Chapter Four

EMPIRICAL RESULTS AND ANALYSIS

This chapter presents the empirical results along with economic and statistical explanation or validation. First, the descriptive statistics are presented in tabular form and the graphical representations are shown in appropriate cases, i.e., wherever necessary. The descriptive statistics basically show the statistical features of the data collected. Tabular presentations of frequency distributions are presented where ever found suitable. Moreover bi-variate simple correlation coefficients between pair of variables used in the frontier model are also presented and analysed. The summary statistics are routinely presented before each frontier regression results.

The complete parameter estimates of each frontier model for both team as well as individual catchers are presented with significance levels. The distributions of technical efficiency score of single and paired boats teams with multiple catchers as well as distribution technical efficiency of single boat single catchers are shown in the form of frequency distribution tables. Maximum, minimum, mean and standard deviation of technical efficiency on the basis of each model is also presented. Data on selected socio economic (non-input) variables of the fishing households was collected for the present study and used for the econometric estimation of technical efficiency and its non-input influencing factors. The models are estimated on the basis of primary data which have been outlined in detail in the previous chapter on methodological issues. In the first subsection (4.1), the counting of boats visible in the water body during peak fishing hours of the survey week along with counting of the number of boats at the time of arrival are shown in tabular form. The type of fishes caught by the catchers is presented along with their scientific names. This section also presents summary statistics of variables for multiple team catchers. Then in the second section (4.2), the ordinary least squares (OLS) estimates of the Cobb-Douglas model are first presented along with heteroscedasticity test of OLS residuals. The results of technical efficiency along with inefficiency effects model of single and paired boats teams with multiple catchers (sample size is 165) are also shown. Results of hypothesis tests are then presented. All econometric results are logically analysed and appropriate economic interpretations are provided. In section (4.3), profile of socio-economic characteristics of individual catchers or single catchers (sample size is 160) is presented. In section (4.4) the summary statistics of all variables used for the production frontier estimation along with the inefficiency effects variables for single or individual catchers team are presented. And then the results of technical efficiency along with inefficiency effects model for single catcher teams (sample size is 100) are shown. The results of ordinary least square production function of single catchers using some traditional fishing inputs are presented in section (4.5). Lastly in section (4.6), the socio economic status and overall standards of living of fishing households are described and analyzed. This section also examines whether fishing can be considered as a sustainable livelihood for traditional fishermen dependent on the Sone Beel.

4.1 Analysis for Net Using Fishing teams with Single and Paired Boats (Sample size = 165)

To begin with, the counting of boats visible in the water body during peak fishing hours of the survey week along with counting of the number of boats at the time of arrival are pivotal to the present study. The primary reason being that, there are no boat registration systems or log-books in place that can trace or record the exact number of boats or catchers during any point of time in the Sone Beel. For the present study hourly recording of the counting of boat sightings and arrival are found to be suitable in preparing a rough estimate of (i) approximate number of boats during the best fishing hours, and (ii) the population of boats as well as that of catchers. Both (i) and (ii) are largely unknown in the study area and have not been recorded by either the Panchayat or any other government or semi-government agency. According to unofficial estimates, apart from the numbers provided by the Sone Beel Fisherman's Co-operative Society (which is 4934 registered catchers) there exists a large sub-population of catchers who are active in fishing during the free fishing season. These catchers are neither enrolled nor registered in the Co-operative Society's list. Thus the registered catcher's list of 4934 fishermen comprise only a part of the total existing catchers engaged in the Beel during the peak fishing season when Sone Beel is an open access water body where fishing is free. Table 4.1.1 presents the data on counting of boat sightings and arrival in the Sone Beel during Survey Week (last week of July, 2013). The observations have been recorded in the fishing boat-landing sites throughout all days of the survey week.

Table 4.1.1. Boat Sightings and Arrival in the Sone Beel during Survey Week

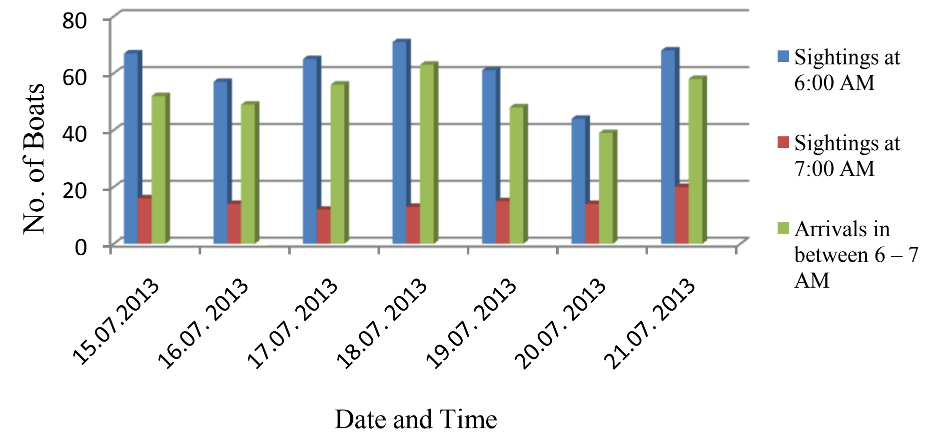
Date	Sightings at 6 AM	Sightings at 7 AM	Arrivals in between 6 – 7 AM
15.07.2013	67	16	52
16.07. 2013	57	14	49
17.07. 2013	65	12	56
18.07. 2013	71	13	63
19.07. 2013	61	15	48
20.07. 2013	44	14	39
21.07. 2013	68	20	58
Mean	63.2	14.9	52.1

Source: Authors' estimates based on observations during field survey.

A'priori information seems to suggest that fishing in the Sone Beel starts as early as 4:30 AM although some catchers exist who start late and stay on the water even beyond 9 AM. However, most catchers flock the Beel early in the morning, as the harvest has to be transported to nearby markets within 7 – 8 AM. Unfortunately due to practical reasons (infrastructural short comings) the survey could not be started before 5 AM although a significant number of boats are expected to be sighted even before the 5 – 6 AM interval. As observed above sightings of boats fluctuate across the survey days. The figure varies between 44 and 71. Practically the same catchers are not expected to be present during the same hours on all days in a week as such unorganized system of fish catch is largely labour intensive and physically involving. Thus day to day fluctuations in boat count (sightings) are expected. Interestingly the count data on the number of boat arrivals in the ghats or landing sites are very similar to data on sightings. Since the catchers' primary objective is to sell the day's catch to dalals or middlemen (who are either the agents of some hotels/restaurants) or to final sellers the maximum concentration of arrivals is expected to be between 6 and 7 AM. However the maximum concentration of sightings is expected to be in between 5 to 6 AM. Hence these two time intervals are not arbitrary, rather they have been deliberately and purposefully chosen. The mean sightings are slightly higher compared to the mean number of arrivals. Expectedly the arrivals would go down with time as majority of catchers would try to market their catch within the time deadline. If the mean arrivals during the rush hour (6 – 7 AM) represent almost 50 percent of the total boats venturing out in the Sone Beel on a particular day, then the actual number of boats in the Beel during 4 AM and 9 AM (on a particular day) could be a little more than double the observed mean of 52.1. This is an effective but indirect (non-statistical) way of ascertaining the population of boats in the water body on any random day during the peak fishing season. Expressed otherwise there could be around 104 – 115 boats fishing in the Sone Beel waters in between 5 to 6 AM.

The total crew member ranges between two to four persons. After fishing they return the landing points or the ghats and have to queue up for grading and selling in the fish auctions (called *macher arath*, i.e., the whole sale trading and transaction place). The catch by each team has to be sorted according to species or fish types. This makes the process of sale easier. The number of fish auctions appearing in the landing site is 3 to 4 and this number fluctuates depending on quantity of harvest or catch. However 2 – 3 auctions are regularly and continuously found to be active in fish transactions. The corresponding bar diagram is depicted in figure 4.1.1.

Fig. 4.1.1 Boat Sightings and Arrival in the Sone Beel during Survey Week



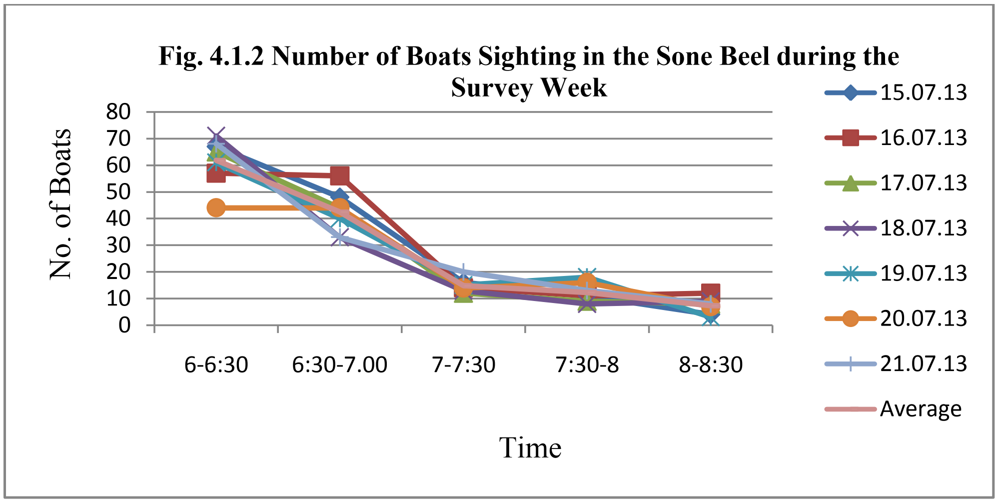
Source: Author's estimates based on sample observations.

Table 4.1.2. Number of Boats Sighting in the Sone Beel during the Survey Week

Time	6-6:30	6:30-7	7-7:30	7:30-8	8-8:30
15.07.13	67	48	16	11	04
16.07.13	57	56	14	11	12
17.07.13	65	44	12	09	08
18.07.13	71	33	13	08	09
19.07.13	61	40	15	18	03
20.07.13	44	44	14	16	07
21.07.13	68	33	20	13	08
Mean	61.8	42.5	14.8	12.3	7.3

Source: Author's calculation based on observations during field survey.

Figure 4.1.2 shows the number of boats sighted in Sone beel on different days in a particular week. The number of boat varies on an average from 61 to 7 in a survey week has been recorded at fish landing site or ghat from 6 to 8.30 AM. The table clearly shows that number of boats sighted in the water body gradually decline over time. The corresponding line diagram is depicted in figure 4.1.2.



Source: Authors' calculation based on observations during field survey.

Table 4.1.3. Types of Fish Commonly Caught by Catchers in the Sone Beel

Traditional Local Name	Scientific Name‡
Aar	*Sperata aor*
Baim	*Mastacembelus armatus*
Bele	*Glossogobius giuris*
Boal	*Wallago attu*
Chapila	*Gudusia Chapra*
Darkina	*Rasbora daniconius*
Katla	*Catla catla*
Koi	*Anabas testudineus*
Moka/Morola	*Amblypharyngodon*
Pabda	*Ompok pabo*
Pangas	*Pangasius pangasius*
Punthi	*Puntius chola*
Rohu	*Labeo rohita*
Shingi/magur	*Gagata youssoufi*
Shol	*Channa striata*
Silver carp	*Hypophthalmichthys molitrix*
Tengra	*Batasio batasio*

Source: Observations based on sample survey. ‡ scientific names are retrieved from http://en.bdfish.org/2010/07/freshwater-and-estuarine-fishes-of-bangladesh/

Table 4.1.3 shows the types of fish commonly found and caught in the Sone Beel. Most of the fishes enlisted above fall under small species (such as *moka, punthi, tengra, shol,* etc.) These are usually caught by using gill nets and some other traditional non-net fishing equipments in form of fish traps like cylindrical drum traps, vertical slit traps (locally known as *dori* and *kathi*) popularly used in northeastern India (including Bangladesh, and Myanmar region). The bigger sized species like *Rohu, Katla, Boal,* *Aar,* etc, are mainly caught by using seine net or drag net mainly by the paired boat fishing teams – i.e., pair boats with 6 to 8 catchers.

