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Economic evaluation on fish production and demand in Tripura – strategic options

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ABSTRACT

Tripura, witnessed an impressive growth in fish production during the past decade, because here fish culture is recognized as a vital activity for economic development. The state is presently undergoing a transitional phase and developing several plans to achieve self-sufficiency in fish production. The present study aims to workout strategic options that harmonize production and consumption. Stochastic frontier production function and technical efficiency of fish production estimates yielded positive coefficients for majority of factors of production. It showed significantly higher mean technical efficiency for adopted villages than that for non-adopted villages. At consumption front, demand estimation using multiple budgeting framework of household showed significant and positive income elasticities of demand for local carps, local non-carps, inter-state non-carps and small weed fish. But income elasticity for inter-state carps was less and insignificant among all selected choice fish groups (CFGs). Demand for the fish under the baseline scenario (base year 2004) is likely to grow at an annual rate of 3.38% for the State. The demand for fish by 2015 was projected as 80,153 mt of which nearly 50% (40,624 mt) is constituted by local carps. The study suggested prioritizing technological and management options after synchronizing present policy of the fisheries development, institutional environment, support services and profile of different stakeholders of the state.

Key words: Demand elasticity, Demand estimation, Production elasticity, Strategy formulation, Technical efficiency

The paper attempted to formulate strategic options for fisheries development by analyzing fish production and demand in Tripura state of North-Eastern (NE) region of India, where high preference for fish has made 'fisheries' a vital and potential sector for economic development. The per capita annual consumption of fish in Tripura is 14.12 kg and 17.86 kg in rural and urban areas, respectively, which is the highest among all the inland states of the country including NE India (Government of India 2014).The requirement of fish in Tripura is higher than production and it is importing fish from other states and also from Bangladesh (Government of Tripura 2009). Enhancement in productivity of local fish culture from the present level of 2,074 kg/ ha/ year to about 3,000 kg/ ha/ year is, therefore, recognized as a viable option for meeting the high demand of fish. In this context, the State Department of Fisheries adopted 34 villages (adopted villages) till 2008–09 through implementation of area-based demonstration schemes on scientific fish culture to enhance productivity. The present study examined the existing fish production efficiency across adopted and non-adopted villages and estimated consumption demand of different fish species in the state using econometric techniques. The empirical evidences on production efficiency and household demand for fish would help in devising strategic options for harmonizing the local production and consumption imbalance.

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MATERIALS AND METHODS

Production efficiency (Producer core)

The study is primarily based on primary survey conducted in all the 4 districts in 2010. The data was collected from 2 categories of villages i.e. adopted villages (AD) and non-adopted villages (NA); 180 samples from non-adopted and 90 samples from adopted villages were considered for the analysis. The Stochastic Frontier Production Function (SFPF) approach, (Aigner *et al*. 1977, Meeusen, van den Broeck 1977, Colli *et al.* 1998, and Singh *et al.* 2009) were used as the data are likely to be influenced by measurement errors and the effect of weather conditions, diseases etc. (Dey *et al.* 2000). The functional model for fish culture in Tripura is specified as frontier production function which is defined as:

$$\text{In } Y = \alpha + \beta_1 \text{ In } X_1 + \beta_2 \text{ In } X_2 + \beta_3 \text{ In } X_4 + \beta_4 \text{ In } X_4 + \beta_5 \text{ In } + \beta_6 \text{ In } X_6 + \beta_7 \text{ In } X_7 + \beta_8 \text{ In } X_8 + (V_i - U_i) \quad \text{... (1)}$$

where, Y, fish production (kg); α, $\beta_{1\ to\ 8}$ are the parameters to be estimated and $X_{1\ to\ 8}$ are the different factors of production considered in the study; V_i, random error having zero mean which is associated with random factors; U_i, one-sided inefficiency component. The technical efficiency index (TE) of the i^{th} farm is derived as TE_i, exp $(-U_i)$.

The MLE of parameters of the model defined by equation (1) and the generation of farm-specific technical efficiency (TE) are estimated using the FRONTIER 4.1 package developed by Coelli (1996) and Battese and Coelli (1995). The mean values of technical efficiency between adopted and non-adopted villages were tested for significance difference using normal test.

