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Determinants of Farm Productivity in Flood Prone area: A Study in Dhemaji District of Assam

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ABSTRACT
Floods have threatened the agricultural productivity in Assam every year. Quality of soil, which is one of the important factors, that determines the production and income of farm, has been damaged by flood. Various study and secondary data reveal that deposition of sand due to flood has negative impact on farm productivity. This paper tries to investigate the impact of flood induced sand deposition and other factors on farm productivity in Dhemaji district, one of the mostly flood effected area of Assam. The study is based on primary survey which included 10 flood effected villages and 276 agricultural plots for testing the quality of soil. After testing the soil quality, the paper attempts to establish the relationship between quality of soil and paddy productivity. To identify the factors affecting the productivity of the paddy and estimate the damage due to flood induced sand deposition, the study used regression models by taking productivity of paddy as dependent variable. The regression model is estimated using Ordinary Least Square (OLS) method. In order to ensure the validity of OLS results, this study also tested a Tobit model. Results of the paper revealed that sand deposition created huge damage to the paddy fields and poor agricultural outcomes from the degraded lands were forcing people to look for other livelihood and opportunities.

Key words: Farm productivity, Flood prone area, Migration, Sand deposition, Soil quality.

INTRODUCTION

Natural disasters like earthquakes, flood, volcano, *etc.*, have brought disastrous consequences for human beings. Floods are one of the most common natural hazards that have been a recurrent phenomenon in the developing world. It has both positive and negative effects. In a positive sense, it can replenish the productivity of soil through deposition of alluvium and in a negative sense; it can affect human beings through destruction of standing crops, damage livestock, human property, human life *etc*., (Das, 2012). Agriculturally dominant country like India, agriculture is deciding factor for country's economic growth. Due to increase in population, there is also increase in demand on agriculture. The continuous expansion of agricultural areas under cultivation is not possible in the long run due to fixed supply of land. Only an increase in productivity of land will bring further growth of agriculture (Goyari, 2005). In order to absorb increases in population, sustainability of agriculture is important. But, a number of agricultural related environmental concerns have been raised at the path of agricultural growth, in the last couple of decades (Goyari, 2005). Natural disasters like flood, drought, landslide, hailstorms *etc.*, have threatened the sustainability of agriculture (Goyari, 2005). Labour and other inputs such as fertilizers, mechanization is important factors for farm productivity, but quality of soil are one of the crucial factors of agricultural productivity (Jaenicke *et al*, 1999, Bhalla, 1988). Depositions of sandy layer, through flood have long-term impact on soil quality and hence affect farm productivity (Das, 2012). Decrease in farm productivity and farm income due to climate change leads the people to take various diversified sources of income for their survival (Oyakhilomen, 2016). For livelihood security, people have decided to migrate to the urban centres, where they can find multiple sources of livelihood (Standly, 2018). Since, very little importance has given to environmental degradation as a cause of decrease in farm productivity. Therefore, in this paper, focus is given to explain the impact of decrease in quality of soil due to deposition of sand on agricultural productivity and emphasis is also given on the other determinants of farm productivity in the flood prone areas of Assam.

Flood in India and Assam: India is the second largest flood affected country in the world (Doley, 2016). The area liable for flood in India is 426,255 million hectares and average area affected by flood annually is about 7.225 million hectares (Anonymous, 2012). The North Eastern part of India, mainly Assam is one of the worst suffers of flood due to river Brahmaputra and its tributaries. Therefore, flood is the chief natural calamity that destroys the state every year.

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Assam is an agricultural state. Almost all the neighbouring hilly NER states can depend on Assam for food grains and other agricultural products (Goyari, 2005). About 80 per cent of people depend on agriculture in Assam. However, one of the major problems of agricultural development in this state is frequently occurrence of flood every year. Assam is possibly India's most flood prone state and has been experienced at least 12 major floods since 1950, excluding the regular annual episode (Doley, 2016). The frequency of flood has increased in this state after the "1950 great earthquake". Annonymous, (2012) reported that during the period 1953-2011, in Assam 50.624 million hectares of area and 163.369 million people were affected due to flood.