Table 4.1.4. Summary Statistics of Variables for Multiple member Team Catchers (N =165)

Variables	Min.	Max.	Mean	S.D.
Value of fish caught (Rs./month)	5000	130000	33981.82	24382.24
Labour (man-hours/month)	100	1200	370.7121	218.51
Net (meter)	30.48	548.64	198.91	112.67
Boat Size (meter)	3.66	9.75	5.50	1.44
Age of catchers (year)	25	61	33.71	6.27
Experience (year)	1	33	6.17	5.22
Education (year)	0	8	4.83	1.99
Non Fishing Income (Rs./month)	1000	6000	3193	863.34

Source: Author's estimates based on sample observations on multiple member team catchers.

The summary statistics of all variables used for the production frontier estimation along with the inefficiency effects variables are presented in Table 4.1.4. From the figures, it is evident that there is substantial variation in the outputs and inputs across catchers. Value of fish caught ranges between Rs. 5000 and Rs 130000 per team per month. Labour hours also vary significantly across fishing teams. Length of net could be a distinguishing factor in determining size of catch as because variability of net size is very high across teams. Age, education and experience exhibit smaller variability across fishing teams. Although variation in boat size is small, it could be a significant factor in determining catch effort. Finally non fishing income is an important indicator of dependence on fishing. Higher levels of non fishing income may be indicative of a shift from fishing to other occupations. Usually fish catch using traditional method is physically involving and physical fitness of each catcher is vital from the view point of efficient functioning of the team. The average age of catchers is below 34 years which is perhaps appropriate at the team level. Although experience ranges between 1 and 33 years, with mean years of experience is below 7 years. The wide variation in experience suggests that the experienced catchers play the role of team leaders or skippers, while the younger members assist in the catch. It is possible that young and relatively inexperienced catchers are included by the leaders since the new comers are already acquainted to the fishing system childhood, as they are mostly born and brought up in the area.

Table 4.1.5. Pair-wise Correlation Matrix[1] (N= 165)

Variables	Y	L	B	N	AGE	EXP	NFI	EDU
Y	1.00							

L	0.87*	1.00						
	(22.98)	-----						
B	0.86*	0.92*	1.00					
	(21.85)	(31.02)	-----					
N	0.75*	0.69*	0.64*	1.00				
	(14.26)	(12.05)	(10.51)	-----				
AGE	0.07	-0.03	0.02	0.09	1.00			
	(0.96)	(-0.34)	(0.24)	(1.17)	-----			
EXP	0.03	-0.01	-0.03	0.11	0.73*	1.00		
	(0.32)	(-0.17)	(-0.34)	(1.39)	(13.56)	-----		
NFI	0.06	0.21*	0.25*	0.01	0.02	-0.04	1.00	
	(0.81)	(2.78)	(3.36)	(0.14)	(0.28)	(-0.48)	-----	
EDU	-0.16*	-0.02	-0.03	-0.24*	-0.57*	-0.40*	0.06	1.00
	(-2.13)	(-0.24)	(-0.40)	(-3.11)	(-8.96)	(-5.64)	(0.79)	-----

Source: Author's estimates based on sample observations.

Notes: 1. * implies correlations significant at 5 % ($P < 0.05$, one tailed). 2. t-values are in parenthesis below each correlation value. 3. Y – output or catch at the team level converted to monthly figures, L – labour hours per month, B – size of the boat or fishing vessel in meters, N – length of the net in meters, AGE – average age of catchers in the team, EXP – Number of years of catch experience on an average in the team, NFI – average Non-fishing income of the fishing team, EDU – average years of formal schooling of the fishing team members.

The pair wise correlation coefficients between all variables considered in the study are presented in Table 4.1.5. Expectedly inputs are positively and significantly associated with output. Moreover since higher catch effort would imply higher output, all inputs are expected to have positive association among each other (within themselves). Absolute values of correlation coefficient of experience with output, labour and boat respectively are small but the correlations are significant. The level of formal education is negatively correlated with output which is expected in view of the primitive nature of this occupation. And finally, non-fishing income is positively associated with output but the correlation coefficient is insignificant.

4.1.6. Frequency Distribution of Value of Catch (Rs/month) of team catchers (N=165)

Class Interval	Frequency	Percentage distribution
5000-20000	49	29.70
20000-40000	65	39.39
40000-60000	29	17.57
60000-80000	11	6.67
80000-100000	06	3.63
100000-above	05	3.03
Total	165	100

Source: Author's calculation based on primary data

The frequency distribution of value of fish caught by team catchers are shown in table 4.1.6. As shown the majority of catchers (multiple member teams) have value of catch in between Rs.20,000 per month and Rs. 60,000 per month. In case of paired boat teams the monthly catch is as high as Rs. 1, 30,000. As the table shows, the present sample is dominated by small catchers who perhaps have subsistence levels of monthly earnings. The distribution of boat size across the team catchers sample is shown in table 4.1.7. The table shows that the most common type of boat used for fishing in the Sone Beel is about 4 to 6 meters long. In fact more than 80 percent of the teams use a particular type of boat that is approximately 5 meters long.

Table 4.1.7. Frequency Distribution of Boat size in meters of the team catchers. (N=165)

Class Interval	Frequency	Percentage
2-4	08	4.84
4-6	133	80.60
6-8	08	4.84
8-10	16	9.70
Total	165	100

Source: Author's calculation based on primary data

Table 4.1.8. Frequency Distribution of Net size in meters of the team catchers (N=165)

Class Interval	Frequency	Percentage
0-100	47	28.48
100-200	42	25.45
200-300	27	16.36
300-400	46	27.87
400-above	03	1.81
Total	165	100

Source: Author's calculation based on primary data

Table 4.1.9. Frequency Distribution of Labour hours of the team catchers (N=165)

Monthly Labour hours	Frequency	Percentage
100-300	55	33.33
300-500	94	56.97
500-800	03	1.82
800-above	13	7.87
total	165	100

Source: Author's calculation based on primary data

As table 4.1.8 shows majority of the fishing teams have net size below 200 meters. In fact a considerable percentage of fishing teams have net size below 100 meters. From the distribution of net size it is evident that small catchers are dominant in the sample. Interestingly net size is also a determinant of catch effort. In other words both net size and boat size are directly proportional to catch effort. Since it is observed that boat size does not vary much across catchers it may be argued that it is the net size that determines the harvest capacity (catch capacity) of the team. Alternatively for a given boat size a larger net can encircle a larger volume of water thus, directly influencing both catch effort as well as catch capacity. Moreover, it is found that almost 28 percent of fishing teams have net size in between 300 and 400 meters which is a satisfactory indicator.

Coming to distribution of labour hours across fishing teams (table 4.1.9.), almost 57 percent of catchers spent 300 to 500 hours per month. In fact very few fishing teams spent more than 500 labour hours in the waters.

Table 4.1.10. Frequency Distribution of Average Age across fishing teams (N=165)

Class Interval	Frequency	Percentage
25-35	103	62.42
35-45	56	33.93
45-55	05	3.03
55-65	01	0.60
Total	165	100

Source: Author's calculation based on primary data

Table 4.1.10 shows the distribution of average age of the fishing teams. In case of fishing teams average age of the team members is important. As seen from table 4.1.10 more than 62 percent of the fishing teams have an average age in between 25 to 35 years. Since this occupation is physically challenging this age range is perhaps is most appropriate. Physical ability reduces considerably during post forty as result of which fishing teams do not prefer too many middle aged catcher in the team. This is evident from the average distribution table.

Table 4.1.11. Frequency distribution of average years of formal Schooling of fishing teams (N=165)

Years of Schooling	Frequency	Percentage
Illiterate (0 years)	05	3.03
1-5	106	64.24
6-8	42	25.45
9-10	12	7.27
Total	165	100

Source: Author's calculation based on primary data.

As table 4.1.11 shows there are very few fishing teams where none of the members are literate. That is 5 such fishing teams are found in the sample where all the team members do not have any formal schooling i.e., 3 percent of fishing teams have members without formal schooling. On the other hand more than 64 percent of the teams have average years of schooling in between 1 to 5 years. A fewer percentage of fishing teams have more than 5 years of schooling. In other words formal educational attainments are low among the fishing teams although literacy levels seem to be high. It may be argued that formal education does not directly influence fishing skills. It can at best act as an indicator or proxy for overall awareness and social reach out. Since fishing skills are not directly influence by education beyond 8 (eight) standard formal education is not necessary for catchers.

4.1.12. Frequency Distribution of Average monthly Non-fishing Income (in Rs/month) of Fishing teams (N=165)

Class Interval	Frequency	Percentage
1000-2000	08	4.84
2000-3000	54	32.72
3000-4000	66	40.00
4000-5000	33	20.00
5000-6000	04	2.42
Total	165	100

Source: Author's calculation based on primary data

It is evident from table 4.1.12 that all fishing teams have non-fishing incomes. Non fishing income (NFI) by the team members may be earned either during slack season (i.e., winter months) or even during peak season depending on the nature of the source of non fishing income. In the sample of 165 team catchers there are 495 members or fishermen in all. Out of the total members in the sample of 165 fishing teams, almost 72 percent team members are found to be earning from agriculture and allied activities during slack seasons, 18 percent members are purely dependent of fishing across all seasons and the rest (around 10 percent of team members) are depend on non-fishing sources during slack seasons (winter months).

Non-fishing income has varied sources in the present sample. These include agricultural income from cultivation on own land, agricultural wage income for catchers having very small personal holdings, MNREGS related wage income linked to the local Panchayats, other wage incomes from casual labour either in agriculture or elsewhere, petty business like small shops and finally few other skilled occupations such as carpentry, masonry, etc. Almost 15 percent of the fishing team members were found to migrate to nearby small towns to seek mostly unskilled jobs during the non agricultural seasons. Daily wage earning by assisting in building construction work is most common, followed by various casual labour oriented works. Obviously the fishermen who move around as migrant workers (during winter months only) have little or no agricultural holdings. As table 4.1.12 shows more than 72 percent of fishing teams have monthly non-fishing income in between 2000 to 4000 rupees. Very few fishing teams have an income more than 5000 rupees per month from non-fishing sources. Non-fishing income (NFI) for team analysis has been taken as mean non fishing income across members of a fishing team. In other words NFI for the i^{th} team equals total non-fishing income of all members of the i^{th} team divided by number of catchers (or members) of the i^{th} team.

4.2 Regression Results of Team Catchers – Estimation of Team Level Technical Efficiency with and without Inefficiency Effects

The ordinary least squares (OLS) estimates of the Cobb-Douglas model are first presented along with heteroscedasticity test of OLS residuals. Table 4.2.1 presents the ordinary least square (OLS) estimates of Cobb-Douglas production function for the sample of 165 single and paired boat teams. As seen from the *t* values, all the coefficients including the intercept are statistically significant. The R^2 value is 77.4 percent which means almost 78 percent of the total variation in logged value of catch can be accounted for by the logged values of three inputs labour (L) boat (B) and net (N). The overall regression is clearly significant as the F value is substantially large. These OLS results provide a few important insights about the relationship between inputs and output in open access fishing in the Sone Beel as far as team effort is concerned. The partial output elasticities with respect to inputs are important. As the table shows, all inputs have positive partial elasticities.