Demand estimation for different fishes

The monthly expenditure data of households were collected through primary survey during February to June 2010. Prior to the preparation of interview schedule, heterogeneous fish varieties of Tripura were clubbed under five Choiced Fish Groups *(CFGs)* viz. local carps (LC), local non-carps (LNC), inter-state carps (IC), inter-state non-carps (INC) and small weed fish (SWF). Fish consuming households (407) were covered for demand analysis covering all 4 district of the state (presently state has 8 districts, but during study period, the number of districts was 4).

A multi-stage budgeting framework was used to model the fish consumption behaviour of the households (Blundell *et al*. 1993, Mustapha *et al*. 1994, Fan *et al*. 1995, Gao *et al*. 1996, Tiffin and Tiffin 1999, Dey 2000).

The expenditure functions (for food and subsequently for fish) were specified at different stages of the model as follows:

Equation 1 for first stage: Food expenditure function:

ln (per capita food expenditure)) = $\alpha_1 + \beta_1$ln (per capita family income)

Equation 2 for second stage: fish expenditure function:

ln (per capita fish expenditure) = $\alpha_2 + \beta_2$ln (per capita food expenditure)

Equation 3 for third stage: Specific fish consumption function:

ln (per capita consumption of i^{th} fish) = $\alpha_3 + \beta_3$ln (per capita fish expenditure)

β_1, β_2, β_3 are the elasticity of food expenditure with respect to income, fish expenditure with respect to food expenditure and specific fish consumption to fish expenditure respectively. The equations of different stages were estimated by ordinary least square (OLS) method. The analysis was carried out using PASW 18 (Predictive Analytics Software 18). Finally, income elasticity for each CFG could have been estimated by using single equation approach, but system approach was used to reduce the aggregation effect in the estimation.

Demand parameters estimated from the above functional forms were used to work out income elasticity for each CFGs by using the following relations and was rationalized by using correction factor for the probability of positive fish consumption in the state (0.95):

$$E_I^{QF} = [(\beta_3) \times (\beta_2) \times (\beta_1)] \times [0.95]$$

RESULTS AND DISCUSSION

Production efficiency (producer core)

The summary statistics of the variables (mean and standard errors) used for the estimation of Stochastic Frontier Production Function are given in Table 1. Variables were expressed in per acre to account for difference in level of input usage between adopted villages and non-adopted villages. However, the average fish yield (production / acre) was found higher in adopted villages than that in non-adopted villages. Interestingly, the yield in both the village categories was lesser than the expected yield that could be achieved by following recommended practices provided by DoF, GoT (2010). Among several inputs, fish seed stocking density was the only input with the mean value more than that recommended level in both adopted and non-adopted villages. Among the sample villages, the fish seed was higher in the non-adopted villages (Table 1).

Estimation of Stochastic frontier production function

The maximum likelihood (ML) estimates of SFPF for adopted and non-adopted villages were estimated by using FRONTIER 4.1 software (Table 2). All the independent variables had positive coefficients in both adopted and non-adopted villages except for fish seed (β_2) in non-adopted villages. The negative coefficient for fish seed is expected because of its excess use (overstocking) than the recommended level. The average level of stocking fish seed in non-adopted village was relatively higher than that of

Table 1. Summary statistics of variables of SFPF in Tripura 2009–10

Variables		AD	NA	recommendations*
Pond size (acre)	Mean	0.351	0.462	1.00
	SE**	0.027	0.033	
Production	Mean	762.258	624.129	1000 (target)
(kg acre^{-1})	SE	19.441	20.134	
Fish seed	Mean	7397.522	8020.400	5000.00
(no. acre^{-1})	SE	473.758	160.381	
Cow dung	Mean	3605.889	3293.356	9000
(kg acre^{-1})	SE	230.975	185.511	
Lime	Mean	161.789	125.344	280
(kg acre^{-1})	SE	14.429	4.706	
Pellet feed	Mean	136.856	44.383	1050
(kg acre^{-1})	SE	16.242	2.475	
Mustard oil	Mean	185.344	154.094	180
cake (kg acre^{-1})	SE	9.561	6.196	
Rice bran	Mean	306.133	198.100	-
(kg acre^{-1})	SE	28.038	6.790	
Labour	Mean	567.922	418.117	-
(Man-days)	SE	46.72109	22.384	