Flood in Dhemaji: Dhemaji district which is known as 'rice bowl' of Assam, is now transformed into virtual desert due to deposition of sand as a result of flood from Brahmaputra river (Das, 2012). Among all district of Assam Dhemaji happens to be one of the worst affected districts due to flood. People in this district are suffering even after flood due to deposition of sand over the highly productive agricultural land (Doley, 2016). River transports sediments in two ways, i) The bed sediments load of coaser particles and ii) The wash loads of finer particles (Weibe, 2006). Various study revealed that floods now carry relatively bed sediments in Dhemaji district. A study conducted by Das in 2012, including 1059 households from 15 sample villages of Dhemaji, indicates that nearly 83 per cent of the total paddy field, faces sand deposition and there is loss in productivity of rice. More than 20 per cent of the area of the district is sand deposited of various depths that causes major problems in agricultural crop production. According to Dhemaji district flood report, 2014, the total crop area affected by flood is 24,843 hectares, net shown area decreased by about 11 per cent and waste land stood at 30 per cent. This loss in agriculture is due to flood induced erosion and sand deposition (Basumatary, 2017).

Objective: To identify the factors influencing the productivity of paddy and estimate the damage due to flood induced sand deposition in Dhemaji district of Assam.

MATERIALS AND METHODS

Data Source: The present study is entirely based on primary data. For our study, we have selected the area between the river Jiadhal and Kumotia in five flood affected GPs of Dhemaji district of Assam. After the selection of the GPs, 10 villages have been selected randomly from the total number of villages of those selected GPs. After the selection of the sample villages we collected information on the possession of agricultural land, information regarding the agricultural land affected by the sand deposition, land leased for cultivation, total production of paddy and outmigration from the households due to low agricultural productivity. Again, we have collected information from the sample households on household characteristics, level of agricultural mechanization, land improvement measures and level of migration. In addition, we have collected soil sample from every agricultural plots (276 plots) of the sample households. After that, we measure the soil quality to establish its relationship with paddy productivity.

Methods: To see whether there is any kind of association between the level of out migration from the villages and the level of income from agriculture we used correlation coefficient. A correlation coefficient is a numerical measure of some type of correlation i.e. statistical relationship between two variables. The value of the correlation coefficient rage from +1 to -1 where +1 indicates strongest possible agreement and -1 indicates the strongest possible disagreement. The correlation coefficient is calculated by using the following formula.

$$\text{Correlation Coefficient} = \frac{\text{Cov (X,Y)}}{\text{S. D}_X\text{S.D}_Y}$$

Where Cov = Covariance

$S.\ D_X$ = Standard Deviation of X

$S.\ D_Y$ = Standard Deviation of Y.

Again, to identify the factors affecting the productivity of the paddy and estimated the damage due to flood induced sand deposition we use regression models by taking productivity of paddy as dependent variable. The regression model is estimated using Ordinary Least Square (OLS) method. The model used for the present study is given below:

$$Y = \alpha + \beta_1X_1 + \beta_1X_1 + \beta_1X_1 + ... + \beta_1X_1 + u$$

Where Y is dependent variable and Xs are independent variables.

In order to ensure the validity of our OLS results, we also tested a Tobit model with left censoring at 0 as out of 276 plots 50 plots recorded 0 productivity and thus setting a limit. Hence, left censored TOBIT regression has been formulated as follows:

$$Y^* = \alpha + \beta_1X_1 + \beta_1X_1 + \beta_1X_1 + ... + \beta_1X_1 + U_i$$

Where $y = 0$ if $y^* < 0$

$y = y^*$ if $y^* > 0$

And, Ui s are the usual disturbance terms.