Table 4.2.1. OLS Estimates of Cobb-Douglas Production Function (N=165)

Dependent Variable: Ln (Y)[1]

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.91	0.34	11.65	0.0000
ln L	0.56	0.13	4.32	0.0000
ln B	0.68	0.24	2.83	0.0052
ln N	0.38	0.07	5.46	0.0000
R-squared	0.774	Mean dependent var		10.19
Adjusted R-squared	0.770	S.D. dependent var		0.73
S.E. of regression	0.35	Akaike info criterion		0.75
Sum squared resid	19.48	Schwarz criterion		0.82
Log likelihood	-57.84	Hannan-Quinn criter.		0.78
F-statistic	184.42	Durbin-Watson stat		1.35

Source: Author's estimates based on primary data using EVIEWS 8.
Notes: 1. Y is rupee value of fish catch per month at the fishing team level. 2. *ln* denotes natural logarithm.

Table 4.2.2. White's Heteroscedasticity Test

Null Hypothesis: OLS Residuals are Homoscedastic

F-statistic	1.48	Prob. F(9,155)	0.1615
Obs*R-squared	13.02	Prob. Chi-Square(9)	0.1617
Scaled explained SS	12.48	Prob. Chi-Square(9)	0.1877

Source: Author's estimates based on primary data using EVIEWS 8.

Table 4.2.2 presents White's heteroscedasticity test results based on the OLS residuals. Moreover White's heteroscedasticity test confirms that the null hypothesis of homoscedasticity is accepted at 16 percent which is desirable and essential for robust econometric estimation.

Table 4.2.3. Cobb-Douglas Stochastic Production Frontier Estimates under Normal – Half-normal Error Structure (N=165)				
	OLS		**MLE**	
Variables	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	3.909 (0.34)	11.66**	4.83 (0.32)	14.87**
ln Labour	0.554 (0.13)	4.30**	0.524 (0.10)	4.98**
ln Boat	0.684 (0.24)	2.86*	0.603 (0.19)	3.02**
ln Net	0.378 (0.07)	5.47**	0.34 (0.06)	5.57**
Variance Parameters				
$\sigma^2 = \sigma_v^2 + \sigma_u^2$			0.29 (4.45)	6.60**
σ_v^2			0.02	
σ_u^2			0.27	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)			0.93 (0.03)	27.69**
Log Likelihood Value	-57.807 (OLS)		-49.878 (MLE)	
LR Test of the One-Sided Error (H_0: $\gamma = 0$)			15.856	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: **1**. Test for $\gamma = 0$ follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm (1986) is 2.706 for 1 degree of freedom. **2**. (*) and (**) indicate that coefficients are statistically significant at the 0.05 and 0.01 levels respectively. **3**. Standard errors are given in parentheses. 4. *ln* is natural logarithm.

Table 4.2.3 presents the maximum likelihood estimates of the Cobb-Douglas production frontier model assuming the Aigner *et al* (1977) Normal-half normal error structure. Most of the coefficients are highly significant and very similar to the OLS estimates of table 4.2.1. But more importantly variance parameters of the stochastic frontier model $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ are statistically significant [Battese and Corra (1977) parameterization]. The likelihood ratio test for the absence of the one sided error (which is tantamount to an OLS regression model, assuming γ=0) reveals that computed *LR* statistic of 15.856 far exceeds the Kodde and Palm (1986) critical value for 1 degree of freedom (tabulated value being 2.706). The estimated value of γ is 0.93 and is statistically different from zero at 1 percent level of significance. This suggests that ordinary least squares or the average production function is an inappropriate statistical specification for describing the underlying relationship between inputs and output in case of single and paired boat using fishing teams operating in the Sone Beel of Assam. Furthermore, this suggests that about 93 percent of variation in value of catch is as a result of technical inefficiency rather than due to random factors beyond the control of catchers.

Table 4.2.4 presents the maximum likelihood estimates of the Cobb-Douglas stochastic production frontier with normal – truncated normal error structure. The normal – half normal model results are also presented in the same table for quick comparison. μ, the constant mode of the truncated normal error distribution is negative and statistically significant but null hypothesis of Aigner *et al.,* (1977) normal – half normal error specification is statistically more appropriate. Other estimates are hardly any different.

Table 4.2.4. Cobb-Douglas Stochastic Production Frontier : Normal half-Normal and Normal - Truncated Normal Error Models Compared

	Normal half-Normal		Truncated Normal	
Variables	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	4.83 (0.32)	14.87**	4.81 (0.32)	14.98**
ln Labour	0.524 (0.10)	4.98**	0.52 (0.10)	5.13**
ln Boat	0.603 (0.19)	3.02**	0.59 (0.19)	3.02**
ln Net	0.340 (0.06)	5.57**	0.34 (0.06)	5.76**
Error Distribution Parameters				
μ (Stevenson,1980)	**NA**	**NA**	-0.131 (0.47)	25.79**
$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.29 (4.45)	6.60**	0.33 (0.17)	2.04*
σ_v^2			0.02	
σ_u^2			0.33	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)	0.93 (3.37)	27.69**	0.93 (0.03)	25.79**
Log Likelihood Value	-49.878		-49.826	
LR statistic for absence of one-sided error (*df*)	15.856 (*df*, χ^2=1,095=2.706)		15.96 (*df*, χ^2=2,095=5.138)	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: 1. Test for gamma=0 follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm [1986]. 2. * and ** indicate statistical significance at the 0.05 and 0.01 level respectively. 3. NA, not applicable. 4. Standard errors are in parentheses.5. 'ln' is natural logarithm. 5. μ represents constant mode of the Stevenson (1980) truncated normal error.

Table 4.2.5 presents the maximum likelihood estimates of the Battese and Coelli (1995) technical inefficiency effects model. The production function parameters are all positive and significant which is economically meaningful and desirable. The estimates of the production function parameters are found to vary only slightly across frontier and OLS models. The coefficients of the technical inefficiency variables are of profound economic importance in the present context. The constant γ_1 (equivalent to δ_0 as per Battese and Coelli, 1995 specification) is negative but statistically insignificant.

Table 4.2.5. Cobb-Douglas Stochastic Production Frontier with Inefficiency Effects

Variables	Coefficient	t-ratio
Constant	4.765 (0.32)	14.75**
ln Labour	0.563 (0.10)	5.39**
ln Boat	0.670 (0.20)	3.33**
ln Net	0.288 (0.06)	4.71**
Technical Inefficiency Model		
Constant	-2.95 (2.21)	-1.33
Experience	-0.005 (1.42)	-0.39
Education	0.09 (0.043)	2.08*
Non Fishing Income	0.33 (0.26)	1.26
Error Variance Parameters		
$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.24 (0.091)	2.66**
σ_v^2	0.02	
σ_u^2	0.22	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)	0.924 (0.041)	22.67**
Log Likelihood Value	-57.807 (OLS)	-44.266 (MLE)
LR Test of the One-Sided Error [Kodd-Palm (1986) $\chi^2_{0.05,5}$ = 10.371]	27.081	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: 1. Test for gamma=0 follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm [1986]. 2. * and ** indicate statistical significance at the 0.05 and 0.01 level respectively. 3. NA, not applicable. 4. Standard errors are in parentheses. 5. 'ln' is natural logarithm. 6. μ represents constant mode of the Stevenson (1980) truncated normal error.

The coefficient of experience is negative implying that higher the number of years of experience in fishing, lower is the technical inefficiency, or, higher is the level of technical efficiency. However the *t*-value is insignificant at 5 percent level. The coefficient of education on the other hand is positive and statistically significant at 5 percent implying that higher the number of years of formal education of the catcher the lower the level of the technical efficiency. This is expected as because, higher is the educational attainments, lower would be the attention or focus on traditional (or ancestral) occupation, i.e. fishing, and hence greater would be the focus on non-fishing earning avenues. Formal education can hardly raise traditional fishing skills. On the contrary it is likely to reduce the levels of fishing skills. Spending more years in school also implies lesser exposure to traditional occupation during childhood years, hence resulting in lower fishing skills. Furthermore, higher the number of years of schooling lower is the catch experience (correlation coefficient between education and experience in table 4.1.5 is -0.40 which is statistically significant) for the present sample of fishermen which is anticipated. Thus formal education may adversely affect fishing skills through lower experience as well as shift of focus to non-fishing earning avenues. Incidentally, around 31 percent catchers in the present sample have non-fishing occupations during the slack season. The rest are either unemployed or rely on very scanty fish catch during winter months when the water body goes dry.

The coefficient of experience is negative thereby implying that higher the experience in fish catch higher is the technical efficiency which is expected and economically desirable. However non-fishing income or income from sources other than fishing has a dampening impact on technical efficiency. In other words, as non-fishing income of the team members rises, the technical efficiency of the team falls. As attention is diverted to other sources of income beyond fishing (say agricultural labour, non-agricultural day labour, petty businesses, among few others), fishing is no longer reckoned as primary occupation. So, dependence on fishing for livelihood falls, and arguably catch efficiency falls as catchers take fishing less seriously with growing non-fishing income. Expressed otherwise, dedicated fishermen who have little or no non-fishing income are technically more efficient.

Table 4.2.6. Likelihood Ratio Tests of Restrictions on Production Frontier Parameters (N = 165)

Null hypothesis	Log Likelihood function under		Likelihood Ratio Statistic (λ)	df	Critical value (χ^2) (5%)	Decision
	H_0	H_1				
1. $\gamma = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$ (No inefficiency & No Inefficiency Effects)	-57.807 (OLS or symmetric error)	-44.266 (Inefficiency Effects)	27.082	5	10.371	Rejected
2. $\gamma = 0$ (One sided inefficiency random error absent or OLS)	-57.807 (OLS)	-49.878 Normal/Half-Normal Error	15.858	1	2.706	Rejected
3. $\mu = 0$ (Normal –Half Normal)	-49.878 (Normal –Half Normal Error)	-49.826 Normal-Truncated Normal Error	0.104	1	3.84	Accepted
4. $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$ (Normal-Half Normal Error)	-49.878 (Normal/Half-Normal Error)	-44.266 (Inefficiency Effects)	11.224	4	9.49	Rejected
5. $\gamma_2 = \gamma_3 = \gamma_4 = 0$ (Truncated Normal)	-49.826 Normal-Truncated Normal Error	-44.266 (Inefficiency Effects)	11.12	3	7.81	Rejected
6. $\beta_1 + \beta_2 + \beta_3 = 1$ (CRS technology)	-56.252 Under restriction $\beta_1 = 1 - \beta_2 - \beta_3$	-49.878 No Restrictions $\beta_1 + \beta_2 + \beta_3 \neq 1$	12.748	1	3.84	Rejected

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: 1.The critical values for the first and second null hypotheses are obtained from Table 1 of Kodde and Palm (1986). 2. *df* implies (degrees of freedom).

Generalized likelihood-ratio tests of various null hypotheses involving restrictions on parameters of the composed error distribution as well as that of the production function are presented in table 4.2.6. The first null hypothesis is formally expressed as $\gamma = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$. This implies that there is no technical inefficiency among the fishing teams and naturally no inefficiency effects. Here γ captures the proportion of error variance due to the inefficiency random variable u_i out of total variance($\sigma_u^2 +$

σ_v^2). If the inefficiency random variable u_i is absent, σ_u^2 and γ are both reduced to zero, the only error is the white random noise and thus the model is simply an OLS. Thus under the above restriction the frontier model reduces to ordinary least squares. As seen in table 4.2.5, the computed LR statistic far exceeds the Kodd and Palm (1986) critical values implying that both the first and the second null hypotheses are rejected at 5 percent level. Thus OLS (which estimates the average production function) would be statistically inappropriate to specify the stochastic functional relationship between inputs and output. Acceptance of the frontier model also implies that technical inefficiency exits among the fishing teams. The third null hypothesis tests whether the one-sided inefficiency random error follows normal – half normal distribution (Aigner *et al.,* 1977) as against the alternative of normal – truncated normal distribution with constant mode μ (μ is same as the constant $\gamma_1$used here or δ_0 of the Battese and Corra, 1977 parameterization). As the LR statistic falls short of the critical chi-square value the null hypothesis of normal-half normal error structure is accepted. The fourth null hypothesis tests for the presence of normal-half normal error structure against the alternative of the full Battese and Coelli (1995) inefficiency effects in the one sided errors. The computed LR statistic just exceeds the critical 5 percent value implying that the null hypothesis of Aigner *et al.* (1977) error structure is rejected and the alternative of the Battese and Coelli (1995) inefficiency effects is accepted. In other words experience, education and non-fishing income jointly influences technical efficiency of the fishing team. The fifth null hypothesis is nested in the fourth and asserts that experience, education and non-fishing income jointly does not influences technical efficiency of the fishing team (the constant γ_1 is just left out). In fact this is equivalent to testing the null hypothesis of normal – truncated normal error against the alternative of Battese and Coelli (1995) inefficiency effects. The fifth null hypothesis is rejected at 5 percent implying that normal – truncated normal error is rejected and the inefficiency effects (i.e., experience, education and non-fishing income jointly influences technical efficiency) is accepted.

