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Impact of Land Use for Shrimp Cultivation instead of Crop Farming : The Case of Southwest Coastal Region of Bangladesh

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This study examines the overall impacts of land transformation from crop farms to shrimp ponds and develop of approach for the management strategy of shrimp ponds. To fulfill the research objective this study carried out through questionnaire survey under the purposive sampling technique. It also runs the linear regression model for impact assessment of brackish water and apply Chow test method for differentiating the impacts of brackish on crop productivity between shrimp ponds adjacent crop farms and normal crop farms. Provision of land zoning, organic shrimp culture, appropriate land settlement, education and training, income stability of the non-agriculture sector and location of shrimp ponds can help to improve the crop productivity condition in this region as they are all statistically significant at the convenient levels.

Keywords: Land transformation, Shrimp pond, Southwest coastal region, Chow test, Bangladesh

JEL Classification: C31, Q12, Q15, Q57

1. Introduction

Shrimp farming in the southwest coastal region of Bangladesh plays an important but controversial role in the economic development of many countries because of high economic returns and often catastrophic environmental impacts of production in coastal areas (Anh et al. 2010). It has been causing severe threat to local ecological systems, such as deterioration of soil and water quality, depletion of mangrove forest, decrease of local varieties of rice and fish, saline water intrusion in ground water, local water pollution and change of local hydrology (Kabir& Eva 2014).Water pollution is largely associated with the use, exchange and discharge of water in the shrimp ponds.

Shrimp farmers apply different types of chemicals, medicine, fertilizer and feeds in their shrimp pond to protect the shrimp from oxygen deficiency, subsequent disease and control water quality. About 21% farmers used Potassium permanganate, 18% used Aqua-nourish, 17% used Capsule and 14% fish and almost all chemicals were used mainly for improving water quality and preventing diseases. Use of the chemical might

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be the cause of the killing of many living organisms (Rahman et al. 2013). Shrimp ponds are enriched in suspended solids, chemicals, fertilizer, nutrients such as ammonia, nitrate, chlorophyll and biochemical oxygen demand (Hill 2004; Peaz-Osuna 2001).

Directly discharge water and prolonged saline water logging in shrimp ponds accelerates the leaching of base minerals and increases salinity and acidity of soil (Deb 1998).The expansion of shrimp farming is responsible for the increase the soil salinity, acidity, and depletion of soil Calcium (Ca), Potassium (K), Magnesium (Mg), and organic Carbon (C) content which lead to soildegradation (Ali 2006). Inundation of land by saline water for long periods leads to its percolation into the surrounding soils, resulting in altered soil chemistry (Islam 2003).Once the soil becomes saline, subsequent floods and monsoon rainfall may not leach out the salt completely and residual soil salinity is likely to increase over time and make it difficult to produce crops in the future (Karim2006).

Shrimp aquaculture farmstocks wild caught juveniles rather than hatchery reared post-Larvae that cause loss of biodiversity (Hossainet al. 2013). Shrimp ponds in the southwest coastal region highly required wild spawn from estuaries and coasts. Trawl fishermen collect mother shrimps as brood stock from the deep sea. This collection of brood stock and spawnplays a major role in the loss of capture fisheries as the by catch increases (Primavera 2006).Over exploitation of the adults and larvae of both target and incidental shrimp species could be the cause of declining wild shrimp stocks in the southwest coastal region (Hossain et al. 2013). Furthermore, coexistence of shrimp and other animals like Frogs, Turtles, Tortoise, Crocodiles, Foxes, Wildcat, and various types of white fishes are impossible in the surrounding area of the shrimp pond. For the protection and survive of the shrimp, coastal people drive away and sometimes killed these animals. As a consequence, more than 300 species are gradually extinct and indicated as rare species (DoF 2001).