RESULTS AND DISCUSSIONS

Economic background of the family: The Primary data revealed that the average land holding of the sample household was 1.22 hectare per family and their mean monthly return from agriculture was estimated to be only rupees 762. Since very little output is sold in the market, therefore, we multiplied the annual agricultural product with the current market price to estimate the income from the agricultural production. The Table 1 shows the average monthly household income from agriculture of the 10 sample villages.

From Table 1 we could see that the returns from agriculture were very low and the production was not adequate even to ensure the minimum requirement of the family of 5 in a month. The return from agriculture was highest in Tekjuri Village followed by Ming Mang. However, the return was lowest in Lalukijan village followed by Ajuha Village.

We found that the low agricultural return was pushing people to seek to alternate jobs for livelihood security in the rural areas. Due to the decline in the agricultural income, a large section of the villagers migrated to other places of the state and country in search of better employment opportunities. The details of migration of households in search of better employment opportunities are shown in Table 2.

From the above Table we could see that percentage of migration was highest in Kosutoli village i.e. approximately 49 per cent and percentage of migration was lowest in Diprai Village was approximately 6 per cent. Here, we have calculated the correlation coefficient between the percentage of migration and the mean income from agriculture, to see whether there was any kind of association between the two variables and found that, there was a negative relationship between the percentage of migration and the mean income from agriculture (-0.27), which indicated that as the income from agriculture decreased the

Table 1: Average monthly household income from agriculture in Rupees (10 Villages).

Villages	Mean	Max	Min	SD	N
Tekjuri	1970	3100	1280	225.7	130
Lalukijan	185.4	420	50	127.5	51
Ajuha	256.8	450	65	169.3	81
KahiKuchi	591.2	1180	0	399.2	114
Kosutoli	501.2	830	140	240.3	45
Balisori	410.5	650	40	222.5	49
Bogipung	1445.4	2480	350	640.5	88
Ming Mang	1340	2320	115	285.2	54
Dirpai	328.5	540	120	199.5	84
Bordoi	590	1280	300	410.3	17
All Villages	761.9	3150	0		713

Source: Primary Survey

Table 2: Details of migration of sample households.

Villages	HH List	Out Migration from the Households	% of migration
Tekjuri	129	22	16.92
Lalukijan	60	16	31.37
Ajuha	68	19	23.45
KahiKuchi	59	15	13.15
Kosutoli	48	22	48.88
Balisori	59	19	38.77
Bogipung	66	21	23.86
Ming Mang	49	8	14.81
Dirpai	75	5	5.95
Bordoi	22	3	17.64
Average	63.5	15	21.03

Source: Primary Survey

Table 3: Yield of paddy (kg ha^{-1}) in different villages.

Villages	Mean	Max	Min	SD	N-Plots
Tekjuri	91.9	249.22	0	62.86	33
Lalukijan	15.77	93.26	0	27.67	35
Ajuha	57.45	155	0	51.78	35
KahiKuchi	83.46	250	0	58.58	39
kosutoli	59.25	178	0	54.13	20
Balisori	136.31	250	43	60.43	16
Bogipung	299.68	561.5	170.5	96.07	38
Ming Mang	485.4	890	144.5	205.05	20
Dirpai	541.22	976	333.33	168.19	31
Bordoi	314.22	552.75	234.5	132.1	9
All Villages	182.5	976	0	201.93	276

Source: Primary Data.

percentage of migration to other places in search of employment opportunities increases.

Paddy productivity of the agricultural plots: Here, an attempt has been made to assess the productivity of the sample plots of the sample villages. The details of the village wise average productivity of paddy is shown in Table 3.

From the above Table 3, we could see that the average productivity of the sample plots was very low that was 182.5 kg per hectare. However, there was a significant variation in the paddy productivity of different sample plots as indicated by a very high standard deviation of 201.93. Among the villages the average productivity is highest in Diprai village (542 kg per hectare) followed by Ming Mang village (485 kg) and Bordoi village with 314 kg per hectare. However, the productivity was lowest in Lalukijan Village (15.7 kg) followed by Ajuha village (57.4 kg) and Kosutoli Village (59.25 kg per hectare).

