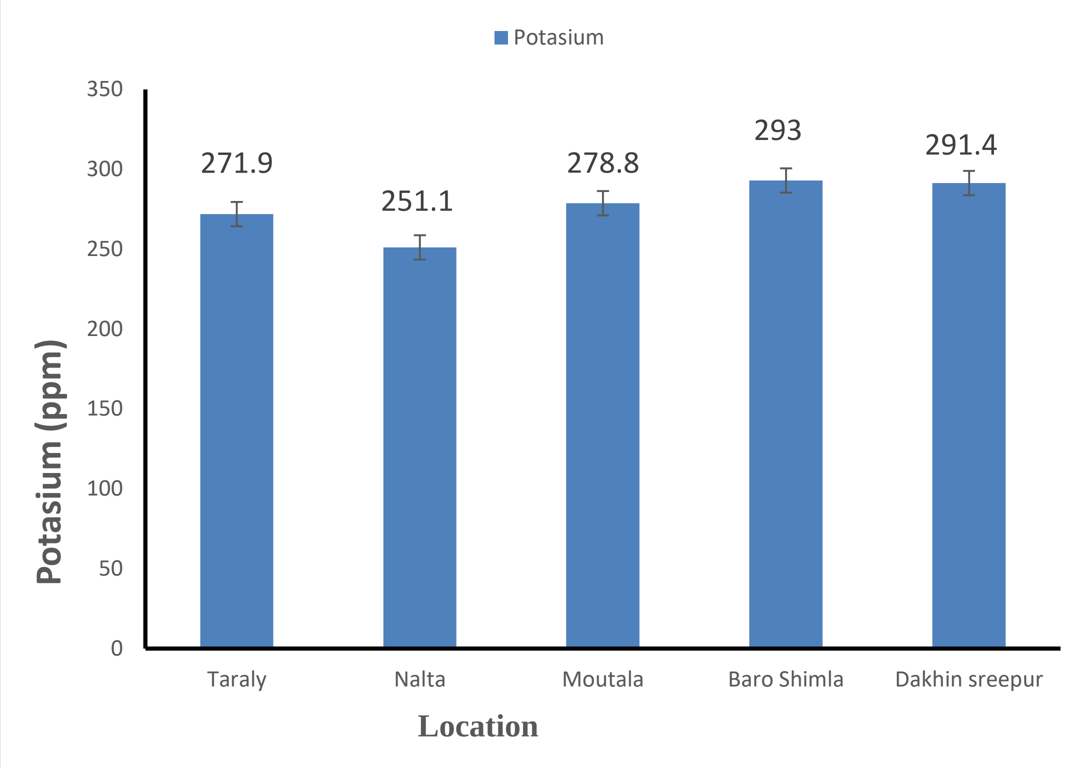


**Figure 6.** Amount of Potasium (K) present in the studied area

**Available Phosphorus**

Phosphorus is one of the most important element for plant productivity. The amount of available phosphorous ranged from 28.09 to 41.12 ppm in the selected gher area (Fig. 7, Appendix 1) in the selected gher area. The highest and lowest value of phosphorous was found at Dakhin Shreepur, Baro Shimla respectively. Rahman (2013) found that the range of available phosphorous 12 to 24 ppm in coastal and off shore areas of Bangladesh.

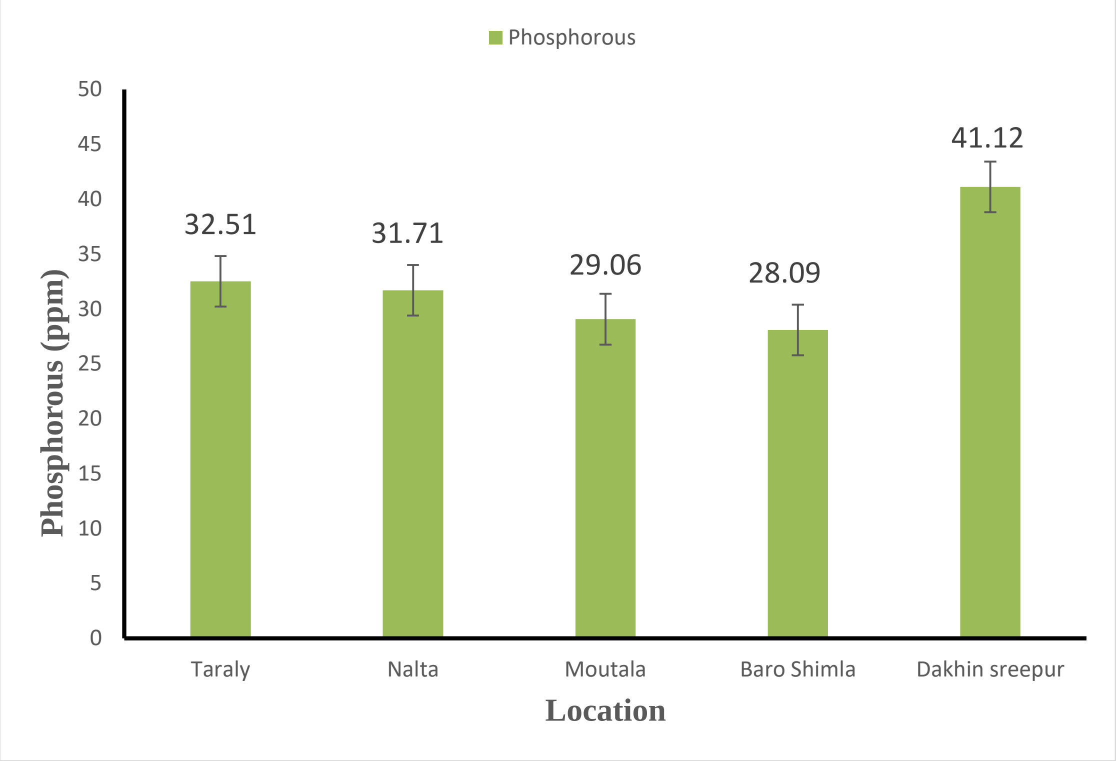


**Figure 7.** Amount of Phosphorus (P) present in the studied area

**Calsium (Ca)**

Calcium plays a very important role in plant growth and nutrition as well as in cell wall deposition. In the studied area it was observed that the available Ca ranged from (1071.01 to 1501.01 ppm) in the study area (Fig. 8, Appendix 1). Karim *et al.*, (1990) observed that the saline soil contained $Ca^{2+}$ at the concentration 460 to 1140 ppm at exchangeable state. Due to natural disasters and shrimp cultivation or intrusion of saline water, exchangeable Ca was increased over time.