*Department of Fisheries (2010), Government of Tripura. **SE, standard errors

Table 2. MLEs of the stochastic production frontier, fish production, Tripura 2009–10

Variables		Adopted villages	Non-adopted villages
		Co-efficient	Co-efficient
Constant	α	4.5715**	7.0734**
		(0.9845)	(1.3199)
Pond size (acre)	β_1	0.6968**	0.8239**
		(0.0972)	(0.1444)
Fish seed (no. per farm)	β_2	0.0141	(-) 0.2951**
		(0.0803)	(0.1089)
Cow dung (kg per farm)	β_3	0.0810*	0.1396*
		(0.0355)	(0.0611)
Lime (kg per farm)	β_4	0.0348	0.1185*
		(0.0240)	(0.0497)
Pellet feed (kg per farm)	β_5	0.0444*	0.0269
		(0.0219)	(0.0271)
Mustard oil cake (kg per farm)	β_6	0.0185	0.0279
		(0.0387)	(0.0581)
Rice bran (kg per farm)	β_7	0.0353	0.1677**
		(0.0437)	(0.0558)
Labour (man-days)	β_8	0.2769*	0.0439
		(0.1100)	(0.1197)

Figures within parentheses are standard error estimated coefficients.

adopted villages. Positive coefficients indicated that there is a scope for increasing production by increasing level of these inputs. The estimated elasticities of production of all the inputs are less than one in both the categories of villages. It indicated positive decreasing function to the factors i.e the input allocation is in the stage II of production surface.

Farm specific technical efficiency

The mean technical efficiency in adopted and non-adopted villages was estimated at 86 and 77% respectively (Table 3). Maximum numbers of farm (48.9% in adopted villages and 40% in non-adopted villages) had technical efficiency in the class interval of 80 to 90%. Other studies (Singh 2008, Singh *et al.* 2009) on technical efficiency of fish production in Tripura found that the mean technical efficiency in Tripura was 68.38 and 66.58% (using one stage with technical inefficiency model). The difference in technical efficiencies might be due to varying study area, sample size and methodology followed in different studies.

Mean technical efficiency of adopted and non-adopted areas were tested using normal test to know if any significant differences existed between the mean of 2 samples. The calculated Z% value was 6.2890, which was more than the critical value (1.96 at 5% and 2.58 at 1% level of significance) and hence, null hypothesis of no difference in mean values across 2 groups was rejected. This indicated that technical efficiency in fish production varies significantly across adopted and non-adopted villages with comparatively higher level in the former.

Table 3. The frequencies of occurrence of fish production technical efficiency in decile range for adopted and non-adopted villages of Tripura 2009–10

TE level	Adopted		Non-adopted	
	Frequency	%	Frequency	%
< 0.40	0	0	7	3.9
0.40 – 0.50	2	2.2	12	6.7
0.50 – 0.60	0	0	3	1.7
0.60 – 0.70	1	1.1	12	6.7
0.70 – 0.80	9	10	48	26.7
0.80 – 0.90	44	48.9	72	40
> 0.90	34	37.8	26	14.4
Total	90	100	180	100
Maximum	0.979113		0.976122	
Minimum	0.472183		0.248454	
SE	0.008839		0.01139	
Mean	0.86456206		0.77389124	
Median	0.88718750		0.81502250	

Demand estimation for different fish groups

The summary statistics of variables used in the study are given in Table 4. The average per capita annual income of Tripura was ₹ 24,114. The annual per capita food and fish expenditures were ₹ 8,956 and ₹ 2,289, respectively. High per capita annual fish consumption was observed at state level (16.54 kg).

Estimation of demand model

The estimated parameters of 3 functional forms (from the 3-stage budgeting framework, as explained in methodology) are summarized in Table 5. The explanatory variable included in the food and fish expenditure model explained 86.6 and 62.9% of the total variation respectively. The adjusted R-square value of specific fish consumption function varied widely with respect to different fish types. Explanatory variables of the overall fish consumption (quantity) function of Tripura state for local carps, local non-carps, inter-state non-carps and small weed fish (SWF) explain 59.7, 54.3, 41 and 30.8% of the total variation, respectively. The inter-state carp consumption (quantity) function showed low R-square values (2.6%).