Salinity in shrimp cultivating areas may be 500% higher than in non-shrimp cultivating (Rahmanet al.2011). This leads to greater concerns about coastal water pollution and salinity intrusion in the surrounding fresh water source and agricultural land (Sohel&Hadayetullah2012). Social conflicts and more widespread social disturbance are also associated with shrimp cultivation. Landholding and tenure systems in the southwest coastal region are mostly affected by its shrimp farming system. The politically and financiallystrong owners of the shrimp ponds captured nearby small farmer's crop land for expansion of their shrimp pond by force. The transformation of crop land leads to the marginalization of coastal farmers. For example the development of shrimp farming in the Satkhira district has displaced nearby 120,000 people from their farmlands (Baird & Quarto 1994).

The following research questions are addressed in the study: (i) Which socioeconomic-natural factors play an important role to improve the vulnerability conditions generated from shrimp cultivation?(ii) What are the management strategies of shrimp culture practice? To answer the research questions, the general objective of this study attempts to conduct a credible assessment of vulnerability from crop farms to the shrimp ponds in the southwest coastal region of Bangladesh with respect to socioeconomic and natural context. The specific objectives of this paper attempt to assess the overall impacts of

land transformation from crop farm to shrimp pond and develop of approach for the management strategy to produce more shrimp in the shrimp ponds and more crops in the adjacent crop farms in the southwest coastal region of Bangladesh.

Due to the lack of appropriate guideline, socioeconomic-natural factors and impact assessment of shrimp farming in the existing recent credible study, this study considers specific and relevant socioeconomic-natural factors in its applied econometric model to generate empirically supported assessment. It is expected that the findings of the study will be improved the livelihood conditions of the affected crop farmers by shrimp ponds. The findings of the study will also be helpful for the similar region. The authors have given an introduction followed by the literature review. Section 3 covers study area and research design. Section 4 includes results and discussion and Section 5 gives conclusion and policy implications of the study.

2. Literature Review

Bangladesh is one of the major shrimp producing countries in the world. It is blessed with an advantageous natural setting for shrimp farming and contributes the national economy of Bangladesh since 1980s. It is growing in Bangladesh due to suitable agro-climatic conditions, adequate water resources, cheap labor force, support for the marketization process of international donor agencies and the involvement of multinational corporations (Paul &Volg2011). Maximum people of the southwest coastal region are involved in shrimp culture because soil is not suitable for agricultural crops due to the high salinity percentage (Mitro et al. 2014; Shindaini&Baqui 2012).

Shrimp farming has been associated with a number of negative environmental and social impacts which hinder the sustainable development of this booming sector. Islam &Bhuiyan (2016) in their article “Impact Scenarion of Shrimp Farming in Coastal Region of Bangladesh: an Approach of an Ecological Model for Sustainable Management” Vol 24, No. 4 has made an accentuated study on the effects of shrimp farming of the southwest coastal region. Their study revealed that the continuous and unregulated shrimp farming has immense impacts on human, ecology, environment and sustainability through saline water intrusion, soil and water quality deterioration, mangrove destruction, pollution, sedimentation, disease outbreaks, loss of biodiversity and destruction of the local ecosystem. This study also identifies some socioeconomic consequences, including traditional livelihood displacement, change in agricultural pattern, loss of land security, food insecurity, marginalization, reduction of social security, rural unemployment, social unrest and conflict in the wake of shrimp culture development in the southwest coastal region (Hossain et al. 2013).Mitro et al. (2014) studied socioeconomic and environmental impacts of shrimp culture in some selected areas of Bangladesh district and found that shrimp farming has negative impacts on water quality such as the range of *K* and *Na* in water has been increased and the range of *Ca* has been decreased than normal range. Inappropriate management, practices and inadequate plans regarding water quality, inappropriate irrigation facilities, strong political commitment and institutional weakness are the main reasons for these impacts of shrimp farming (Hossain et al. 2013).

The above discussed literatures are mainly discussed with qualitative point of view. But this paper attempts to explore the effects of shrimp farming in terms of quantitative point of view. The existing study properly addressed the negative impacts of shrimp farming. But very few papers are able to address the adaptive measures under the shrimp farming practice with respect to socioeconomic-natural context. Suggested policies of this study are derived from its research questions and objectives. The study seeks to answer theseunexplored research questions which didn't address in the recently published credible journal articles.