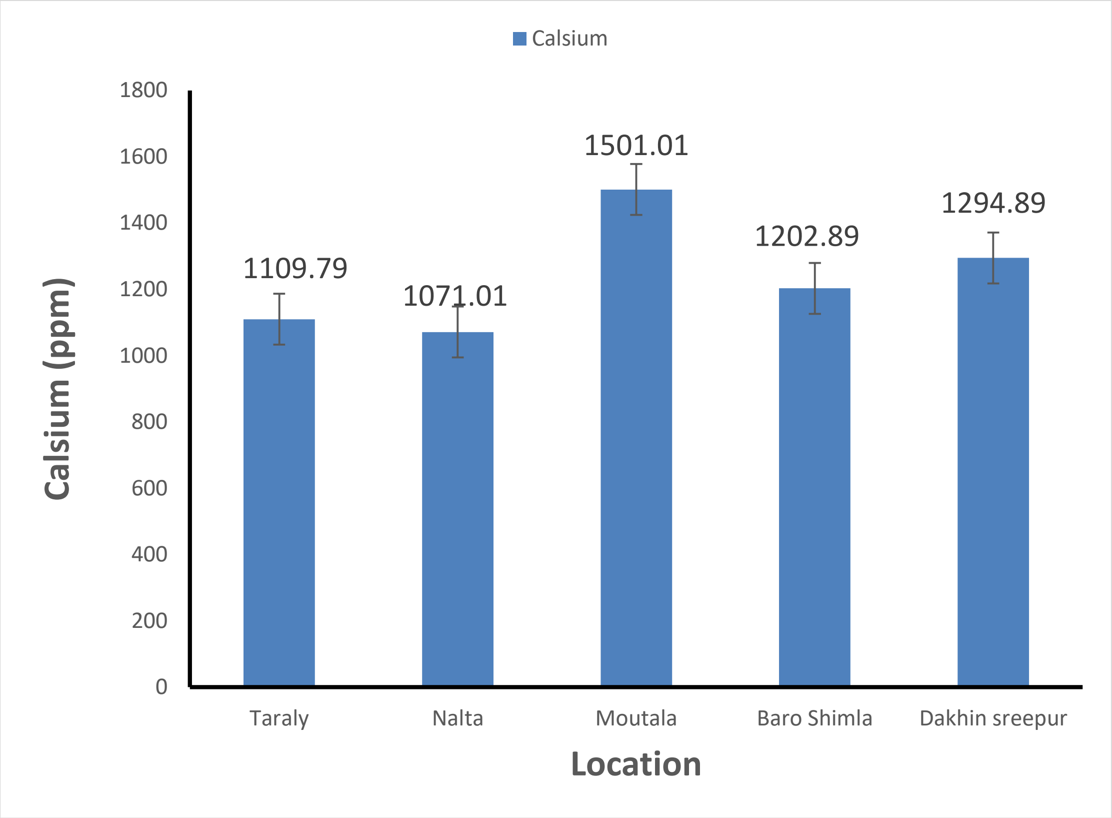


**Figure 8.** Amount of Calsium (Ca) present in the studied soil

**Exchangeable Sodium (Na)**

High levels of sodium are detrimental to soil tilth and plant growth (Marx *et al*., 1999). From the laboratory experiment it was found that the highest and lowest value of Na were 718.9 ppm, 679.6 ppm respectively (Fig. 9) in the studied area. The average value of exchangeable Na increased over time. In the year 1972, the highest value of exchangeable Na of the studied samples was 12.65 ppm soils and the lowest value was 7.82 ppm soils (SRDI, 1972). Mamun (2014) observed that the average value of exchangeable Na in the coastal areas of Bangladesh was 363.5 ppm .