The coefficients of food and fish expenditure functions

Table 4. Summary statistics of variables, Tripura: 2009–10 (Units: per capita/year, except family size)

Variables**	Tripura state (n = 407)
Family size (No.)	5.18 (0.107)
Family income (Rs)	24114.20 (962.3224)
Food expenditure (Rs)	8956.48 (128.558)
Fish expenditure (Rs)	2288.92 (51.955)
Consumption of LC (kg)	7.52 (0.2215)
Consumption of IC (kg)	5.63 (0.103)
Consumption of LNC (kg)	0.85 (0.040)
Consumption of INC (kg)	0.78 (0.040)
Consumption of SWF (kg)	1.76 (0.046)
Consumption of fish (kg)	16.546 (0.355)

Figures within the parenthesis are standard errors

Table 5. Estimated parameters of food expenditure and fish expenditure system, Tripura: 2009–10

Functions	Food expenditure function (Rs)		Fish expenditure function (Rs)	
	Estimated value	t-value	Estimated value	t-value
Intercept	3.749	60.067	- 3.956	- 10.327
Coefficient	0.915	48.107	0.784	24.395
Dummy	- 0.049	- 2.557	- 0.025	- 0.784
Adjusted R-square	0.866		0.629	
Functions	LC Consumption function (Qty.)		IC Consumption function (Qty.)	
Intercept	- 7.684	- 23.314	- 1.282	- 3.617
Coefficient	0.770	22.742	0.097	1.843
Dummy	- 0.008	- 0.226	- 0.097	- 1.850
Adjusted R-square	0.597		0.026	
Functions	LNC Consumption function (Qty.)		INC Consumption function (Qty.)	
Intercept	- 12.506	- 26.058	- 11.361	- 21.951
Coefficient	0.752	20.836	0.681	16.552
Dummy	0.045	1.242	0.159	3.858
Adjusted R-square	0.543		0.410	
Functions	SWF Consumption function (Qty.)			
Intercept	- 6.384	- 17.500		
Coefficient	0.563	12.695		
Dummy	0.023	0.523		
Adjusted R-square	0.308			

were positive and significant, indicating that the response of food expenditure to income changes and fish expenditure to food budget changes was substantial. All the coefficients of specific CFG (LC, LNC, INC and SWF) were significant at 5% and 1% levels of significance, except for inter-state carps consumption function. It indicated that the response of consumption of LC, LNC, INC and SWF to the fish budget changes was significant. But the response of quantity of IC consumption to fish budget changes was meagre and econometrically insignificant. This might be because of the fact that the consumers of Tripura consider inter-sate carps to be an inferior fish item, compared to other CFGs. This issue has further been discussed in the next section of income elasticity estimation.

Table 6. Income elasticity of specific CFG in Tripura: 2009–10 (P_c = 0.95)

CFGs↓	e^{QF}_{fi}	E^{QF}_{I} = [(β_3) × (β_2) × (β_1)] × [0.95]
Co-efficient→	e^{fd}_{I} = 0.915	e^{fi}_{fd} = 0.784
Local carps (LC)	0.770	0.525
Inter-state carps (IC)	0.097	0.066
Local non-carps (LNC)	0.752	0.512
Inter-state non-carps (INC)	0.681	0.464
Small weed fish (SWF)	0.563	0.384

Income elasticity of demand

The income elasticities of demand for different CFGs (Table 6) were positive and less than 1 for all the CFGs indicating substantial response of fish consumption with respect to income changes in the state. The IC did not show variability with the change in income of the consumers. The income elasticity of demand for IC in the state was the least (e^{fd}_{I} = 0.066) among all the CFGs indicating the most inferior CFG of Tripura. The income elasticity of demand for local carps in Tripura was the highest among all the CFGs. Therefore, the demand for local carps is likely to be more responsive to change in income than for any other CFG. Local non-carps also showed a positive and second highest elasticity of demand after LC.