Finally the sixth null hypothesis tests for the presence of constant returns to scale technology against the alternative of increasing returns to scale (in view of the fact that the sum of the partial input elasticities adds up to 1.52) under the framework of Cobb-Douglas stochastic production frontier with inefficiency effects. The sixth null hypothesis is rejected thereby meaning that the underlying technological relationship between inputs and output exhibits increasing returns to scale (IRS). The microeconomic interpretation of returns to scale in the present context needs to be done with caution. Fixed input like the boat is on the one hand indivisible and is surely impractical to multiply (say double) on the other. One can however imagine a certain percentage increase in boat size. Again, given the boat size and number of catchers, there exists an optimum net size (length) which is most suited for catchers. Other things unchanged, a rise in net size would create difficulties in catch and would lead to lower team level efficiency. Thus a practical interpretation of the IRS finding could be that, 'if boat size, man hours and net length are increased by a certain φ percent, the catch would rise by more than φ percent'. However the practical relevance or field level relevance of the IRS finding may still seem doubtful. In sum, the most significant finding seems to be that the inefficiency effects model best suits the data and the inefficiency effects variables such as experience, education and non-fishing income influence technical efficiency both jointly as well as individually.

The frequency distributions of technical efficiency scores are also presented in Table 4.2.7. The results indicate that the overall level of efficiency ranges from 23 to 96 percent with a sample mean technical efficiency of 68.18 percent. About 33.94 percent of fishermen are operating at 80 percent or more levels technical efficiency. In other words fishing teams are largely heterogeneous in terms of technical efficiency as there exists wide variations in technical efficiency across catch teams.

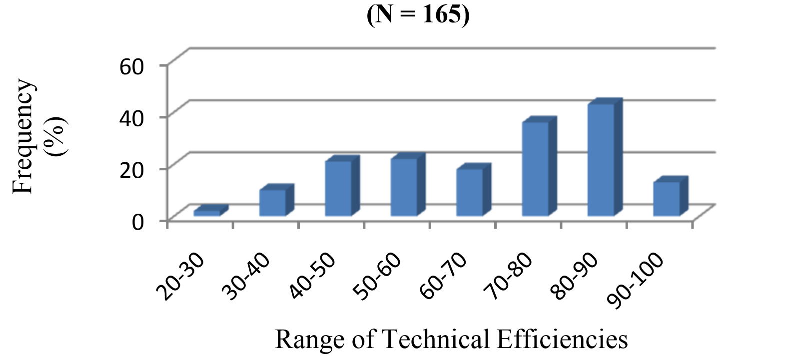
Table 4.2.7. Distribution of Technical Efficiency of all Teams (N = 165)

TE(%) intervals	Frequency	Distribution (%)
20-30	02	1.21
30-40	10	6.06
40-50	21	12.73
50-60	22	13.33
60-70	18	10.91
70-80	36	21.82
80-90	43	26.06
90-100	13	7.88
Total	165	**100**
Mean TE	68.18	
Max. TE	96	
Min. TE	23	
S.D.	17.69	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.

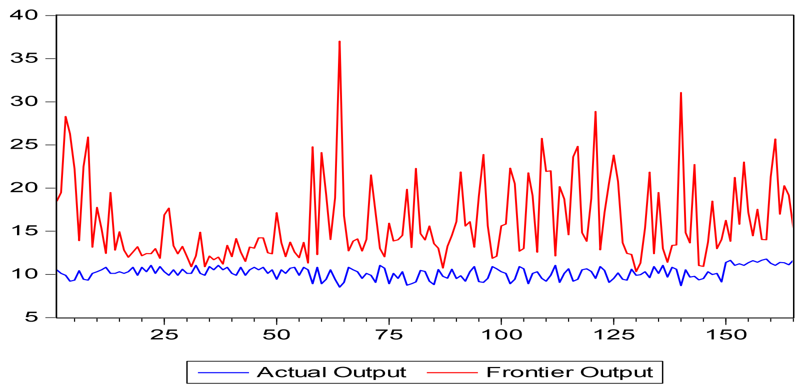
Also about 33.33 percent of the fishing teams are operating at technical efficiency level of 60 percent or less. Furthermore, about 66.67 percent of fishing teams are operating at a technical efficiency level of 70 percent or more. Thus on the basis of team level estimation and analysis mean technical efficiency is below 70 percent which is far from satisfactory. In other words there is much scope of improvement in team level technical efficiency of fish catch.

Fig. 4.2.1. Frequency Distribution of Technical Efficiency of all Teams (N = 165)



Source: Author's estimates based on sample observations using EVIEWS 6 for WINDOWS.

Figure 4.2.1a. Log of Actual output and log of frontier output for Team catchers (N=165)



Source: Author's estimates based on sample observations using EVIEWS 6 for WINDOWS.

On the one hand a small percentage of fishing teams have technical efficiency levels above 90 percent, and on the other hand a considerable proportion of fishing teams (around 44 percent) have technical efficiency levels below 70 percent. This is a skewed picture of team level technical efficiency. The overall mean level can only improve if the bottom 50 percent can improve their catch efficiency. Only three measureable factors are included as non-input inefficiency variables in case of team level analysis. Other factors may include individual health, the ability to market the daily catch, bargaining power of the individual members as well as that of the team leader or skipper, experience of the team leader as well as individual members, among a few others. From the field experience it was evident that every team had a team leader who basically organized the entire team. Experience, skill and expertise of the other members depend heavily on his leadership skills. In particular a skipper with leadership qualities is able to get physically fit, able and experienced members in his fishing team, as he posses the ability to convince his members about the revenue earning capacity of the team. Weaker and inefficient skippers end up having less skilled and less experienced people in his team. Teams without a proper leader like figures suffer from indecision about the choice of correct fishing days, fishing region (within the lake), exact hours to be spent on the water, and even optimum number of members needed.

4.3 Socio-Economic Characteristics of Individual Catchers or Single Catchers

The previous section has focused on team level analysis of estimation and measurement of technical efficiency. However as already described in the methodology section, all fishermen do not belong to fishing teams. A significant number of Sone Beel fishermen are single catchers or individual catchers. The present sample of Sone Beel fishermen includes 160 single catchers. Interestingly not all out of these 160 fishermen are boat and net users. 100 single catchers in this sub-sample use nets and boats but the remaining 60 use age-old traditional fishing tools and equipments like the “dori” and “kathi”.

4.3.1. Table. Livelihood pattern of the sample fishing households (N=160)

	No. of respondents	Percentage
Housing Status		
Mud and bamboo straw	95	59.37
Concrete (pucca)	65	40.63
Total	160	100
Type of Sanitation facility		
Katcha	135	84.37
Sanitary latrine	25	15.63
Total	160	100
Energy for Cooking		
Fire wood	124	77.50
Stoves	36	22.50
Total	160	100
Source of Power		
Electricity	34	21.25
Kerosene	126	78.75
Total	160	100
Source of Drinking Water		
Own dug well	35	28.00
Ponds	45	22.00
Community tube well or tap	80	50.00
Total	160	100

Source: Author’s calculation based of sample survey.

This sub-section is dedicated to descriptive statistical analysis of key socio-economic indicators of the single catcher fisherman's households. It is important to see the socio-economic conditions and physical quality of life for these catchers as because these factors are intricately associated with the principal livelihood of these people. Thus an overall picture of physical quality of life indicators for the selected fishermen can credibly capture their socio-economic status.

Table 4.3.1 shows the overall physical conditions of living among the selected sample of Sone Beel fishermen who are individual or single catchers. Housing condition is an important determinant of the socio-economic condition of people. The modern concept of housing is not only a physical shelter. Besides the shelter, house is a place where family members can develop physically, mentally and socially. Almost 60 percent of the sample fishermen (59.37 percent) are found to be living in katcha houses with mud or earthen walls and thatched roofs. On many occasions the walls were found to be made bamboo, and some houses were found to have tinned roofs. Consequently almost all such houses have no access to safe or improved sanitation. On the other hand 40.63 percent sample fishermen (among the individual catchers) are found to live in concrete houses. These are not entirely RCC type buildings but have brick walls with tinned roofs. Unfortunately during the survey it was found that majority of these houses had dirty floors, i.e., earthen or clay floors without any cemented layer.

The houses are clustered in a small area which indicates that the fishing community of the region is closely knit with a high level of social contact within themselves. From the observations it is further clear that almost all houses are single storied (96 percent) with only a few double storied ones. At first glance it is evident that housing conditions among the sample fisherman is far from satisfactory. They are living in a congested, dilapidated and in an unhygienic condition. There are only few households (21.25

percent) having access to electricity but most of the poor households do not have access to electricity. The source of internal lights during evenings and night are oil lamps or lanterns etc (78.75 percent).

According to the WHO/UNICEF Joint Monitoring Programme (JMP)[29], an "improved" sanitation facility is one that hygienically separates human excreta from human contact." Of course, the JMP's definition differs from country level definitions. As per NSSO 69th round survey report, India[30], that 59.4 percent and 8.8 percent households in rural and urban India respectively had no latrine facilities whereas the same for Assam, it was estimated that 13.7 percent 0.30 percent households in rural and urban respectively had no sanitation facility. However, the sanitation facility among fishing households is very poor in the study region. Almost 85 percent of the fishing households have poor and unconstructed toilets systems and only 15 percent of the total households having semi-pucca sanitary facility. Open-air defecation is common sight for children, the ponds being used for this purpose. Ponds are also used for washing clothes, utensils and animals. Because of lack of safe sanitation coupled with several other unhygienic practices fishing household in the region face severe health problems and water borne diseases are common, especially during monsoon months.