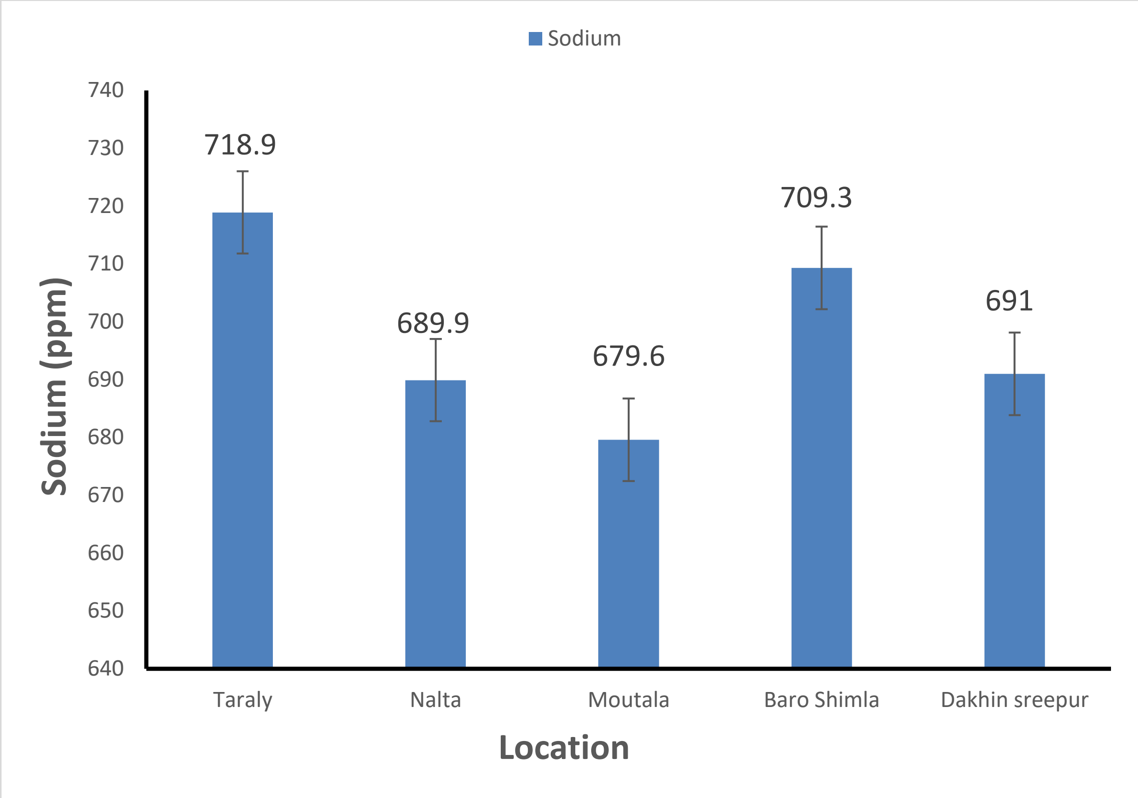


**Figure 9.** Amount of Sodium (Na) present in the studied area

**Sulpher (S)**

Sulphur (S) is one of the essential nutrients for growth of plant. Its requirement is the same as of phosphorus (De Kok *et al*., 2002; Ali *et al*., 2008). The available S content (179.32to 231.12 ppm) (Fig. 10) in the gher area. The highest and lowest value of Sulpher was found at Dakhin Shreepur and Moutala respectively. The available S contents of soils showed wide variation among the studied sites. Mitro *et al*., (2014) observed that the available S content ranged from 64.25 to 246.32 ppm in the selected area of Bagherhat district.


**Figure 10.** Amount of Sulpher (S) present in the studied area

### 4.4 Physico-chemical parameters of water samples collected from different shrimp Gher

Water quality is one of the important factors in the determination of shrimp culture activity. The result of the shrimp gher water have been presented in the Table 16.

#### Water pH

For aquaculture a standard value of pH had to be maintained in the range of 7.5 to 8.5 (CIBA, 2001) and the optimum pH value for shrimp cultivation was also within this range and this value should not vary more than 0.5 unit. In some cases, the pH value in the studied gher water was less than the optimum value which was not favourable for shrimp cultivation. In the studied area the pH value ranged from 7.1 to 8.1 (Table 16). There was no remarkable change was found in the gher water in the studied area.

**Electrical Conductivity (EC)**

In the studied areas the EC values ranged from 13.75 to 18.72. At Boro Shimla and Dakhin Shreepur it was higher than the optimum value.

**Salinity**

For shrimp cultivation the minimum level of salinity in water was 5 ppt (Alam, 2007). To get optimum production salinity level should be 15-25 ppt (Central Institute of Brackish Water Aquaculture, 2001). The salinity level of gher water was ranged from 8.5 to 11.1 percent which was not harmful for aquaculture.

**Total Dissolved Solid (TDS)**

Normally TDS ranges from 5 to 1000 mg $L^{-1}$ (Brady and Weil, 2004). The TDS values ranged from 6.88 to 9.36 g $L^{-1}$ (Table 16) which was not affected by saline water.

**Dissolved Oxygen (DO)**

Maintenance of an adequate level of DO in pond water is very important for shrimp survival and prolonged exposure to the stress of low concentration of oxygen can inhibit shrimp growth. In studied areas, the DO ranged from 7.0 to 7.2 mg $L^{-1}$ (Table 16) which was within the range. Poernomo (1992) reported that the tolerance DO for shrimp culture is <3 mg $L^{-1}$(3-10 mg $L^{-1}$) and the optimum DO ranges from 4-7 mg $L^{-1}$. Cheng *et al.*, (2003) reported that DO values higher than 5 mg $L^{-1}$ had often been recommended for intensive culture practices.

**Table 16. Physico-chemical parameters of water samples collected from different shrimp Gher**

| Sample area | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| | pH | EC mS/cm | TDS g/L | Turbidity (NTU) | DO (mg/L) | Salinity (%) | Temperatures ($^0$C) |
| Tarali | 7.1 | 14.68 | 7.34 | 63.4 | 7.1 | 8.5 | 31 |
| Nalta | 7.2 | 13.75 | 6.88 | 69.2 | 7.0 | 7.9 | 32 |
| Moutala | 7.2 | 16.55 | 8.27 | 11.2 | 7.1 | 9.7 | 31 |
| Boro-Shimla | 8.1 | 18.72 | 9.36 | 196 | 6.8 | 11.1 | 30 |
| Dakhin-Shreepur | 8.0 | 18.61 | 9.31 | 31.7 | 7.2 | 11.0 | 32 |
| Optimum value for aquaculture | 7.5-8.5$^{¥}$ | - | 15-25$^{\#}$ | 0-25$^{\#}$ | 4-7$^{¥}$ | 15-25$^{¥}$ | 28-32$^{¥}$ |

$^{\#}$Hajek and Boyd 1994; $^{¥}$ CIBA 2001

**Turbidity (NTU)**

The turbidity values observed in the 5 mixed shrimp gher water samples was ranged from 11.2 to 196 NTU which was deviated from optimal value (0-25) recommended by Hajek and Boyd (1994). They had reported that turbidity range from 0 to 25 NTU was considered as slight, 25 to 100 NTU as moderate and greater than 200 NTU as severe for agriculture.