Table 7. Demand for fish in Tripura (in Mt)

Year	Population	LC	IC	LNC	INC	SWF	TC	TNC	TF
Baseline									
2004	33,24,000	24,987	18,707	2,819	2,589	5,854	43,694	11,262	54,956
Projected									
2005	33,66,000	26,273	19,035	2,961	2,711	6,094	45,308	11,766	57,074
2006	34,07,000	27,505	19,350	3,098	2,827	6,323	46,855	12,248	59,103
2007	34,49,000	28,797	19,673	3,240	2,949	6,561	48,470	12,750	61,220
2008	34,91,000	30,000	19,986	3,373	3,062	6,783	49,985	13,218	63,203
2009	35,32,000	31,091	20,282	3,494	3,164	6,985	51,374	13,643	65,017
2010	35,74,000	32,298	20,592	3,627	3,277	7,205	52,890	14,110	67,000
2011	36,16,000	33,630	20,910	3,774	3,401	7,445	54,540	14,621	69,161
2012	36,58,000	35,106	21,238	3,937	3,538	7,708	56,344	15,182	71,526
2013	37,00,000	36,746	21,576	4,117	3,688	7,995	58,322	15,801	74,123
2014	37,42,000	38,576	21,925	4,318	3,856	8,310	60,501	16,484	76,985
2015	37,84,000	40,624	22,287	4,543	4,042	8,658	62,910	17,243	80,153
ACGR (%)	1.18	4.36	1.58	4.28	3.99	3.51	3.26	3.81	3.38

*Source (Population data): NSSO (2007).** ACGR, Annual compound growth rate.

Fish demand projection

The increase in availability of fish from local or inter-state sources will increase fish consumption in Tripura. The demand for fish under the baseline scenario is likely to grow at an annual rate of 3.38% by 2015. The highest growth in demand in Tripura state is projected (Table 7) for local carps (4.36%), followed by local non-carps (4.28%), inter-state non-carps (3.99%), small weed fish (3.51%) and inter-state carps (1.58%). But on clubbing all carp species (LC and IC) and other fish species (LNC, INC and SWF), the growth in demand is expected to be higher for other fishes than carps. It may be because of lower expected growth in demand for inter-state carps. Overall, local carp is expected to play an important role in meeting the demand of fish in Tripura. The demand for fish by 2015 has been projected as 80,153.25 Mt comprising 62,910 Mt of carps (local and inter-state) and 17, 243 Mt of non-carps. The demand for local carps was projected to be nearly 50% (40,624 Mt) of the total projected demand of fish in 2015.

At production front, this study showed that the average fish yield (production per acre) was higher in adopted villages than that of non-adopted villages during 2009–10. But the yield in both the village categories was lesser than the expected yield from 1 acre that could be achieved by following recommended scientific fish culture practice. Production elasticities for several variable inputs showed the possibility of achieving optimum fish production by using recommended level of inputs except fish seed. Fish seed stocking density is the only input with the mean value more than scientific recommendation and higher in non-adopted villages while comparing both categories of villages. Technical efficiency of fish production was higher in adopted villages than that of non-adopted villages, indicating the positive impact of technology demonstration in adopted villages. It must be noted that the significant difference in mean technical efficiency does not necessarily reflect total impact of government activities. Several other demographic, institutional, social, political factors may be involved to measure actual impact of activities carried out by state government under adopted villages. Indeed, scope exists for technical improvement in fish culture development in Tripura state of India.

At consumer core, the present per capita consumption of fish in Tripura (16.543 kg^{-1} $capita^{-1}yr^{-1}$) was higher than the national average fish consumption indicating the importance of fisheries sector in the State. DoF, GoT has initiated the perspective plan to achieve self-sufficiency in fish production. The targeted fish production (target of 13 kg^{-1} $capita^{-1}yr^{-1}$ fish) for 2010–11 was 43,280 mt assuming 95% of expected population (36.71 lakhs by 2010–11) is fish eater. But in this study the demand for fish by 2015 was projected to be 80,153mt and local carps are projected to share nearly 50% (40,624 mt) of total projected demand of fish in 2015. It showed the necessity to revise the targeted fish production for achieving self-sufficiency i.e. to meet the demand of fish in Tripura. A medium term fish production target for 2015 could be formulated by using the findings of present study.