3. Research Design

A significant number of people in the study area have recently left crop cultivation as they do not make profit out of crop production due to the disturbance of shrimp ponds. The study conducted informal group discussion and focus group discussion to find out the difficulties of crop cultivation, and their present socioeconomic status. Three FGDs were conducted at PaikgachhaUpazila, Khulna district, ShyamnagarUpazila, Satkhira district and RampalUpazila, Bagerhat district carried out with more than 10 people each who were earlier engaged in crop farming but have recently left this practice. The findings of the current situation of land transformation from crop farms to shrimp ponds in the southwest coastal region were of great value since no study or information on this issue could be found. Based on these findings, a pre-test had been implemented for variable selection, questionnaire formation, and collect other relevant data on the said topic, to be used in the final survey.

This study has followed the US National Oceanic and Atmospheric Administration (NOAA) and the Food and Agriculture Organization (FOA) guideline for the layout of its questionnaire. A five page questionnaire was developed to collect household cross-section data. The full contents of the questionnaire included respondents' basic household information (e.g., age, sex, educational attainment, work status, farm size, source of income, household size, expenditure for health service) and agricultural related activities (e.g., the land tenure system, crop growing status, and cost of production of crops). The questionnaire was in English, but interviews were conducted in the local language, Bangla.

To represent the population as a whole, a complete and accurate sample framework is necessary. In this study, a sample frame is the set of two groups of crop farmers: first group (n_1) consists of affected farmers as their crop farms are affected by the expansion of shrimp ponds, and the second group (n_2) consists of non-affected farmers as their crop farms are not affected by the shrimp ponds. This study followed the purposive sampling approach to collect household cross-section data from the crops farmers in the southwest coastal region. The final samples for the questionnaire survey were selected on the basis of FGD and pre-test findings.

The economic agent and sample unit 'household' was chosen because decisions on crop production come from the household level, rather than at the individual level. The household appeared to be a suitable unit of data collection and analysis. The head of household represents his household members as the respondent for the survey of this study. This study interviewed the head of the household, usually a male member (father

or eldest son) who had two major characteristics: he was the (solo or one of the) main earning member (s) and he exercised substantial authority over family decisions.

To obtain relevant data through questionnaire survey, the southwest coastal region was visited one timesince(7 -28) May, 2015. The survey of this study was introduced to 347 households, of which 317 household representatives agreed to participate from both groups to activate the survey and complete the questionnaire. The response rate was 91%. Thus, the sample size included in this study (n_1=122, n_2= 195,$n_1+n_2=n$= 317). The latitude and longitude, and salinity level (dS/m) data were collected by using the iPhone (Apple) and a Salinometer. Selected characteristics of the heads of the sample households, the overwhelming majority of whom were male are presented in Table 1. As many as 22 percent of the sample households was engaged in active farming activities and 78 percent of the sample households were engaged in casual farming activities in the affected crop farms by the expansion of shrimp ponds. On the contrary, it was 68 percent and 32 percent respectively in the non-affected crop farms. In addition, small trading, remittance, and service are the alternative sources of income of sample households.

Table 1: Sample Household: Some Selected Characteristics

Characteristics	Southwest coastal region			
	Crop farms are affected by the expansion of shrimp ponds		Crop farms are not affected by the shrimp ponds	
	Number	Percentage	Number	Percentage
Work status				
Active farmer	27	22	132	68
Casual farmer	95	78	63	32
Tenancy status				
Owner	42	34	109	56
Tenant	80	66	86	44
Educational attainment	17	14	19	10
0	25	20	33	17
1-5	80	66	143	73
Family size				
3	7	6	28	14
4-7	83	68	124	64
>8	32	26	43	22

(**Source:** Calculated by the authors 2015)