**Water Temperature**

Temperature with range from 20-320$^0$C were recommended tolerance value for shrimp culture and 29-300$^0$C were the optimum temperature for cultured shrimp growth. In aquaculture, high temperatures could also increase intensity and frequency of disease outbreaks of shrimp and adversely impact on water quality in source water bodies (Goggin and Lester (1995), (Vilchis *et al*., 2005). In the studied area it was found that the temperature was 30 – 32$^0{}_C$ which was optimum for shrimp farming.

# CHAPTER V

# SUMMARY, CONCLUSION AND RECOMMENDATION

## SUMMARY

The study was conducted at Kaligonj upazila of Satkhira district to investigate the status of shrimp cultivation along with their socio-economic and environmental impacts during the period from August to December 2016. Data were collected from 100 respondents. A summary of the major findings was given in the subsequent sections.

In the studied area most of the respondents belonged to medium to old aged categories and only 21% respondents were in the young aged group. Majority (62%) of the respondents had primary and higher secondary level of education followed by higher secondary level (20%), graduate and above level (14%). It was clear from the study that all the respondents who were involved in shrimp farming were moderately educated. From the study area the highest category farmers were minimum in number (who had >20 decimal of land) and maximum farmers had low category shrimp farm (≤10) in the homestead area. Medium type farmers had minimum gher area (800- 1600 decimal) and maximum farmers had lower (≤800 decimal) type gher area (leased out) and the mean was 2.65. In the study area, 83% farmers had changed their land use by shrimp culture 12% farmers by integrated rice-fish cultivation and 5% by integrated rice-fish-vegetables cultivation.

Around 81% respondents told that the fertility of the land was decreased day by day in the study area. According to the respondents, due to continuous farming of shrimp various problems were arisen. Soil erosion problem was one of them. Among the respondents, about 64% told that soil erosion was increased due to shrimp culture in the study area.

From the survey it was found that among the selected unions the pH values ranged from 8.1 to 8.7. The highest EC value was 12.34 dS/m at the Nalta union and the lowest EC value was 10.79 dS/m at the Baro Shimla union. The average value of salinity was 6.4 %, the highest value of organic carbon of the studied areas was Boro Shimla (1.96%) and the lowest was Dakhin Shreepur (0.83%). The organic matter content ranged from 1.37% to 2.11% in the study area. The highest value of phosphorous was found in soils of Dakhin Shreepur (41.12 ppm) and the lowest value of phosphorous was found in Baro Shimla (28.09 ppm), The highest value of Calcium was found in the soils of Moutala union (1501.01 ppm) and the lowest at Nalta union (1071.01 ppm), The available Na ranged from 679.6 to 718.9 ppm and mean value was 697.74. The average value of exchangeable Na was much increased over time, the highest value of Sulphur was found in soils of Dakhin Shreepur (231.12 ppm) and the lowest value of Sulphur was found at Moutala (179.32 ppm). Results showed that except dissolved oxygen (DO: 7.0 to 7.2 mg $L^{-1}$) and temperature (30 to $32^{0}$C) other physicochemical parameters of shrimp gher water were not suitable for shrimp cultivation.

## CONCLUSION

Shrimp is a cash crop which creates employment opportunities and improves the livelihood of shrimp farmers as well as related intermediaries. From the experiment it was found that the annual income of the respondents was increased from the past. Shrimp cultivation has ecological impact in terms of salinity increase and loss of biodiversity. But the salinity was increased both in soil and water. So farmers had changed their cropping pattern. In the soil of the study OM, EC and Na were more than the optimum limit.

## RECOMMENDATION

1. Similar research should be conducted by the researchers in other region of Bangladesh.
2. The coastal areas should be categorized into several zones on the basis of salinity and agro-ecosystem to ensure proper use of valuable land resources and accordingly, eco-friendly shrimp culture and improved management should be introduced to increase both private and social benefits.
3. The Government should give more concern about the adverse impact of climate change on the coastal environment to successfully face the natural disasters.

# CHAPTER VI

# REFERENCES

Abedin, M.A., Habiba, U. and Shaw, R. (2012). Impacts of Salinity, Arsenic, and Drought in Southwestern Bangladesh. In: Environment Disaster Linkages (Community, Environment and Disaster Risk Management, Volume 9), eds. R. Shaw and P. Tran, *Emerald Group Publishing Limited, pp.* 165–193.

Ahamed, F., Fulanda, B., Siddik, M.A.B., Hossain, M.Y., Mondol, M.M.R., Ahmed, Z.F. and Ohtomi, J. (2014). An Overview of Freshwater Prawn Fishery in Bangladesh: Present Status and Future Prospect. *J. of Coastal Life Medicine.* **2**: 580-588.

Ahmed, A.U. (2008). Assessment of Vulnerability to Climate Change and Adaptation Options for the Coastal People of Bangladesh. Practical Action Bangladesh, Dhaka, Bangladesh.

Ahmed, N. (1999). Socio-economic aspects of freshwater prawn culture development in Bangladesh. Ph.D. thesis, Institute of Aquaculture, University of Stirling, UK, pp. 3-20.

Ahmed, S.A., Mallick, D.L., Ali, M.L. and Rahman, A.A. (2002). Literature Review on Bangladesh Shrimp. Policy Research for Sustainable Shrimp Farming in Asia (PORESSFA), European Commission.

Ahsan, M**. (**2010). *Saline Soils of Bangladesh.* SRMAF Project, Soil Resource Development.

Alam, S., Hossain, M.L., Foysal, M.A. and Misbahuzzaman, K. (2014). Growth Performance of Mangrove Species in Chakaria Sundarban. *Int. J. Ecos.* **4**: 233–238.

Alam, S.M.N. (2007). Factors affecting penaeusmondon yield in extensive farming system in Southwest Bangladesh, *J. of Fish. Int.* **2**(2): 162-170.

Alam, S.M.N. and Phillips, M.J. (2004). Coastal shrimp aquaculture systems in Southwestern Bangladesh. *Asian Fisheries Sci.* **17**: 175-189.