With an overview at fish production and demand in Tripura during the year 2009, the demand of fish in Tripura has not been met through local production. The findings of present study revealed that the state produced sufficient local carps in 2009 to meet the demand, but local non-carps (including small weed fish) production was nearly half of the quantity demanded (Table 8). Given the high income elasticity of local carps, Tripura would continue production of carps to meet demand growth driven by growth in population and income. But it is high time for the state to look at the local production of fish species other than carps. Fish producers of Tripura can consider the advantage of such demand and its growth for local non-carps in the State. But on the other hand, a mismatch could be observed while making the balance of fish availability and consumption during 2008 – 09 as depicted in Table 8. Unaccounted flow of fish from neighbouring Bangladesh and poor database of fish production and consumption might have led to this mismatch. The projected local fish production and demand situation of 2015, Tripura is expected to produce 63, 616 mt local fish while availing 24,513 mt inter-state fish against the estimated demand of 80,153 mt by 2015. As the estimated demand is lesser than the projected availability of fish by 2015, the state may source less quantity of interstate fish as the demand for local fish is more elastic in nature. This is so as the projected local fish production alone

Table 8. Balance of fish availability and consumption in Tripura, 2008–09

Fish availability, 2008–09		Estimated fish consumption, 2008–09	
Local fish production:	36,990 mt	Total consumption*	55,508 mt
Inter-state fish:	11,504 mt	*Mismatched Consumption*	*7,014 mt*
Total availability:	48,494 mt	Estimated fish demand:	65,017 mt
Scenario of State carp and non-carp production and estimated demand 2009:			
Local Carp production:	31,433 mt	Demand for local carps:	31,091 mt
Local Non-carp production:	5,558 mt	Demand for local non-carps:	10,479 mt
Projected availability and estimated demand of fish by 2015			
Expected production of fish	63,616 mt		
Expected inter-state fish	24,513 mt		
Total availability	88,129 mt	Estimated demand for fish	80,153

*Assumption: 95 % of State population (2009) i.e. 35,32,000 consumed 16.54/ kg/ capita/ year.

cannot meet the estimated demand by 2015. But scope exists for reducing inter-state fish.

Strategic planning and management towards augmenting the production of local fish will meet the requirement and demand of fish in Tripura. Tripura has witnessed an impressive growth during last few years but still the state is not producing enough fish to become self-sufficient. Major options to augment the production of fish are either by expansion of the water resources under fish culture or by improving the productivity of present fish production or both. In other words, it is nothing but the horizontal or vertical expansion of the sector or combination of both. Indeed, study revealed that good scope exists to improve the productivity of fish production through efficient use of factors of production. It was observed that though fish farmers of Tripura were stocking fish seed at higher density but quantity of other inputs like manure, fish feed etc. were not sufficiently used to match scientific recommendations leading to lower production efficiency than achieving the potential frontier. Scope existed to increase fish production through more use of inputs except fish seed.

At consumption side, it was specifically found that a small group of fishes, viz. moca, puti, botia, chanda etc., which is considered as weed fish in scientific carp culture has got good demand and fetches high market price in Tripura. Populace of the state prefers to consume these species. But the established fish culture technology recommends removing such species from grow-out pond so as to boost up the production of target species (IMC, exotic carps etc.). Interestingly, the species which were ignored in scientific grown-out culture were observed to have good market orientation. Hence, alternative technology is required to be developed to culture such fish commercially by following mono or mixed culture with carps. Besides, fish consumers of Tripura have high preference towards non-carps as indicated by demand study. The breeding and culture technology for the popular non-carp species like *magur, singhi, koi, tilapia, pungus, paco* etc. is a viable strategic options for improving production and consumption pivot of the state.

Fisheries being a State subject, it is relevant to work out strategic options for development of fisheries sector of Tripura especially when it is in transitional stage. Several such studies were conducted through pilot projects at country level, and World Fish Centre is one of the major contributors in Asia in these aspects. NCAP and World Fish Centre (2004) discussed the strategies and options for increasing and sustaining fisheries and aquaculture production to benefit poor households in Asia. But such studies were not conducted at state level. This study, being a unique effort at state level, compiled various strategic options for development of fisheries sector in general and increasing fish production specifically to meet the requirement and demand of fish in Tripura.