Almost in all fishing household, cooking generally takes place in the courtyard or out in the open. Table 4.3.1 shows that 77.50 percent family use clay ovens with fire wood (timber) and other biomass fuels made from cow dung and the remaining 22.50 percent use kerosene stoves. LPG penetration rate among these households have been near zero. The source and quality of drinking water is yet another vital indicator of human

[29] See for details "Improved and unimproved water and sanitation facilities", retrieved from http://www.wssinfo.org/definitions-methods/watsan-categories/ dated 19th June, 2016

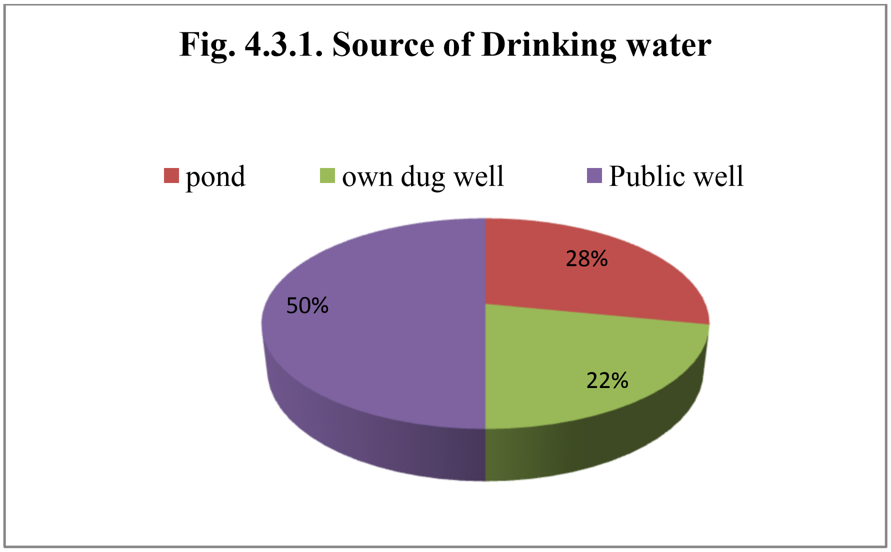
[30] See for details "Key Indicators of Drinking Water, Sanitation, Hygiene and Housing condition in India", (July-December, 2012), Ministry of Statistics and Programme Implementation, December 2013. Retrieved from http://mospi.nic.in/Mospi_New/upload/kye_indi_of_water_Sanitation69rou_24dec13.pdf

health of the population of the study region. Surprisingly some households attempt to improve the quality of water they drink by adopting various methods for treating the water before drinking. According to the WHO/UNICEF Joint Monitoring Programme (JMP),[31] an "improved" drinking-water source is one that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly fecal matter". According to NSS 69th round sample survey report (July-December, 2012)[32] "improved" source of drinking water include: bottled water, piped water into dwelling, piped water to yard/plot, public tap/standpipe, tube well/borehole, protected well, protected spring and rainwater collection. As per NSS 69th round sample survey report of India, the number per 1000 households having improved source of drinking water. It was estimated that during 2012 in rural India, 88.5 percent households had improved source of drinking water while it was 95.3 percent in urban area. The NSS survey also showed that Assam had only 8.51 percent of rural households and 9.28 percent in urban households got drinking water from 'improved sources'.

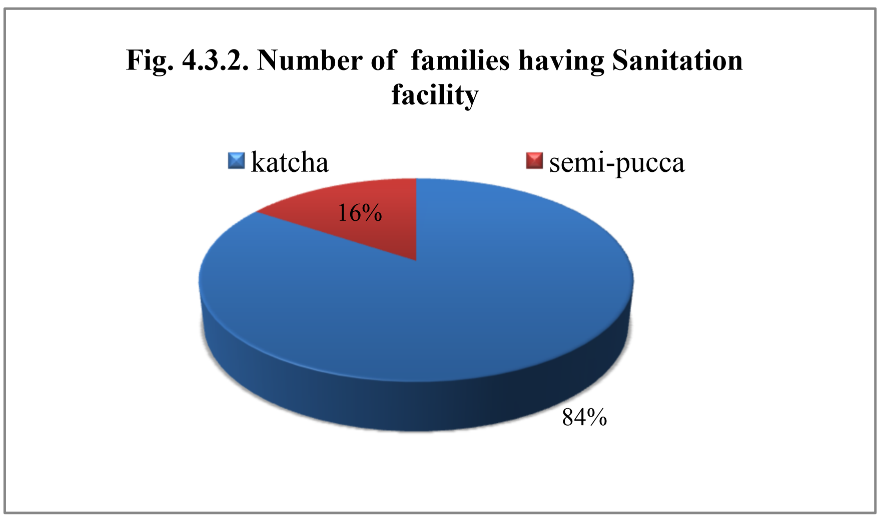
However, in case of Sone Beel and neighboring villages, households get their drinking water from pond, community tube wells or public taps. From the survey it is found that 50 percent of the samples fishing households draw their drinking water from community tubes well or taps while only 28 percent manage water from their own dug wells. In other words almost 50 percent of the sample households draw water from unsafe sources. This raises the risk of contamination and hence the possibility of water borne diseases especially during monsoon months by many a times. The corresponding pie diagram in figure 4.3.1 depicts the distribution of drinking water source in the

[31] Op.cit.
[32] See for details "Key Indicators of Drinking Water, Sanitation, Hygiene and Housing condition in India", (July-December, 2012), Ministry of Statistics and Programme Implementation, December 2013. Retrieved from http://mospi.nic.in/Mospi_New/upload/kye_indi_of_water_Sanitation69rou_24dec13.pdf

sample. Figure 4.3.2 shows the distribution of type of sanitation facilities among sample fishing households.



Source: Author's calculation based of primary data.



Source: Author's calculations based on primary data.

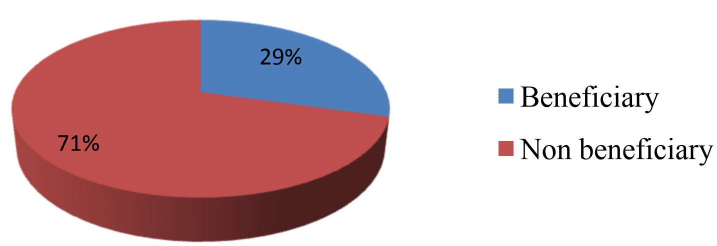
Table 4.3.2.Number of fishing households received Housing Scheme (Indira Awaas Yojana)

	No. of household	Percentage
Beneficiary	47	29.37
Non beneficiary	113	70.63
Total	160	100

Source: Author's calculations based on primary data.

Table 4.3.2 shows number of families having received Government sponsored Indira Awaas Yojana (IAY)[33]. The Indira Awaas Yojana, now it is now known as Pradhan Mantri Awaas Yojana (Grameen) (PMAY-G) is a Centrally Sponsored Scheme funded on cost-sharing basis between the Government of India and the State Governments in the ration of 75:25. From the field survey it is found that 47 fishing households out of 160 sample fishermen have received assistance under Indira Awaas Yojana (IAY)[34] from the government. From the survey it is further observed that beneficiaries under the IAY lie below the poverty line. Moreover almost all the beneficiary households belong to Scheduled Caste category. The survey clearly revealed that the rest of 113 fishing households are deprived from benefit of Indira Awaas Yojana (IAY). However the non beneficiary reported during the interviews that they have to face lots of hurdles due to wide spread corruption in order to get into this scheme. The corresponding pie diagram in figure 4.3.3 depicts the percentage share of housing both under and outside the IAY scheme for the present sample of single catcher households.

Fig. 4.3.3. Distribution of Beneficiaries and Non-beneficiaries under Indira Awaas Yojana



Source: Author's calculations based on primary data.

[33] Indira Awaas Yojana (IAY) is the biggest and most comprehensive rural housing programme ever taken up in the country. It has its origin in the wage employment programmes of National Rural Employment Programme (NREP), which began in 1980, and the Rural Landless Employment Guarantee Programme (RLEGP), which was started in 1983, as construction of house was permitted under these programmes. Indira Awaas Yojana was made an independent scheme with effect from 1st January, 1996.

[34] Indira Awaas Yojana (IAY), Guidelines. Government of India Ministry of Rural Development Department of Rural Development Krishi Bhavan, June 2013.
URL: http://iay.nic.in/netiay/IAY%20revised%20guidelines%20july%202013.pdf

Table 4.3.3. Access to Micro-credit		
Access to Credit	**No. of respondents**	**Percentage**
Yes	30	18.75
No	130	81.25
Total	160	100

Source: Author's calculations based on primary data.

Table 4.3.3 shows the number of fishing household having access to micro-credit facilities. The area of concern here is to see whether or not respondents have access to micro-credit or small loan facilities. It was asked to the respondents if they had ever received a loan, either informally from money lenders and relatives, or formally from registered lending institutions like micro finance institutions (MFIs) and banks. This is found that only 18.75 percent of the sample fishing households had ever borrowed money from formal credit institution like banks. On the other hand 81.25 percent of the fishing households do not have access to credit facility either from formal or informal sources.

Table 4.3.4. Age distribution of Single Catchers		
Age (years)	**No. of person**	**Percentage**
18-30	62	38.75
30-42	56	35.00
42-56	44	27.50
56+	04	2.50
Total	160	100

Source: Author's calculations based on primary data.

Table 4.3.4 shows the frequency distribution of age of the selected sample of single catcher fishermen in the Sone Beel. Almost 74 percent catchers belong to the 18 – 42 years age group which arguably is the most active age group as far as fishing is concerned. Single catchers do not have assisting staff and the entire operation has to be managed singlehandedly. Thus for single catchers physical fitness and physical capability is more vital for successful fishing. Surprisingly a significant proportion of single catchers belong to the above 42 years age group as well.

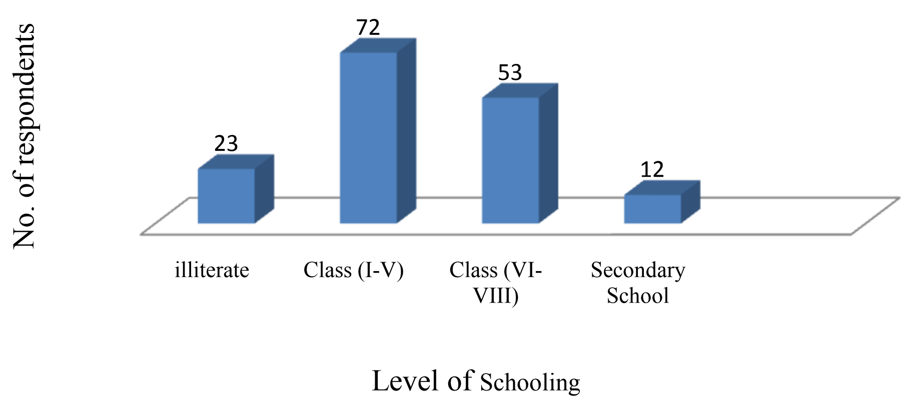
Level of Schooling	Number of persons	Percentage
No formal Education	23	14.37
Lower Primary school (I-V)	72	45.00
Upper Primary School (VI-VIII)	53	33.12
Secondary School (beyond VIII)	12	7.50
Total	160	100

Table. 4.3.5. Educational attainments of Single Catchers in Sone Beel

Source: Author's calculations based on primary data.

Education attainment of the fishermen and also that of family members is one of the most significant factors behind the socio-economic status and overall quality of life of fishing households. Education leads to awareness and greater consciousness about one's own surroundings. Education is also vital from the point of view of information gathering. Surprisingly the percentage of illiterate fishermen in the sub-sample has been found to be incredibly low at about 14 percent only. As the table 4.3.5 indicates that 45 percent of the fishers have completed lower primary education, while 33.12 percent of them have completed their upper primary schools. Only 12 fishermen have managed to do their secondary schooling. On the whole it is apparent that attainments in basic education for the sample of single catcher fishermen are rather unsatisfactory. Perhaps formal education directly does not influence their job skill and hence earnings and living standards resulting in a drift away from formal education at an early age.

Fig. 4.3.4. Educational attainments of Single Catcher Fishermen in Sone Beel (N=160)



Source: Author's calculations based on primary data.

The corresponding bar diagram in figure 4.3.4 clearly shows the domination of primary schooling and the lack of secondary schooling of individual sample catchers fishing in the Sone beel. The column bars are on the basis of absolute frequencies or numbers.