Alauddin, M. and Hamid, M.A. (1996). Shrimp Culture in Bangladesh, Sustainable and Research Issue, NACA and ACIAR Workshop on Key Researchable Issues in Sustainable Shrimp Aquaculture, Songkhla, Thailand, 28-31 October.

Ali, A.M.S. (2006). Rice to Shrimp: Land Use/Land Cover Changes and Soil Degradation in Southwestern Bangladesh. Land Use Policy. **23**: 421–435.

Ali, A.M.S. (2006). Rice to Shrimp: Land Use/Land Cover Changes and Soil Degradation in Southwestern Bangladesh, Land Use Policy, 23, pp. 421-435.

Anonymous (1994). Fight for survival turns into bloodshed. The Bangkok Post.

Anonymous (1995). Water so salty it can kill a horse. The Bangkok Post.

Anwar, S.M. (2003). Effect of Shrimp Culture on Ecology in the Coastal Areas of Bangladesh.

Barraclough, S. and Fingher-Stich, A. (1996). Some Ecological and Social Implications of Commercial Shrimp Farming in Asia. UNRISD Discussion Paper 74. UNRISD (United Nations Research Institute for Social Development), Geneva, Switzerland, pp. 71.

Battacharya, D., Rahman, M. and Khatun, F.A. (1999). Environmental Impacts of Trade Liberalization.

Bouyoucos, G.J. (1962). Hydrometer method improved for the mechanical analyses of soil. *J. of Agronomy,* pp. 54:464.

Boyd, C.E., Thunjai, T. and Boonyaratpalin, M. (1995). Dissolved Salts in Water for Inland, Low- Salinity Shrimp Cultivation, Global Aquaculture Advocate, pp. 40-45.

Brady, N.C., and Weil, R.R. (2004). The Nature and Properties of Soil, ($13^{th}$ ed.) Singapore, Pearson Education.

Cheng, W., Liu CH, Kuo C.M. (2003). Effects of dissolved oxygen on haemolymph parameters of freshwater giant prawn, Macro brachium Rosenberger (de Man), Aquaculture 220, pp. 843-856.

Chowdhury, A. (2015). Shrimp: The Devastating Delicacy: The Explosion of Shrimp Farming and the Negative Impacts on People and the Environment. Greenpeace report, Greenpeace and University of California, USA.

Chowdhury, M.A., Shivakoti, G.P. and Salequzzaman, M. (2006). A conceptual framework for the sustainability assessment procedures of the shrimp aquaculture industry in coastal Bangladesh. *Int. J. Agric. Resour. Governan. Ecol.* **5**: 162-184.

Chowdhury, M.B.R. and Muniruzzaman, M. (2003). Shrimp Diseases and Its' Consequences on the Coastal Shrimp Farming in Bangladesh,

CIBA (Central Institute of Brackish Water Aquaculture) (2001). Soil and water quality management in brackish water aquaculture, special publication 13, pp. 1-99.

CIBA (Central Institute of Brackish Water Aquaculture) (2001). Soil and water quality management in brackish water aquaculture, special publication 13, pp. 1-99.

De Kok, R. J. (2002). Sulphur in Plants: An Ecological Perspective, pp. 97

Deb, A.K. (1998). Fake Blue Revolution: Environmental and Socio-Economic Impacts of Shrimp Culture in the Coastal Areas of Bangladesh. Ocean & Coastal Management. 41, pp. 63-88.

Deb, A.K. Fake Blue Revolution (1998): Environmental and Socio-Economic Impact of Shrimp Culture in the Coastal Areas of Bangladesh, Community Development Centre (CDC), Canada.

Debapriya, (1999). Environmental Consequences of Structural Adjustment: Towards Sustainable Shrimp Culture in Bangladesh.

Dillon, J.L.Hardaker, J.B. (1993). Farm management research for small farmer development University of New England, Armadale, NSW, Australia, FAO, Rome (Italy). Agricultural Services Div.

DoF, (2009). Fishery Statistical Yearbook of Bangladesh 2007-08: fifth ed. Department of Fisheries, Ministry of Fisheries and Livestock, Matshya Bhaban, Dhaka, Bangladesh.

DoF, (2014). Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

DoF, (2014a). Annual Report 2013. Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

DoF, (2014b). Fisheries Statistical Yearbook of Bangladesh 2012-2013: Fisheries Resources Survey System (FRSS), Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

DoF, (2016). National Fish Week 2016 Compendium (in Bengali). Department of Fisheries, Dhaka, Bangladesh. pp. 148.

EJF, (2004). Desert in the Delta: A Report on the Environmental, Human Rights and Social Impacts of Shrimp Production in Bangladesh. Environmental Justice Foundation (EJF), London, UK.

Elmanama, A. A., Afifi, S. and Bahr, S. (2006). Seasonal and Spatial Variation in the Monitoring Parameters of Gaza Beach during 2002-2003, Environmental Research, 101, pp. 25-33.

Environmental Justice Foundation. (2004). Farming the Sea, Costing the Earth. Why We Must Green the Blue Revolution, Series Report, London, UK, pp. 2-11.

FAO, (1995). Review of the state of world fishery resources: aquaculture. FAO Fisheries Circular 886, pp.127.

Gain, A.K., Uddin, M.N. and Sana, P. (2008). Impact of River Salinity on Fish Diversity in the South-West Coastal Region of Bangladesh. *Int. J. Ecol. Environ. Sci.* 34: 49–54.

Gammage, S., Swanburg, K., Khandkar, M., Islam, M.Z., Zobair, M. and Muzareba, A.M. (2006). A Gendered Analysis of the Shrimp Sector in Bangladesh. Greater Access to Trade and Expansion. USAID, Bangladesh.

Goggin, C.L, Lester, R.J.G. (1995) Perkinsus; A protistan parasite of abalone in Australia review: Marine and Freshwater Research, 46, pp. 639-646.