Soil analysis of the agricultural plots: From the above discussion we can see that, the average productivity of the sample plots was very low i.e. 182 kg per hectare. Again there is significant variation in paddy productivity as shown by the very high standard deviation which is 201.93.

There are different studies, which have established that soil quality is a very important in explaining the productivity of farms (Andrews and Carroll, 2011; Das, 2012). Again flood induced sand deposition has a very long-term impacts on the soil fertility and hence farm productivity also (Das, 2012).

The below Table depicts the details of the sand magnitude (percentage) in the study villages.

From Table 4 we could see that sand magnitude was quite high in the sample plots of the sample villages. Among the sample villages, average sand proportion was

Table 4: Sand magnitude (%) in the study villages (N=276 Sampled Plots).

Villages	Sand Average in%	Max	Min	N-Plots
Tekjuri	83.45	96.4	71.7	33
Lalukijan	90.08	96.3	81.8	35
Ajuha	93.79	99.1	89.7	35
Kahikuchi	90.28	100	82.6	39
Kosutoli	98.45	100	91.2	20
Balisori	88	92.9	82.8	16
Bogipung	86.15	90.5	82.1	38
Mingmang	84.4	89	74	20
Dirpai	78	88	68	31
Bordoi	71.55	76	63.5	9

Source: Primary Survey

Table 5: Summary statistics of variable used in regresssion (N=276).

Variables	Mean	Std. Dev.	Min	Max
Paddy Yield Per Hectare	182.5	201.97	0	976
Sand Proportion in Paddy Plots	87.33	7.47	63	100
Distance of Paddy Plots from River in mt	1525.37	1726.09	50	9720
HYV Dummy	0.6168	0.487	0	1
Plot Size in Hectare	2.6	1.794	1	13
Labour Hour Used	599.38	391.168	130	2210

Source: Primary Survey

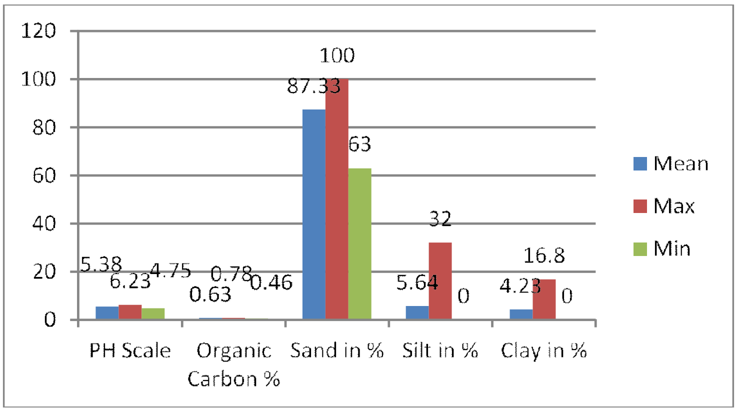

Fig 1: Soil characteristics of the sampled paddy plots (N = 276).

Table 6: Regression results of determinants of paddy yield.

Variables	OLS			Tobit		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Paddy Hectare	Paddy Hectare	Paddy Hectare	Paddy Hectare	Paddy Hectare	Paddy Hectare
Sand Proportion	***-16.189	***-16.00	***-12.315	***-19.9842	***-19.0234	***-14.3239
in Paddy Plots	(1.306)	(1.382)	(1.234)	(1.5735)	(1.61571)	(1.37084)
Distance of Paddy		**0.13	.007		**0.015022	.006578
Plots from river in mt		(.006)	(.005)		(.0066049)	(.005521)
HYV dummy		***85.593	***33.786		***121.1451	***56.32707
used of hyv seeds		(20.041)	(17.841)		(23.3838)	(19.9525)
Plot size in hectare		***-20.909	***-39.787		***-18.07429	***-42.0880
		(5.847)	(5.324)		(6.69765)	(5.84113)
Log of Labour			***385.37			***499.9678
hour used			(38.151)			(44.2298)
Constant	***1596.417	***1561.318	**289.704	***1901.401	***1766.016	119.7027
	(114.711)	(130.80)	(168.182)	(136.839)	(150.998)	(187.379)
Observations	276	276	276	276	276	276
R Squared	0.35	0.436	0.591	0.0428	0.0549	0.0900