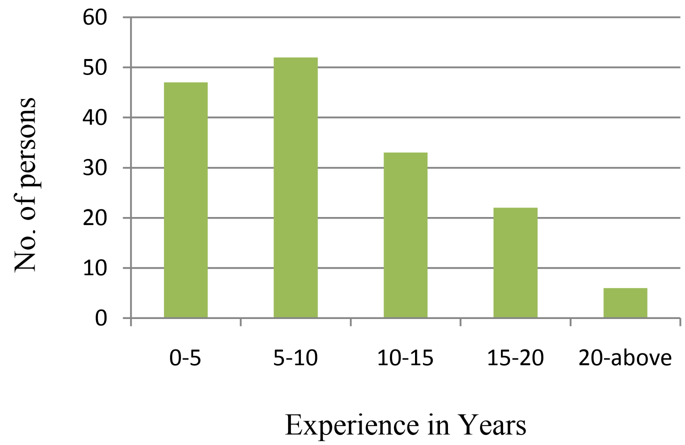
Table.4.3.6. Distribution of Experience of Single Catcher fishermen in the Sone Beel

Year	Number of persons	Percentage
0-5	47	29.37
5-10	52	32.50
10-15	33	20.62
15-20	22	13.75
20-above	06	3.75
Total	160	100

Source: Author's calculations based on primary data.

Fishing experience is one of the most important determinants of technical efficiency in this study. Higher the experience better would be the catch with the same level of fishing effort. Table 4.3.6 shows the distribution of fishing experience of the sample of single catcher fishermen fishing in the Sone Beel. Around 30 percent of the single catchers are found to have a fishing experience of 0 to 5 years. These fishermen are relatively new comers into the profession. Since they traditionally belong to fishing families and have seen and observed fishing activities in the Beel since childhood (some have even actively helped in fishing since adolescent years) such low experience does not act as an impediment primarily due to ample traditional knowledge and knowhow. Almost 53 percent of the catchers have experience ranging between 5 to 15 years. Only 3.75 percent of the sample fisherman's experience ranges from 20 and above years. Since age and experience are highly positively correlated it expected that very few catchers in the sample would be aged more than 50 years. Consequently very few catchers would have more than 20 years of fishing experience. Figure 4.3.5 depicts the distribution of experience across single catchers.

Fig. 4.3.5. Experience of fishing of single catcher team (N=160)



Source: Author's calculations based on primary data.

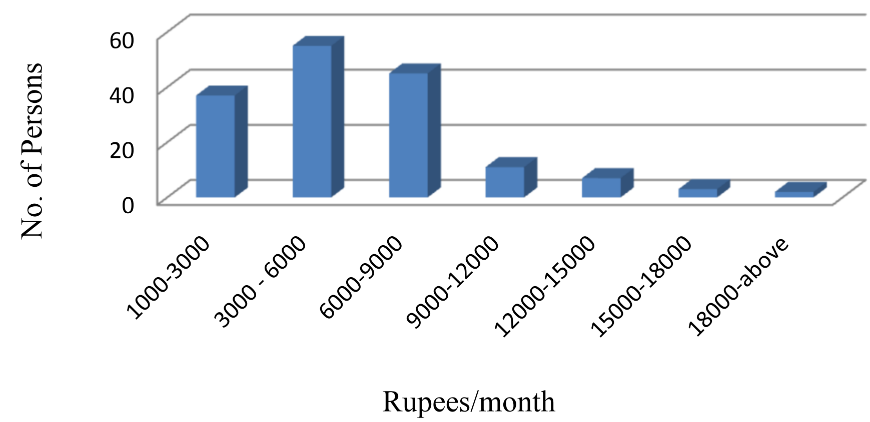
Table 4.3.7. Frequency Distribution of Value of Catch of Single catchers (Rupees/month)

Class Interval	Frequency	Percentage
1000-3000	37	23.13
3000 - 6000	55	34.37
6000-9000	45	28.13
9000-12000	11	6.87
12000-15000	7	4.37
15000-18000	3	1.88
18000-above	2	1.25
Total	160	100

Source: Author's calculations based on primary data.

The distribution of value of catch is presented in table 4.3.7. Around 23 percent of the catchers have a monthly value of fish catch between Rs.1000 and Rs. 3000. Almost 62 percent of the single catchers have monthly value of catch between Rs. 3000 and Rs. 9000. Very few catchers have value of catch beyond Rs.9000 per month. The situation is depicted in figure 4.3.6.

Fig. 4.3.6. Monthly value of fish caught by Single catchers (N=160)



Source: Author's calculations based on primary data.

4.4 Production Frontier Analysis of Single Catchers Using Boat and Net

The summary statistics of all variables used for the production frontier estimation along with the inefficiency effects variables are presented in Table 4.4.1. From the figures, it is evident that there is substantial variation in the outputs and inputs across catchers. Value of fish caught ranges between Rs. 2000 and Rs 12000 per team per month.

Table 4.4.1. Summary Statistics of variables for single catchers team (N=100)

Variables	Min.	Max.	Mean	S.D.
Value of fish caught (₹/month)	2000	12000	5862	2288
Labour Hours (man-hours/month)	40	140	83.60	21.15
Net (meter)	45.72	365.76	144.35	71.67
Boat Size (meter)	3.65	6.09	4.51	0.63
Age of catchers (year)	18	60	31	7.51
Experience (year)	0	35	6.31	6.06
Education (year)	0	10	5.40	2.65
Non Fishing Income (Rupees/month)	500	5000	3116	1052

Source: Author's estimates based on sample observations.

Labour hours also very significantly across single catchers. Length of net could be a distinguishing factor in determining size of catch as because variability of net size is very high across teams. Age, education and experience exhibit smaller variations across catchers. Although variation in boat size is small, it could be a significant factor in determining catch effort. Finally non-fishing income is an important indicator of dependence on fishing. Higher levels of non fishing income may be indicative of a shift from fishing to other occupations. Usually fish catch using traditional method is physically involving and physical fitness of each catcher is vital from the view point of efficient functioning of the team. The average age of catchers is 31 years which is perhaps appropriate for single catchers without any helpers or support staff. Although experience ranges between 0 and 35 years, mean years of experience is below 7 years. It is possible that this is just sufficient for productive fish catch as catchers are acquainted to the system since childhood.

Table 4.4.2 presents the maximum likelihood estimates of the Cobb-Douglas production frontier model of single catchers assuming the Aigner *et al* (1977) Normal-half normal error structure. Most of the coefficients are highly significant except input boat and very similar to the value of OLS estimates. The constant term is found to be significant. So are the coefficients of labour and net. Although boat is an important factor input but it is statistically insignificant in the single catcher teams.

Table 4.4.2. Cobb-Douglas Stochastic Production Frontier Estimates under Normal – Half-normal Error Structure (N = 100)				
	OLS		MLE	
Variables	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	4.54 (0.53)	8.50**	5.13 (0.50)	10.32**
ln Labour	0.45 (0.16)	2.83**	0.37 (0.14)	2.60**
ln Boat	0.15 (0.27)	0.59	0.25 (0.22)	1.12
ln Net	0.37 (0.09)	3.98**	0.36 (0.09)	3.98**
Variance Parameters				
$\sigma^2 = \sigma_v^2 + \sigma_u^2$			0.21 (0.04)	4.91**
σ_v^2			0.19	
σ_u^2			0.02	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)			0.89 (0.06)	14.72**
Log Likelihood Value	-21.057 (OLS)		-16.769 (MLE)	
LR Test of the One-Sided Error (H_0: $\gamma = 0$)			8.575	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: 1. Test for $\gamma = 0$ follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm (1986) is 2.706 for 1 degree of freedom. 2. (*) and (**) indicate that coefficients are statistically significant at the 0.05 and 0.01 levels respectively. 3. Standard errors are given in parentheses. 4. *ln* is natural logarithm.

But more importantly variance parameters of the stochastic frontier model $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ are statistically significant [Battese and Corra (1977) parameterization]. The likelihood ratio test for the absence of the one sided error (which is tantamount to an OLS regression model, assuming γ=0) reveals that computed *LR* statistic of 8.575 far exceeds the Kodde and Palm (1986) critical value for 1 degree of freedom (tabulated value being 2.706). The estimated value of γ is 0.89 and is statistically different from zero at 1 percent level of significance. This suggests that ordinary least squares or the average production function is an inappropriate statistical specification for describing the underlying relationship between inputs and output in case of single and paired boat using fishing teams operating in the Sone Beel of Assam.

Table 4.4.3. Cobb-Douglas Stochastic Production Frontier : Normal half-Normal and Normal - Truncated Normal Error Models Compared for Single Catchers (N = 100)				
	Normal half-Normal		**Truncated Normal**	
Variables	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	5.13 (0.50)	10.32**	5.05 (0.53)	9.56**
ln Labour	0.37 (0.14)	2.60**	0.36 (0.14)	2.56**
ln Boat	0.25 (0.22)	1.12	0.25 (0.22)	1.16
ln Net	0.36 (0.09)	3.98**	0.38 (0.09)	3.93**
Error Distribution Parameters				
μ (Stevenson,1980)	**NA**	**NA**	-0.36 (1.15)	-0.31
$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.21 (0.04)	4.91**	0.29 (0.29)	0.99
σ_v^2	0.19		0.02	
σ_u^2	0.02		0.26	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)	0.89 (0.06)	14.72**	0.91 (0.07)	12.37**
Log Likelihood Value	-16.769		-16.655	
LR statistic for absence of one-sided error (*df*)	8.575 (*df*, χ^2=1,095=2.706)		8.802 (*df*, χ^2=2,095=5.138)	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: 1. Test for gamma=0 follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm [1986]. 2. * and ** indicate statistical significance at the 0.05 and 0.01 level respectively.
3. NA, not applicable. 4. Standard errors are in parentheses. 5. 'ln' is natural logarithm. 6. μ represents constant mode of the Stevenson (1980) truncated normal error.

Furthermore, this suggests that about 89 percent of variation in value of catch is as a result of technical inefficiency rather than due to random factors beyond the control of catchers.

Table 4.4.3 presents the maximum likelihood estimates of the Cobb-Douglas stochastic production frontier with normal – truncated normal error structure. The normal – half normal model results are also presented in the same table for quick comparison. μ, the constant mode of the truncated normal error distribution is negative but statistically insignificant thereby suggesting that the Aigner *et al* (1977) normal – half normal error specification is statistically more appropriate. Other estimates are hardly any different.

Table 4.4.4 presents the maximum likelihood estimates of the Battese and Coelli (1995) technical inefficiency effects model. The production function parameters are all positive and significant which is economically meaningful and desirable. The estimates of the production function parameters are found to vary only slightly across frontier and OLS models. The coefficients of the technical inefficiency variables are of profound economic importance in the present context. The constant γ_1 (equivalent to δ_0 as per Battese and Coelli, 1995 specification) is positive and statistically significant at 1 percent level. The non-fishing income or income from sources other than fishing has a dampening impact on technical efficiency. In other words, as non-fishing income of the catcher rises, the technical efficiency falls. As attention is diverted to other sources of income beyond fishing (say agricultural labour, non-agricultural day labour, petty businesses, among few others), fishing is no longer reckoned as primary occupation and the dedication towards fishing is gone. So, dependence on fishing for livelihood falls, and arguably catch efficiency falls as catchers take fishing less seriously with growing non-fishing income.

Table 4.4.4. Cobb-Douglas Stochastic Production Frontier with Inefficiency Effects (N = 100)

Variables		MLE Coefficient	t-ratio
Constant		6.68 (0.52)	12.71**
ln Labour		0.23 (0.12)	1.90*
ln Boat		0.12 (0.21)	0.58
ln Net		0.23 (0.07)	3.11**
Technical Inefficiency Model			
Constant		1.32 (0.20)	6.49**
Experience		-0.03 (0.08)	-3.71**
Non-Fishing Income		0.04 (0.03)	1.43
Sanitation dummy		-0.04 (0.10)	-0.46
House type dummy		-0.31 (0.09)	-3.34**
Error Variance Parameters			
$\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.07 (0.01)	4.34**
σ_v^2		0.01	
σ_u^2		0.06	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)		0.86 (0.11)	8.15**
Log Likelihood Value	-21.057 (OLS)	9.437 (MLE)	
LR Test of the One-Sided Error [Kodd-Palm (1986) $\chi^2_{0.05,5}$ = 10.371]		60.988	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes: 1. Test for gamma=0 follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm [1986]. 2. * and ** indicate statistical significance at the 0.05 and 0.01 level respectively. 3. NA, not applicable. 4. Standard errors are in parentheses. 5. 'ln' is natural logarithm. 6. μ represents constant mode of the Stevenson (1980) truncated normal error. 7. Sanitation dummy assumes 1 for safe sanitation and 0 otherwise and house-type dummy assumes 1 for RCC type construction and zero otherwise.