Habiba, U., Abedin, M.A., Shaw, R. and Hassan, A.W.R. (2013). Salinity-Induced Livelihood Stress in Coastal Region of Bangladesh. In: Water Insecurity: A Social Dilemma (Community, Environment and Disaster Risk Management, Volume 13), eds. Abedin, M.A., Habiba, U. and Shaw, R. Emerald Group Publishing Limited, Uk, pp. 139 –165.

Hagler, M., Gianni, M. and Lorenzo, C. (2009). Shrimp: The Devastating Delicacy: The Explosion of Shrimp Farming and the Negative Impacts on People and the Environment. Greenpeace report, Greenpeace and University of California, USA.

Hajek BF, Boyd CE (1994). Rating soil and water information for aquaculture, Aquacult; Eng. 13, pp. 117-128.

Haque, S., Bhatta, G.D., Hoque, N., Rony, M.H. and Rahman, M. (2008). Environmental Impacts and their Socioeconomic Consequences of Shrimp

Farming in Bangladesh, M.S. thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hasan, M.N., Hossain, M.S., Bari, M.A. and Islam, M.R**. (**2013). Agricultural land availability in Bangladesh. SRDI, Dhaka, Bangladesh, pp. 42.

Hossain, M.A.R., and Hasan, M.R. (2017). An Assessment of Impacts from Shrimp Aquaculture in Bangladesh and prospects for Improvement. *FAO Fisheries and Aquaculture Technical Paper No*. 618. Rome, FAO, pp. 96.

Hossain, M.A.R., Kabir, H., Faruque, A.M.O. and Hossain, M. (2015a). Assessment of Agro-Ecological Zone Specific Risks, Vulnerabilities of Disaster and Climate Change and Climate Change Adaptation (CCA) In Fisheries Sector of Bangladesh. Report on Disasterand Climate Risks Management in Fisheries Project, Department of Fisheries/CDMP-II, Matshya Bhaban, Ramna, Dhaka 1000, Bangladesh.

Human, Landscape Ecology (MNFEL 330). 18 pp. (available at e.g. http://www.scribd.com/ document/53695320/Effect-of-Shrimp-Culture).

Humayun, A.H. and Jahan, A.B. (1995). Dissolved Salts in Water for Inland, Low-Salinity Shrimp Cultivation, Global Aquaculture Advocate, pp. 40-45.

Huntington, T.C., (2003). Environmental Issues in Shrimp Farming in Bangladesh. ARDMCS, Dhaka, Bangladesh. 24 pp.

Institute (SRDI), Ministry of Agriculture, Government of the People's Republic of Bangladesh, pp. 62.

Islam, A. (1992). Review of soil fertility research in Bangladesh. In "Proceedings of the Inter-Congress Conference of Commission IV of ISSS on Improving Soil Management for Intensive Cropping in the Tropics and Sub-Tropics, pp. l-18

Islam, M.S. (2003). Perspectives of the Coastal And marine Fisheries of the Bay of Bengal, Bangladesh. *Ocean & Coastal Management* 46: 763–796.

Islam, M.S. (2003). Socioeconomic Impacts of Alternative Shrimp-Crop Farming in Bangladesh, In M. Wahab, (ed.) *Environmental and Socioeconomic Impacts of Shrimp Farming in Bangladesh*, Dhaka, pp. 61-78.

Islam, M.S., Azahar, M.A.W. and Miah, A. (2002). Socioeconomic and Environmental Impacts of Alternate Shrimp-Crop Farming in Bangladesh. *Bangladesh J. Agric. Econs. XXV.* 1: 63-76.

Islam, M.S., Wahab, M.A. and Miah, A.A. (2002). Socioeconomic and Environmental Impacts of Alternate Shrimp-Crop Farming in Bangladesh *Bangladesh J. Agric. Econs. XXV,* ***1*** *(2002): 63-76.*

Ito, S. (2002). From Rice to Prawns: Economic Transformation and Agrarian Structure in Rural Bangladesh. *J. Peasant Studies.* 29: 47–70.

Jackson, C.J., Preston, N., Burford, M.A. and Thompson, P.J. (2003). Managing the Development of Sustainable Shrimp Farming in Australia. The Role of Sedimentation Ponds in Treatment of Farm Discharge Water. Aquaculture. 226: 23-34.

Kabir, M.H. and Eva, I.J. (2014). Ecological Consequences of Shrimp Farming in Southwestern Satkhira District of Bangladesh. *Austin J. Earth Sci.* 1: 1–7.

Kabir, M.H. and Eva, I.J. (2014). Environmental Impacts of Shrimp Aquaculture *J. Asiat. Soc. Bangladesh, Sci.* 40: 107-119.

Karim, M.R. (2006). Brackish-water Shrimp Cultivation Threatens Permanent Damage to Coastal Agriculture in Bangladesh. In: Environment and Livelihoods in Tropical Coastal Zones, eds. *C.T. Hoanh, T.P. Tuong, J. W. Gowing and B. Hardy, CAB International, UK, pp.* 61-71.

Karim, M.R. (2006). Brackish-water Shrimp Cultivation Threatens Permanent Damage to Coastal Agriculture in Bangladesh. In: *Environment and Livelihoods in Tropical Coastal Zones,* eds. CAB International, UK, pp. 61-71.

Karim, Z., S.G. Hussain and M. Ahmed, (1990). Salinity Problems and Crop Intensification in the Coastal Regions of Bangladesh. Bangladesh Agricultural Research Council 33: 63.

Kendrick, A. (1994). "The Gher Revolution: The Social Impacts of Technological Change in Freshwater Prawn Cultivation in Southern Bangladesh", The Report of a Social Impact Assessment Prepared for CARE International in Bangladesh with Support from the Bangladesh Aquaculture and Fisheries Resource Unit (BAFRU).

Khan, A.E., Ireson, A., Kovats, S., Mojumder, S.K., Khusru, A., Rahman, A. and Vineis, P. (2011). Drinking Water Salinity and Maternal Health in Coastal Bangladesh: Implications of Climate Change. *Environmental Health Perspectives.* 119, pp. 1328-1332.