Descriptive statistics or qualitative research does not provide any scientific evidence of the assessment of impacts of land transformation from crop farms to shrimp ponds in the southwest coastal region of Bangladesh. Most of the empirical research of structural change or structural break under certain critical condition addresses to use the Chow test. Thus, this study undertakes to use the convenient Chow test method to generate empirically supported assessment. Chow test is developed by Gregory C. Chow in 1960 (Gujrati 1995). Chow test is preferred due to less computational difficulty compared to alternative approaches suggested in literature such as cointegration tests (Campos et

al. 1996), bootstrap procedure (Diebold and Chen 1996), Bayesian techniques (Kozumi&Hasegawa, 2000) and comparison of slopes alone (Wilcox 1997). Application of the Chow test requires that the number of observations in both sub-samples should be nearly the same. Equality of error variances in two linear regression equations is the main restriction assumed in the Chow test (Chow 1960). This can be illustrated by use of two models for the affected farmers as their crop farms are affected by the transformation from crop farms to shrimp ponds and the non-affected farmers as their crop farms are not being transformed from crop farms to shrimp ponds:

$$Y_g = \beta_0 + X_g\beta_g + \varepsilon_g \; ; g = 1, 2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, n_1 \quad (1)$$

$$Y_j = \beta_1 + X_j\beta_j + \varepsilon_j ; j = 1, 2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, n_2 \quad (2)$$

Where Xi (i = g, j for affected and non-affected farmers sub-samples respectively) are non-singular matrices of explanatory variables, β_i are column vectors that will be estimated, and Y_i are column vectors for the dependent variable. It is assumed that the stochastic terms ε_i are normally distributed with zero mean and variance covariance matrix $\sigma^2 I$, whereby I represent an identity matrix.

A structural change may mean that the two intercepts are different, or the two slopes are different, or both the intercept and the slopes are different or any other suitable combination of the parameters. The main hypothesis in the Chow test is that the coefficients are equal for both sub-samples concern to equations (1) and (2):

$$H_0 = \beta_g - \beta_j = 0 \quad (3)$$

If there is no structural change (i.e., structural stability), we can combine all the n_1 and n_2 observations and just estimate single function as

$$Y = \lambda_1 + \lambda_2 X_i + u_i \quad (4)$$

Three linear regressions were fitted to operate the Chow test; one equation for the restricted model (equation 4) and separate regressions for the unrestricted models (equations 1 and 2).

$$F^* = (RSSw - (RSSg + RSS\ j))/(RSSg + RSS\ j) * (T - 2K)/K \quad (5)$$

Where*F** is the test statistic; *RSSw*= residual sum of squares for the whole sample or restricted model (equation 4);*RSSg*= residual sum of squares for the unrestricted model (equation 1); RSSj = residual sum of squares for the unrestricted model (equation 2); T = total number of observations of the whole sample K = number of regressiors (including the intercept term) in each unrestricted sub- sample regression; 2K = number of regressiors in both unrestricted sub sample regressions.

In the Chow test, if there is no significant statistical difference between two unrestricted models (i.e., if $\sigma_g^2 = \sigma_j^2$), then the regression test statistic in Equation (5) follows an *F(K, T-2K)* distribution. However, if the test statistic (*F**) is greater than the respective *F*-statistic at 10% level of significance (as in this study), the null hypothesis should be

rejected. Consequently the relevant conclusion is that the sub-samples are significantly different.

4. Results and Discussion

4.1 Definitions of Variables

Definition of different variables used in the model is presented in Table 2.

Table 2: Definition of Variables

Variable	Description	Measurement	Hypothesized relation
Specific constant (sc)	Specific constant work as a intercept of the model		**+/-**
Income from farm (inf)	Monthly income of household.	Kg/acre	-
Salt water (sw)	Saline water is essential for shrimp ponds	dS/m	**+**
Health care expenditure (hce)	Skin disease is the outcome of degraded soil and water and it increased monthly health expenditure	Tk./month	**+**
Crop (rice) productivity (cp)	Performance of per acre rice productivity	Ton /acre	-
Education level (ed)	Level of education of the head of household	Literate=1 Illiterate =0	**+/-**
Land zoning (lz)	Soil and water quality determine the land use zoning for integrated coastal zone management	Agree=1 Disagree=0	**+/-**
Land settlement system(lss)	Land settlement consists of land acquisition and requisition system	Agree=1 Disagree=0	**+/-**
Organic shrimp (os)	Organic shrimp requires organic feed.	Agree=1 Disagree=0	**+/-**
Farm distance from shrimp ponds (dis)	Long distance of crop farm from shrimp ponds is good for soil and water quality and vice versa.	Km	**+**

(**Source:** Prepared by the authors 2015)

Crop productivity is bad hampered by salinity in the southwest coastal region of Bangladesh. The situation is very much worsening for the crop farm when it nearly located in the shrimp ponds. For a better assessment and empirical evidence of the negative impacts of shrimp farming with respect to socioeconomic-natural context, it is essential to consider respondent's income, health care expenditure, educational status,

crop productivity status, land zoning and settlement, provision of organic shrimp culture and positional scenario of the shrimp farm.