Expressed otherwise, dedicated fishermen who have little or no non-fishing income are technically more efficient. Socio economic variables like sanitation system dummy and housing type dummy are found to be negative in the inefficiency effects model implying that these variables have a positive impact on technical efficiency of the sample of single catcher fishermen.

Table 4.4.5. Likelihood Ratio Tests of Restrictions on Production Frontier Parameters (N = 100)						
Null hypothesis	Log Likelihood function under		Likelihood Ratio Statistic (λ)	df	Critical value (χ^2) (5%)	Decision
	H_0	H_1				
$\gamma = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$ (No inefficiency & No Inefficiency Effects)	-21.057 (OLS or symmetric error)	9.437 (Inefficiency Effects)	60.988	5	10.371	Reject
$\gamma = 0$ (One sided inefficiency random error absent or OLS)	-21.057 (OLS)	-16.769 Normal/Half-Normal Error	8.576	1	2.706	Reject
$\mu = 0$ (Normal –Half Normal)	-16.769 (Normal –Half Normal Error)	-16.655 Normal-Truncated Normal Error	0.228	1	3.84	Accept
$\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$ (Normal-Half Normal Error)	-16.769 (Normal/Half-Normal Error)	9.437 (Inefficiency Effects)	52.41	4	9.49	Reject
$\gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$ (Truncated Normal)	-16.655 Normal-Truncated Normal Error	9.437 (Inefficiency Effects)	52.18	3	7.81	Reject
$\beta_1 + \beta_2 + \beta_3 = 1$ (CRS technology)	-10.311 Under restriction $\beta_1 = 1 - \beta_2 - \beta_3$	9.437 No Restrictions $\beta_1 + \beta_2 + \beta_3 \neq 1$	39.496	1	3.84	Reject

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.
Notes*:* 1.The critical values for the first and second null hypotheses are obtained from Table 1 of Kodde and Palm (1986*)*. 2. *df* implies (degrees of freedom).

Access to safe sanitation is a proxy for improved living standards as well as physical quality of environment in which the fisherman lives. But most importantly it is a proxy for health status. Similarly, house type dummy acts as a proxy for physical standards of living. The results show that both access to improved sanitation and improved living standards have a positive influence on technical efficiency of the individual catcher. Interestingly the theoretical arguments may be supportive of a reverse causation. That is housing and sanitation qualities are more improved for the catchers who are technically more efficient. Better earnings due to higher efficiency give higher purchasing power and thus greater command over resources. Hence more efficient catchers are able to afford better housing and safe sanitation which are outside the scope of inefficient catchers.

The Generalized likelihood-ratio tests of various null hypotheses involving restrictions on parameters of the composed error distribution as well as that of the production function are presented in table 4.4.5. The first null hypothesis is formally expressed as $\gamma = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$. This implies that there is no technical inefficiency among the single catchers and naturally no inefficiency effects. Here γ captures the proportion of error variance due to the inefficiency random variable u_i out of total variance $(\sigma_u^2 + \sigma_v^2)$. If the inefficiency random variable u_i is absent, σ_u^2 and γ are both reduced to zero, the only error is the white random noise and thus the model is simply an OLS. Thus under the above restriction the frontier model reduces to ordinary least squares. As seen in table 4.4.4, the computed LR statistic far exceeds the Kodd and Palm (1986) critical values implying that both the first and the second null hypotheses are rejected at 5 percent level. Thus OLS (which estimates the average production function) would be statistically inappropriate to specify the stochastic functional relationship between inputs and output. Acceptance of the frontier model also implies that technical inefficiency exits among the single catchers. The third null hypothesis tests whether the one-sided inefficiency random error follows normal – half normal distribution (Aigner *et al,*. 1977) as against the alternative of normal – truncated normal distribution with constant mode μ (μ is same as the constant $\gamma_1$used here or δ_0 of the Battese and Corra, 1977 parameterization). As the LR statistic falls short of the critical chi-square value the null hypothesis of normal-half normal error structure is accepted. The fourth null hypothesis tests for the presence of normal-half normal error structure against the alternative of the full Battese and Coelli (1995) inefficiency effects in the one sided errors. The computed LR statistic just exceeds the critical 5 percent value implying that the null hypothesis of Aigner *et al.* (1977) error structure is rejected and the alternative of the Battese and Coelli (1995) inefficiency effects is accepted. In other words experience, sanitation dummy and housing type dummy jointly influences technical efficiency of the single catchers. The fifth null hypothesis is nested in the fourth and asserts that experience, sanitation dummy and housing type dummy jointly does not influences technical efficiency (the constant γ_1 is just left out). In fact this is equivalent to testing the null hypothesis of normal – truncated normal error against the alternative of Battese and Coelli (1995) inefficiency effects. The fifth null hypothesis is rejected at less than 5 percent implying that normal – truncated normal error is rejected and the inefficiency effects (i.e., experience, education and non-fishing income jointly influences technical efficiency) is accepted.

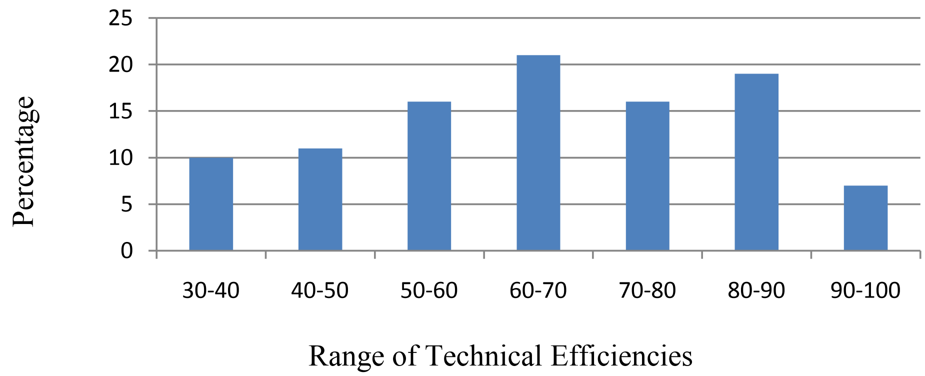
Finally the sixth null hypothesis tests for the presence of constant returns to scale technology against the alternative of increasing returns to scale (in view of the fact that the sum of the partial input elasticities adds up to 0.58) under the framework of Cobb-Douglas stochastic production frontier with inefficiency effects. The sixth null hypothesis is rejected thereby meaning that the underlying technological relationship between inputs and output exhibits decreasing returns to scale (DRS) which in sharp contrast with the results for multiple catchers, where the technological relationship between inputs and output exhibits increasing returns to scale (IRS).

Table 4.4.6. Distribution of Technical Efficiency of single catcher teams (N = 100)		
TE(%) intervals	**Frequency**	**Distribution (%)**
30-40	10	10
40-50	11	11
50-60	16	16
60-70	21	21
70-80	16	16
80-90	19	19
90-100	07	07
Total	100	**100**
Mean TE	65.04	
Max. TE	96	
Min. TE	31	
S.D.	17.61	

Source: Author's estimates based on primary data using *FRONTIER 4.1* for Windows.

The frequency distributions of technical efficiency scores of single catchers are presented in Table 4.4.6. The result indicates that the overall level of efficiency ranges from 31 to 96 percent with a sample mean technical efficiency of 65.04 percent. About 26 percent of fishermen are operating at 80 percent or more technical efficiency levels. Also about 37 percent of the fishing teams are operating at technical efficiency level of 60 percent or less. Furthermore, about 66.67 percent of fishing teams across all methods are operating at a technical efficiency level of 70 percent or more. In other words mean technical efficiency for single catchers is lower than the corresponding figures for team catchers. Thus there is enormous scope for improvement of technical efficiency for both single as well as team catchers.

Fig. 4.4.6. Distribution of Technical Efficiency of single catcher team (N = 100)



Source: Author's estimates based on sample observations

4.5 Analysis of Single Catchers using Traditional Fishing Tools and Equipments

The present sample of single catcher fishermen in the Sone Beel contains 60 fishermen who are not net users but depend on a few traditional fishing tools. The summary statistics of all variables of the stochastic production frontier estimation are presented in table 4.5.1.

Table 4.5.1. Summary Statistics of variables for single catchers without Net (N=60)

Variables	Min.	Max.	Mean	S.D.
Value of catch (Rs/month)	2500	12500	5816	2105
Labour (man-hours/month)	75	175	119	26.47
Boat Size (meter)	7.92	3.65	4.61	0.90
Dori (numbers)	10	35	21	6.97
Kathi (meter)	20.32	50.80	32.34	9.01
Experience (year)	0	22	7.91	6.86
Education (year)	0	10	5.50	2.96
Per capita consumption expenditure (Rs/month)	350	5000	853	590

Source: Author's estimates based on primary data using EVIEWS 8.

As seen from the table variation in value of fish caught is considerably high and as such it leads to large standard deviation. Labour exhibits sizable variation as well. Even for this sub-sample the mean experience is close to 8 years. Average levels of formal education are low as the mean years of schooling is below 6. Even per capita consumption expenditure varies widely across individual fishing households. Wide variations in value of catch as well as per capita consumption indicates that although catch technology is identical for this sub-category of fishermen, there is significant heterogeneity among the present sample of non-net using catchers. Catch size is expected to vary in accordance with catch effort. Since these are single fishermen, their personal labour effort varies across each other along with the fishing tools and equipments used but the labour variability may be due to physical capability differences.

Table 4.5.2. Cobb-Douglas Stochastic Production Balatkar Estimates under Normal – Half-normal Error Structure (ALS, 1977)

	OLS		MLE	
Variables	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	6.24 (0.72)	8.61**	6.27 (1.18)	5.28**
ln Labour	0.06 (0.13)	0.47	0.06 (0.13)	0.49
ln Boat	0.63 (0.13)	3.95**	0.63 (0.15)	4.09**
ln Dori	0.25 (0.09)	2.81**	0.25 (0.08)	2.88**
ln Kati	0.06 (0.11)	0.54	0.06 (0.11)	0.54
Error Variance Parameters				
$\sigma^2 = \sigma_v^2 + \sigma_u^2$			0.0467 (0.08)	0.55
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ (Battese and Corra, 1977)			0.0472 (2.71)	0.017
Log Likelihood Value	7.655		7.655	
LR Test of the One-Sided Error (H_0: $\gamma = 0$)			0.0001	

Source: Author's estimates based on primary data using *BALATKAR 4.1* for Windows.
Notes: 1. Test for $\gamma = 0$ follows mixed chi-square distribution with critical value found in table 1 of Kodde and Palm (1986) is 2.706 for 1 degree of freedom. 2. (**) indicates that coefficients is statistically significant at the 0.01 level. 3. Standard errors are given in parentheses. 4. *ln* is natural logarithm.

The stochastic production frontier on the basis of non-net using single catchers assuming a Cobb-Douglas functional form is estimated using FRONTIER 4.1 and the results are tabulated in table 4.5.2. The constant, boat and dori (DR) are statistically significant whereas kathi (KT) is not.