Present transitional situation of the state need proactive planning regarding the prioritization of technologies and management options for development of fisheries sector. These options are required to be synchronized so as to achieve maximum out of the development efforts made therein. The present study provides only few aspects of fish production, consumption and demand; and related recommendations were discussed. But prioritization of technologies and management options would depend on various policies related issues. Present policy of the fisheries development, institutional environment, support services and profile of the different stakeholders of the state are needed to be studied and synchronized to prioritize the activities.

Good scope exists for the development of fisheries sector through intensification of fish culture systems, development of location specific fish culture technologies, by according special attention for production of non-carp fish species to meet the present and future demands of fish in Tripura.

REFERENCES

Aigner D J, Lovell C A K and Schmidt P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Economics* **6**: 21 – 37.

Anonymous 2009. Economic Review of Tripura. 2008–09. Directorate of Economics and Statistics, Planning (Statistics) Department, Government of Tripura. Available [online] at: http: //www.destripura.nic.in/review 20078.pdf [accessed on 5 January 2011]

Battese G E and Coelli T J. 1995. A model of technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* **20**: 325–32.

Blundell R, Pashardes P and Weber G. 1993. What do we learn about consumer demand pattern from micro data? *American Economic Review* **83**: 570 –97.

Coelli T J. 1996. A Guide to FRONTIER Version 4.1: A computer program for stochastic frontier production and cost function estimation. CEPA Working Paper 96/07, Centre for Efficiency and Productivity Analysis, University of New England, Armidale.

Coelli T J, Rao D S P and Battese G E. 1998. *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers, USA.

Dey M M. 2000. Analysis of Demand for Fish in Bangladesh. *Aquaculture Economics and Management* **4** (1/2): 63 – 81.

Dey M M, Paraguas F J, Bimbao G B and Regaspi P B. 2000. Technical efficiency of tilapia growout pond operations in the Philippines. *Aquaculture Economics and Management* **4** (1&2): 49 – 63.

Fan S, Wailes E J and Cramer G L. 1995. Household demand in rural China: A two-stage LES – AIDS model. *American Journal of Agricultural Economics* **77** (1): 54 – 62.

Gao X M, Wailes E J, and Cramer G L. 1996. A two-stage rural household demand analysis: micro data evidence from Jiangsu Province, China. *American Journal of Agricultural Economics* **78**: 604–13.

Government of India. 2014. *Handbook on Fisheries Statistics* 2014, Department Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, 141 – 42.

Government of Tripura. 2009. Tripura's March towards Self-sufficiency in Production of Fish: Performance of the Fisheries Department (April 2008 – March 2009). Department of Fisheries, Government of Tripura.

Government of Tripura. 2010. *Prasikhan Pustika, Mach Chaser*

Gurutta Abong VigyanVittik Mach Chaser Dainandin Kajjyakramer Sankipta Bibaran.(Booklet in Bengali language).Department of Fisheries, Government of Tripura.

Meeusen W and Van den Broeck J. 1977. Efficiency estimation from Cobb-Douglas production functions with composed errors. *International Economic Review* **18**: 435 –44.

Mustapha N RA, GhaffarRA andPoerwonoD.1994. An almost ideal demand system analysis of fresh fish in Semarang, Indonesia. *Journal of International Food and Agribusiness Marketing* **6** (3): 91–128.

NCAP and WorldFish Centre 2004. *Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to benefit poor household in India*. National Centre for Agriculture Economics and Policy Research and WorldFish Centre.NCAP, New Delhi, India.

Singh K. 2008. Farm specific economic efficiency of fish production in south tripura district: A stochastic frontier approach. *Indian Journal of Agricultural Economics***63** (4): 598 – 613.

Singh K, Dey M M, Rabbani A G, Sudhakaran P O and Thapa G. 2009.Technical efficiency of freshwater aquaculture and its determinants in Tripura, India. *Agricultural Economics Research Review* 2**2** (2): 185 –95.

Tiffin A and Tiffin R. 1999. Estimates of food demand elasticities for Great Britain: 1972 – 1994. *Journal of Agricultural Economics* **50** (1): 140 –47.