4.2 Estimation and Discussion of Results

To estimate the impacts of land transformation of crop farms to shrimp ponds in the southwest coastal region, regression model with different form was developed by using EViews software. Results for all 317 respondents from the unrestricted model 1 for affected crop farms from expansion of shrimp ponds, unrestricted model 2 for not affected crop farms by shrimp ponds, restricted model (combination of two unrestricted models), and extended model that includes directly impacted factors along with other factors are shown in Table 3.

Table 3: Estimated Models

Model	Unrestricted model 1			Unrestricted model 2		
Variable	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
sc	1.64901***	0.72135	0.0000	2.03571 ***	0.64251	0.0001
si	0.83105***	0.20110	0.0000	0.21035**	0.71095	0.0203
inf	-0.23511*	0.53338	0.1044	-0.11053**	0.67435	0.0517
hce	0.31589 *	0.12254	0.0939	0.13014	0.12401	0.2509
cp	-0.56132***	0.78112	0.0000	-0.29005*	0.25090	0.1047
Log-likelihood		-837.4243		-430.7280		
McFadden Pseudo R-squired		0.37130		0.41010		
Number of observations (n)		122		195		

Model	Restricted model			Extended model		
Variable	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
sc	0.78010	0.64900	0.1209	0.23109 ***	0.29083	0.0000
si	0.34908*	0.11130	0.1087	0.57016**	0.20983	0.0410
inf	-0.28012**	0.29416	0.0313	-0.93101***	0.14786	0.0000
hce	0.51097 ***	0.39088	0.0000	0.73120*	0.56908	0.1011
cp	-0.22167***	0.88934	0.0000	-0.47890**	0.67109	0.0209
ed				-0.83159*	0.09701	0.1309
lz				-0.09677*	0.67167	0.1002
lss				-0.56270***	0.74539	0.0000
os				0.23794	0.45320	0.1743
dis				-0.29136***	0.78090	0.0000
Log-likelihood		-378.0865			-330.0984	
McFadden Pseudo R-squired		0.434509			0.247098	
Number of observations (n)		317			317	

*** Significant at level 1% (0.01), ** Significant at level 5% (0.05), and *Significant at level 10% (0.10)
(**Source:** Estimated by the authors, 2015)

4.2.1 Unrestricted Model 1 and Model 2

According to the unrestricted model 1, all of the variables are statistically significant at conventional levels at the 1%, 5%, and 10% respectively with expected sign. Salinity and health care expenditure for skin disease are positively correlated with transformation form crop farms to shrimp ponds in the southwest coastal region, which implies that these variables go in the same direction as crop lands transformed into shrimp ponds. At the time of FGD, and face-to-face questionnaire survey, most of the respondents were given more emphases to stop further expansion of shrimp ponds. They argued that transport of brackish water from nearby sources and discharge

polluted brackish water from shrimp ponds degraded their farm's soil and water quality and hence, leads to hamper and decreased rice productivity and increase skin disease. On the other hand, per acre rice productivity, household income, and crop land transformation to shrimp ponds are negatively related in the same region, which implies that these variables go to the opposite direction under the same scenario. Rice based agriculture is the principal source of income of every household in the southwest coastal region. Their income level, food security, nutrition and livelihood condition are mostly affected by the crop land transformation into shrimp ponds.