*** p<0.01, ** p<0.05, * p<0.1R-squared for Tobit models (4-6) should be read as pseudo R-squared.Figs in brackets are standard errors.

highest in Kosutoli village with 98.48 per cent of sand magnitude in the soil. However, average sand proportion was lowest in Bordoi village with 71.55 per cent sand magnitude in the soil of the agricultural plots.

Again, soil test report revealed that the soil of the sample villages was poorly textured with the presence of slit and sand, which have poor organic content leading to low agricultural productivity. The Fig below shows the soil characteristics of the sampled paddy plots.

From the above Fig, we can see that the sample plots have very low content of organic carbon and very high magnitude of sand proportion indicating low nitrogen content and low fertility.

Determinants of productivity of paddy: To examine the impacts of sand deposits on productivity, we measured productivity as paddy yield per hectare expressed in kilogram and taken it as dependent variable. Again we measured sand concentration in the paddy plots as percentage, the distance of the paddy plots from river in meters and taken them as independent variables. We assumed that the distance of a paddy plot from the river would be an important independent variable in explaining paddy productivity variation. Here, we have taken use of HYV seeds as dummy variable to see its impact on productivity. We have also taken numbers of labor hour used as an independent variable to see its impact of paddy productivity. The summary statistics of the variables used in the regression models are provided in the below Table.

Models 1-3 refer to Ordinary Least Square estimations, while models 4-7 are Tobit estimations. The estimates presented here are tested for significance with robust standard errors in order to avoid problems of heteroskedasticity.

In Models 1 and 4, sand is regress on paddy yields, which establish the strong negative relationship between the presence of sand and productivity. In Models 2 and 5we estimate not only the impact of sand on productivity but also taken additional variables like distance of the paddy plots from river, use of HYV seeds in agricultural field and size of the plot as independent variables. In model 2 we found all the independent variable statistically significant at 1 percent level except distance of the paddy plots from river which is significant at 5 per cent level. Similarly, in model 5 also we got the same results as in model 2.

In the models 1 and 2 (OLS) and model 4 and 5 (Tobit), we find that for every unit increase in sand concentration, production in paddy per hectare decreases by 16.00 kg to 19.98 kg. While the signs of coefficients of the model 4 and 5 remain the same as in the 1 and 2, the co-efficient for sand is higher in the Tobit estimations relative to the OLS estimations.

For better understand the effect of labour, we ran two additional regressions, (model 3 and 6 in Table 6) with labour as an input (log of total labour hours used in paddy plots). The regression results corroborate the possibility of endogeneity. In both the models log of labor hour used is found statistically significant indicating having a positive relationship with the paddy productivity.The hypothesized effects of different independent variables on paddy yield are as expected. Distance between the plot and river showed a positive correlation with the paddy yield. The further the plot was from the river side, the higher the productivity. Similarly, our results also showed that use of HYV seeds contributes to higher yield.

CONCLUSION AND POLICY IMPLICATIONS

The results of the study showed the crisis in livelihood caused by flood induced sand deposition in the agrarian economy. It is evident that sand deposition creates huge damage to the paddy fields and poor agricultural outcomes from the degraded lands is forcing people to look for other livelihood and opportunities. Regression models show huge productivity losses due to the presence of high concentration of sand in the agricultural land.

More effective implementation of rural development and employment programs by the government might be one way to ameliorate the rural distress in this region. The state expenditure to improve water management would be helpful to farmers. Sandy soil cannot retain water for longer time to sustain paddy yield. Since sand deposition is only one of the factors for decline in paddy productivity in the region, there is an urgent need for further research to identify other factors that are also responsible for this decline in productivity.

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