The MLE estimates also do not vary much. Coming to the variance parameters of the composed error, both σ^2 and γ have low *t*-values which are statistically insignificant. Of particular interest is the statistical test of the null hypothesis that the parameter γ, which captures the percentage of error variance due to inefficiency (out of total variation in the composed error), is in fact zero. Here γ is estimated at 0.0472 implying that only 4.72 percent of the total variation in the composed error is due to the one-sided inefficiency random variable alone. The log-likelihood value under OLS is almost identical to that under MLE. Setting $\gamma = 0$ is equivalent to an OLS regression. The LR statistic for the test of the null hypothesis that $\gamma = 0$ is thus very close to zero implying that the null hypothesis of $\gamma = 0$ is accepted, or else OLS is accepted statistically over the stochastic frontier model of Aigner, Lovell and Schmidt (1977). In other words the one-sided error is absent in the composed error specification so that the frontier regression boils down to an OLS regression. Thus the OLS regression which estimates the average production function (due to symmetric white noise error term only) is quite appropriate in capturing the statistical relationship between inputs and output. This is unlike the previous two cases where the frontier model was accepted as the OLS was statistically rejected.

Table 4.5.3. OLS Estimates of Cobb-Douglas Production Function for non net users (N=60)				
Dependent Variable: Ln (Y)[1]				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	6.25	0.71	8.69	0.0000
ln L	0.06	0.13	0.46	0.6423
ln B	0.63	0.15	3.99	0.0002
ln DR	0.25	0.08	2.81	0.0068
ln KT	0.05	0.11	0.52	0.6036
R-squared	0.37	Mean dependent var		8.46
Adjusted R-squared	0.32	S.D. dependent var		0.27
S.E. of regression	0.22	Akaike info criterion		0.08
Sum squared resid	2.72	Schwarz criterion		0.08
Log likelihood	7.65	Hannan-Quinn criter.		0.02
F-statistic	8.15	Durbin-Watson stat		2.02

Source: Author's estimates based on primary data using EVIEWS 8.
Notes: 1. Y is rupee value of fish catch per month at the fishing team level. 2. *ln* denotes natural logarithm.

The ordinary least squares estimates of the Cobb-Douglas model are first presented along with heteroscedasticity test of OLS residuals. Table 4.5.3 presents the ordinary least square (OLS) estimates of Cobb-Douglas production function for the sample of 60 single boat fishing teams without net using traditional fishing equipments in form of fish traps like cylindrical drum traps, vertical slit traps (locally known as *dori* and *kathi*) this is measured physically in the production function. As seen from the *t* values, all the coefficients except labour and Kati are statistically significant. The R^2 value is low at 37 percent which means 37 percent of the total variation in logged value of catch can be accounted for by the logged values of four inputs labour (L), boat (B), dori (DR) and Kathi (KT). The overall regression is clearly significant as the F value is substantially large.

Table 4.5.4. Breusch-Pagan-Godfrey Heteroskedasticity Test			
Null Hypothesis: OLS Residuals are Homoscedastic			
F-statistic	1.78	Prob. F(4,55)	0.1456
Obs*R-squared	6.88	Prob. Chi-Square(4)	0.1421
Scaled explained SS	4.59	Prob. Chi-Square(4)	0.3310

Source: Author's estimates based on primary data using EVIEWS 8.

Moreover Breusch-Pagan-Godfrey's heteroscedasticity test confirms that the null hypothesis of homoskedasticity is accepted at 14 percent (table 4.5.4) which is desirable.

4.6 Economic Viability of Fishing as a Sustainable Occupation

The third objective of the present study is to examine whether fishing can be considered as a sustainable source of livelihood and whether it is capable of providing a decent standard of living. This objective is relevant for the single catchers and their households as during the field survey household level information could be gathered only for these single catchers. The two issues that are directly evident from the objective are (i) economic viability of fish catch as an occupation, and (ii) whether fishermen can stay in this occupation profitably over generations. Both points need elaboration.

Coming to the first point of economic viability of fish catch, it needs to be seen whether members of an average or representative fishing team earn sufficiently on a daily or monthly basis so as to maintain a minimum acceptable standard of living in their respective households. Fishing earns more on a daily basis during the monsoon months. Many catchers in the present sample do not have access to alternative occupation during the dry season or the winter months, i.e., little or no non-fishing income. Thus for a catcher, earning from fish sale has to be sufficient enough to maintain the minimum desirable standards of consumption as set by Government of India's Planning Commission Recommendations 2014-15. In other words earning from sale of catch must at least support a consumption standard that is just above the poverty line level of consumption. Apart from consumption the key factors that can capture standards of living and physical quality of life are, house type and house condition, per capita plinth area, presence of sanitary toilet, drinking water source and quality, nature and frequency of illness of all members including that of children, child immunization, asset holding in the household, financial savings and liabilities (informal loans), among a few others. It must be highlighted that economic empowerment and human development have to be the final goal of any informal sector occupation or economic activity. If earning from sale of fish catch is insufficient to support the minimum desirable or acceptable standards of living at the household level then fishing as a profession or occupation is economically non-viable.

The second point is somewhat related to the first. Insufficient revenue from sale of catch may be the result of low catch per team as a consequence of overcrowding of catchers in the Sone Beel. Overcrowding of catchers may easily occur as catch is practically unrestricted during the peak season. Insufficient catch per team may also result from early or premature catch leading to low stock growth of fish population. A ground rule for sustainability is that rate of catch cannot exceed the natural rate of fish stock regeneration or biological stock growth. Unfortunately fish stock estimation or base level fish population estimation and stock growth or decay is outside the scope and purview of the present study.

According to the Report of Planning commission Government of India June, 2014[35], reviewed the methodology of the Expert Group (Rangarajan Committee) for measurement of poverty is declared. Based on the analysis presented in the report, poverty has been defined as monthly per capita consumption expenditure of Rs. 972 in rural areas and Rs. 1407 in urban areas is treated as the poverty line at the all India level. This implies a spending over Rs. 32 a day in rural areas and Rs. 47 in urban areas should not be considered as poor, which further implies monthly consumption

[35] Report of the Expert Group to Review the Methodology for Measurement of Poverty, Government of India Planning Commission June, 2014.
URL:http://planningcommission.nic.in/reports/genrep/pov rep0707.pdf

expenditure of Rs. 4860 in rural areas or Rs. 7035 in urban areas for a family of five at 2011-12 prices.

The methodology used to mark out BPL households for the present sample of fishermen is rather simple. The number of household members is first determined from primary data collected through the survey on the single catchers. The monthly household income and consumption are also recorded on the basis of the information provided by the catchers during interview. The consumption figure is considered more reliable for the present study. The monthly household consumption expenditure corresponding to each catcher is divided by the number of household members to get the per capita monthly consumption expenditure in current rupees for every sample fishing household. This figure is now divided by 30 to get per capita household consumption per day for each fishing household. This figure is now compared with the Rangarajan Committee prescribed norms of Rs 32 for rural areas during 2011-12. Since the data pertains to 2012 July the issue of statistical discrepancy between Planning Commission figures and those of the present study on account of inflation, does not arise. Based on this information the present study categorizes fishing households into poor (BPL) and non-poor (APL).

Based on this information the present study has compared whether traditional fishers does really have enough source of income from fishing so that there sustainability in this occupation can be reasonably justified.

Table 4.6.1. Single catcher households living Above and Below Poverty Line

Category	No. of Fishing Families	Percentage
BPL	99	61.88
APL	61	38.12

Source: Author's estimates based on primary data

From table 4.6.1 it is observed that out of 160 of single catchers households, 61 fishing households (which is around 38 percent of the total sample size of single catchers household) are living above the poverty line as their minimum consumption expenditure is just above the recommended poverty line standard. The remaining 99 fishing households i.e., around 62 percent of households are living below the poverty line (BPL) as fishing as a livelihoods is insufficient to provide minimum acceptable standards of living and hence a life with dignity, and command over resources or financial freedom. A deeper insight reveals that majority of fishing households who are under BPL category are mainly non net users. This is perhaps because their earnings from fishing, by applying traditional fishing equipments, yield lesser quantity of fish which result low levels of revenue earning from fish sale. Thus majority of the fishing households are under poverty and economically, fish catch in the Sone Beel can neither be termed viable nor sustainable occupation (or source of livelihood).

Coming to the other key factors determining standards of living, only 25 percent (table 4.3.1) of the sub-sample size (of 160) of fishing household have hygienic sanitary facilities while the remaining do not. However around 44 percent of the sample fishing households have brick walled houses with or without clean floor. This difference must directly indicate that some percentage of households who have a desirable housing accommodation do not have access to a sanitary toilet. Proper housing has been possible for a small percentage of households due to government support under *Indira Awaas Yojana which* incidentally has been received by a small percentage of the fishing households.

In sum, for a little more than 60 percent of the sample of single catchers, it may be safely inferred that fishing cannot be considered as a sustainable or financially viable source of livelihood as it is unable to support an average monthly per capita consumption just equal to Rangarajan Committee prescribed minimum necessary level of per capita consumption. Besides this, even for households which are above the poverty line as per estimates of the present study, the general conditions of living, housing quality, sanitation quality, attainments in basic education, access to safe drinking water among a few other indicators are in an abominable state to say the least. In other words, human development levels are far from satisfactory for the sample of single catcher fishing households, although a systematic attempt to capture human development levels among fishing households is beyond the scope in the present study. Hence it may be safely argued that fishing in the Sone Beel is neither financially viable, nor sustainable as an occupation. Here financial viability is interpreted as a minimum essential level of income earning sufficient for a life with command over resources, self esteem and dignity.

The issue of sustainability on the other hand has to be examined in the light of the ability of future generations of fishermen to earn at least as much as the present generation of fishermen from fishing activities in the Sone Beel. In this context, two key areas of concern that emerge from the present study are, (i) socio-economic backwardness (that includes poverty for obvious reasons) of the catchers or fishermen, and (ii) declining fish population or fish stock in the water body even during peak seasons in recent years. For obvious reasons these two issues are related. Higher the level of socio-economic backwardness among the traditional fishing community, higher is the dependence on fishing for livelihood. With low levels of education, alternative occupation and employment opportunities are also low.

Thus a majority of households are rather forced to remain in the traditional occupation which in this case is also the ancestral occupation. A relative small percentage of catchers are engaged in non-fishing activities during the slack season, which implies that the majority are either unemployed or are forced to depend on very scanty fish catch during winter months. This raises their socio-economic distress levels substantially. Naturally, higher the accumulation of catchers during a given time point, higher would be the catch levels (over fishing) finally resulting stock depletion and loss of aquatic species.

During the survey it was revealed that almost 84 percent of the respondents do not have access to a hygienic sanitary toilet. Moreover almost 50 percent of the respondents depend on community tube wells for their drinking water needs. Some were even found to consume pond water. Alarmingly 81 percent of the catchers' households were found to have 4 to 5 children. None of the catchers were found to have crossed the secondary educational level. Paradoxically 96 percent of the respondents were found to be using mobile phones. Regarding overcrowding of fishermen, around 87 percent catchers felt that there are more catchers currently fishing in the Sone Beel than what it should have been. Around 69 percent felt that they had to take up fishing as their primary occupation not by choice but rather by compulsion. Most catchers are not confident about other occupations as they are mostly unskilled in any non-fishing work. Almost all respondents felt that uncontrolled fishing in the area during peak fishing seasons is the consequence of overdependence on fishing. Since an estimate of peak season fish stock and rate of harvest are unavailable, and so is the data on natural rate of regeneration, the inferences drawn about sustainability in the present study is purely perceptive in nature. According to the perceptions of the catchers, more fishing time has to be spent today to harvest the same quantity of fish than was required about 10 years ago. Almost all catchers agreed to the idea that fish stock in the Sone Beel is rapidly on the decline. Thus perceptively, fishing may be regarded as unsustainable in the Sone Beel at present.