On the other hand, all of the variables are also statistically significant at conventional levels at the 1%, 5%, and 10% respectively with expected sign in the unrestricted model 2. Most of the signs and the variables are same in both the unrestricted models except health care expenditure. But the magnitudes of estimated coefficients between the two models are not same. The Difference between the sub-samples of two unrestricted models are tested by The Chow model (see Table 4 for more details). The focused variables of the unrestricted model 2 are not directly affected by the crop land transformation to shrimp ponds. The locations of the respondents' farms under this model are far away from shrimp ponds. But their crop farms are affected by other factors as the geophysical and climatic factors are almost homogenous in all over the southwest coastal region. But we cannot say anything about the health care expenditure due to its insignificant level (higher *P*-value) under this model and thus, it is rejected by alternative hypothesis. It is because climate induced diseases are common in the whole southwest coastal region and thus high health expenditure.

Table 4: Chow Test Outcome

RSSw	RSSg	RSSj	F*	F(K,T-K) at 10% significance level	Decision
101522	42322	53690	3.53	1.85	Separate unrestricted model 1 and 2

(**Source:** Prepared by the authors, 2015)

4.2.2 Restricted and Extended Model

A restricted model of this paper is the combination of two unrestricted models which are described above. Like the others two unrestricted mode, all variables are significant at the 1%, 5%, and 10% levels respectively. The result of the restricted model is better compared to those of other two unrestricted models.

On the other hand, a large number of variables were proposed to include in the extended model. Like the other three models, all variables are significant except a few at the 1%, 5%, and 10% levels respectively. The negative coefficient of education of household indicates that educated man can apply the best management approach to the shrimp pond. Similarly, Negative coefficients of land zoning and land settlement system indicate that shrimp pond should be constructed in high salinity prone areas and it should be restricted for further and illegal construction of shrimp ponds in the less or no salinity presence areas in the southwest coastal region. Lastly, the negative coefficient of distance implies that certain distance should be maintained in the

construction shrimp pond from crop farms. But we cannot say anything about the organic shrimp due to its insignificant level (higher *P*-value) and thus, it is rejected by alternative hypothesis. It is because coastal people are not well known about organic shrimp.

The result of the extended model is also better estimated model. But this model has a lower McFadden Pseudo R-squared value and it is 0.247098 which leads to seem not good fit for this model. But Agimass & Mekonnen 2011 and Birol et al. 2005 argued that McFadden Pseudo R-squired between 0.2 and 0.4 is said to be adequate and have no scope to reject the estimated results (Agimass & Mekonnen 2011; Birol et al. 2005).

5. Conclusion and Policy Implications

The rapid expansion of shrimp farm development during the last three decades along with the adaptation of extensive and improved extensive culture techniques has caused growing concern as to its adverse effect on the coastal environment damage to the traditional agricultural systems and rapid change to the socioeconomic scenarios in the southwest coastal region (Karim 2006). The conventional shrimp production brings, on the one hand, economic profits for the farmers and foreign currency to Bangladesh, while on the other hand there are some negative environmental and social impacts. The absence of R & D based national policy and strategy on sustainable shrimp aquaculture has been a fundamental problem of this sector. In addition, relevant socioeconomic-natural factors can improve the crop productivity conditions when there is coexistence of shrimp farming. More particularly, education and training for both the shrimp farm owners and crop farmers, land zoning and settlement system and certain distance of the construction of shrimp pond from crop farms can reduce the negative impacts of shrimp farming. Land zoning and settlement system should give more priority for the further construction of shrimp ponds. The high saline zone is suitable for more cultivation of shrimp. Thus, it is suggested that stop or minimize the further construction of shrimp ponds in the low salinity presence area or nearby crop farms and constructed it more at the high presence of salinity zone. In addition, Government intervention, better management practices, and introduction of low-salt shrimp aquaculture can control and improve the surrounding conditions of the shrimp ponds in the southwest coastal region of Bangladesh.

This study is able to generate cutting edge knowledge on sustainable ecosystem, seeks to address some unexplored research questions that were not answered previously and able to reduce the research gap on the similar studies in terms of empirical ground of socioeconomic and natural grounds simultaneously. Due to the time limitation, budget constraints and other logistic supports, this study is not free from certain lacunas. This studydoes not include the whole coastal region of Bangladesh and large respondents to participate questionnaire survey. Thus, this study recommends for further study to avoid such shortcomings and get better findings to formulate health policy that will cover UHC properly.

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