Khan, M.M. and Azad, M.A. (2014). The Nexus between Local Politics and Salinity Intrusion in Coastal Area of Bangladesh: Unveiling the Development Myth. *Global J. of Sociology.* 4: 29–40.

M. A. Baten,S. Mitro, and R. Khatun (2014) . Socio-Economic and Environmental Impacts of Shrimp Culture in Some Selected Areas of Bagerhat District. *J. Environ. Sci. & Natural Resources,* **7**(1): 265-269.

Mamun, (2014). Report on Environmental and Social Condition of Satkhira District.

Manju, T. (1996). *Political Economy of Shrimp Culture in Bangladesh*. Poverty Research Report 13, Grameen Trust, Grameen Bank, Dhaka.

Masum, S.J.H. (2008). Working Together for Responsible and Eco-friendly Shrimp Farming in Bangladesh: Exploring Corporate Environmental Responsibility (CER) & Corporate Social Responsibility (CSR) in the context of Commercial Shrimp Sector in Bangladesh. Coastal Development Partnership (CDP), Dhaka, Bangladesh.

Mazid, M.A. and Banu, A.N.H. (2002). An Overview of the Social and Economic Impact and Management of Fish and Shrimp Disease in Bangladesh, with an Emphasis on Small-Scale Aquaculture. In: Arthur JR, Phillips MJ, Subasinghe RP, Reantaso MB, MacRae LH (Eds.) Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development. *FAO Fisheries Technical Paper No*. 406 FAO (United Nations of the Food and Agriculture Organizations) Rome, Italy, pp. 21-25.

MFL, (2014). National Shrimp Policy. Ministry of Fisheries and Livestock (MFL), Dhaka, Bangladesh.

MFL, (2014). National Shrimp Policy. Ministry of Fisheries and Livestock (MFL), Dhaka, Bangladesh.

Michele, P. (2015). Drinking Water Salinity and Maternal Health in Coastal Bangladesh: Implications of Climate Change. Environmental Health Perspectives. 119, pp. 1328-1332.

MoEF, (2005). National Adaptation Programme of Action (NAPA). Ministry of Environment and Forests (MoEF), Dhaka, Bangladesh.

Panayotou and Tokrisna (1998). Shrimp Farming and Mangrove Loss in Thailand.

Paul, B.G. and Vogl, C.R. (2011). Impacts of shrimp farming in Bangladesh. Challenges and alternatives. Ocean. Coast. Manage. 54, pp. 201-211.

Poernomo, A. (1992). The selection of environment friendly shrimp pond, Centre for Research and Development of Fisheries, Jakarta.

Primavera, J.H. (1998). Tropical Shrimp Farming and Its Sustainabbility, in S. S. D. Silva (ed). Tropical Mariculture, Academic Press, pp. 257-290.

Quader, O., Z. Islam, M. Rahman, M.H. Sarkar and A.S. Khan. (2010). Sustainable Site Selection of Shrimp Farming in the Coastal Areas of Bangladesh Using Remote Sensing Techniques (4 S Model), Agargaon, Dhaka: Bangladesh Space Research and Remote Sensing Organization (SPARRSO), pp. 1-6.

Rabhi, M., Hafsi, C., Lakhdar, A., Hajji, S., Barhoumi, Z., Hamrouni, M.H., Abdelly, C. and Smaoui, A. (2009). Evaluation of the Capacity of Three Halophytes to Desalinize Their Rhizosphere as Grown on Saline Soils under Non leaching Conditions. *Afr. J. Ecol.* 47: 463-468.

Rutherford, S. (1994). “CARE and Gher: Financing the Small Fry”, The Report Prepared for CARE International in Bangladesh with Support from the Bangladesh Aquaculture and Fisheries Resource Unit (BAFRU).

Rahman, M. (2005). EU Ban on Shrimp Imports from Bangladesh: A Case Study on Market Access Problems Faced by the LDCs. Consumer Unity & Trust Society (CUTS) International.

Rahman, M. (2014). Ecological Consequences of Shrimp Farming in Southwestern Satkhira District of Bangladesh. *Austin J. Earth Sci.* **1**: 1–7.

Rahman, M.M. (2013). Shrimp Cultivation with Water Salinity in Bangladesh: Ecological Model, *Universal J. Public Health* **1**(3): 131-142.

Rahman, M.M., Flitner, M. and Krause, G. (2009). Environmental Assessment of Shrimp Farming in Relation to Livelihoods in the South-West Coastal Bangladesh. *Bangladesh J. Fish. Res.* **13:** 47–54.

Rahman, M.M., Giedraitis, V.R., Lieberman, L.S., Akhtar, M.T. and Taminskienė, V. (2013). Shrimp Cultivation with Water Salinity in Bangladesh. *The Implications of an Ecol. Model Universal J. Public Health.* **1:** 131-142.

S. Mitro, R. Khatun and M. A. Baten (2014). Socio-Economic and Environmental Impacts of Shrimp Culture in Some Selected Areas of Bagerhat District. *J. Environ. Sci. & Natural Resources*, **7**(1): 265-269.

Sadika, J.A., Rini, M.J. and Tuli, A.T. (2008). Impact of River Salinity on Fish Diversity in the South-West Coastal Region of Bangladesh. *Int. J. Ecol. Environ. Sci.* **34**: 49–54.

Saha, S.K. (2017). Socio-economic and environmental impact of shrimp farming in the south- western coastal region of Bangladesh. *Int. J. Res. on Land Use Sustainability*. **3**: 128-137.

Shahid, M.A. and J. Islam. (2003). Impact of Denudation of Mangrove Forest Due to Shrimp Farming on Coastal Environment in Bangladesh, Dhaka, pp. 49-60.

Shamim, A.H.M., Sobahan, M.A., Saha, B. Sarker, B.K. and Tabrig, M.S.U. (2015). Deterioration of Soil and Water Quality by Practicing Shrimp Culture in Satkhira, Bangladesh. *J. Soil Nature* **8**(3): 7-13.

Swapan, M.S.H. and Gavin, M. (2011). A Desert in the Delta: Participatory Assessment of Changing Livelihoods Induced by Commercial Shrimp Farming in Southwest Bangladesh. Ocean & Coastal Management. 54, pp. 45-54.

Theodore, P. (1998). Instruments of Change: Motivating and Financing Sustainable Development, United Nations Environment Programme, Earthscan Publications Ltd., London.

Vilchis LI, Tegner MJ, Moore JD, Friedman JD, Friedman CS, Riser KL, Robbins TT, Dayton, PK (2005). Ocean warming effects on growth reproduction and survivorship of Southern California abalone, Ecological Applications, 15.

Vincelli, M. (2015). The Impacts of Shrimp Farming on Mangrove Forests Environmental Policy Thesis ENVS, 190A.

Wahab, M.A. (2003). Environmental Impacts of Shrimp Farming in the Coastal Areas of Bangladesh, In M.A. Wahab, (ed.) Environmental & Socioeconomic Impacts of Shrimp Farming in Bangladesh, Dhaka: BRAC Centre, Dhaka, Bangladesh, pp. 19-32.

Williams, D. and Islam, S. (1999). Study report on impacts of gher farming on agriculture and livestock. A study report of GOLDA Project, CARE Bangladesh, Dhaka, Bangladesh. pp. 49.

**APPENDIX I**

# Supplementary Table

| Location | OM (%) | Org. C (%) | Total N (%) | P (ppm) | K (ppm) | Na (ppm) | Ca (ppm) | S (ppm) |
|---|---|---|---|---|---|---|---|---|
| Taraly | 1.51 | 0.93 | 0.17 | 32.51 | 271.9 | 718.9 | 1109.79 | 197.09 |
| Nalta | 1.75 | 0.99 | 0.09 | 31.71 | 251.1 | 689.9 | 1071.01 | 198.56 |
| Moutala | 1.43 | 1.01 | 0.08 | 29.06 | 278.8 | 679.6 | 1501.01 | 179.32 |
| Baro Shimla | 2.11 | 1.96 | 0.19 | 28.09 | 293 | 709.3 | 1202.89 | 193.08 |
| Dakhin sreepur | 1.37 | 0.83 | 0.09 | 41.12 | 291.4 | 691 | 1294.89 | 231.12 |

**APPENDIX I I**

Agroforestry And Environmental Science Department

Sher-e- Bangla Agricultural University

## Interview Schedule

**SOCIO-ECONOMIC IMPACTS AND ENVIRONMENTAL CHANGES DUE TO SHRIMP CULTIVATION IN KALIGONJ UPAZILL OF SATKHIRA DISTRICT**

Sample number------------

Name---------------------------  Fathers name---------------------------------

Village------------------------Union----------------------------------------

**PART: A**

## Socio-economic Impacts

1. Age----------------years
2. Educational qualification
   a. Do not know read and write b. Only name signature c. Passed class------------
3. Family size
   a. Total Members…………… b. Earning members …………
4. Experience in shrimp cultivation---------------------------years
5. Farm size of the respondent

| Land use pattern | Area |
|---|---|
| Homestead area | |
| Gher area(own) | |
| Gher area(leased out) | |
| Cultivated land | |

6. Annual income

| Sources of Income | Amount in Taka | |
|---|---|---|
| | Past | Present |
| Shrimp | | |
| Agriculture | | |
| Business | | |
| Service | | |
| Day laborer | | |
| Others | | |

7. Do you think cropping pattern change due to shrimp cultivation if yes-

| Categories | Seasonal Varieties | | Change varieties | | Agroecological context (Rainfed or Irrigated) | Tested areas |
|---|---|---|---|---|---|---|
| | Rabi | Kharif | past | present | | |
| Shrimp culture | | | | | | |
| Integrated rice-fish cultivation | | | | | | |
| Integrated rice-fish vegetables cultivation | | | | | | |
| Cultivation of saline tolerant vegetable crops | | | | | | |

8. Do you follow any control measure against viral attack?

| Name | Amount(Bigha/Kg) | Frequency/Year |
|---|---|---|
| | | |
| | | |
| | | |

9. What type of fertilizer do you use to shrimp cultivation?

| Name | Amount(Bigha/Kg) | Frequency/Year |
|---|---|---|
| | | |
| | | |
| | | |

**PART: B**

## Environmental Impacts

1. Do you think agricultural crop lands decreases due to shrimp culture?

   **a.** Yes b. No c. Don't know

2. Do you think salinity level increases due to shrimp culture?

   a. Yes b. No c. Don't know

3. Do you think soil erosion increases due to shrimp culture?

   a. Yes b. No c. Don't know

4. Cultivated land decreased due to increase shrimp

   a. Yes b. No c. Don't know

5. Do you think soil fertility is reduced due to shrimp cultivation?

a. Yes b. No c. Don’t know

6. Health hazard increased due to shrimp culture

a. Yes b. No c. Don’t know

7. Do you think environmental pollution increases due to shrimp culture?

a. Yes b. No c. Don’t know

8. Do you think there is any change in your cultivated land due to using chemicals?

a. Yes b. No c. Don’t know

9. Do you think water quality is decreasing due to shrimp cultivation?

a. Yes b. No c. Don’t know

10. Do you think introduction of invasive species due to shrimp culture?

a. Yes b. No c. Don’t know

11. Do you think shrimp culture is responsible for climate change?

a. Yes b. No c. Don’t know

12. Biodiversity loss due to shrimp culture

a. Yes b. No c. Don’t know

14.Do you think organic matter depletes for extensive shrimp farming?

a. Yes b. No c. Don’t know

15.What type of chemical do you use to shrimp cultivation?

| Name | Amount(Bigha/Kg) | Frequency/Year |
|---|---|---|
| | | |
| | | |
| | | |