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Production and market efficiency for inland fisheries in North East India: The empirical study of Lohit and Lower Subansiri districts of Arunachal Pradesh

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Abstract
Arunachal Pradesh is located in the extreme north eastern corner of India. Given the hilly topography (only around five per cent land is available for cultivation) and continuing dominance of low productivity under shifting cultivation, diversification of agriculture that raises the earnings of those dependent on agriculture remains one of the fundamental challenges. On the other hand, the State has untapped potential for fisheries in terms of many rivers, wetlands, ponds, lakes and an area under rice-fish culture system. Hence, in this background the present paper makes an in-depth study of productivity and marketing structure of fisheries in Arunachal Pradesh. The study was based on both secondary data and primary data which is collected from 300 sampled fish farmers. The study found that there are large variations of productivity of fishes in terms of pond size. However the existing system of fish marketing was by and large inefficient.

Keywords: Inland fisheries, rice-fish culture, productivity, marketing

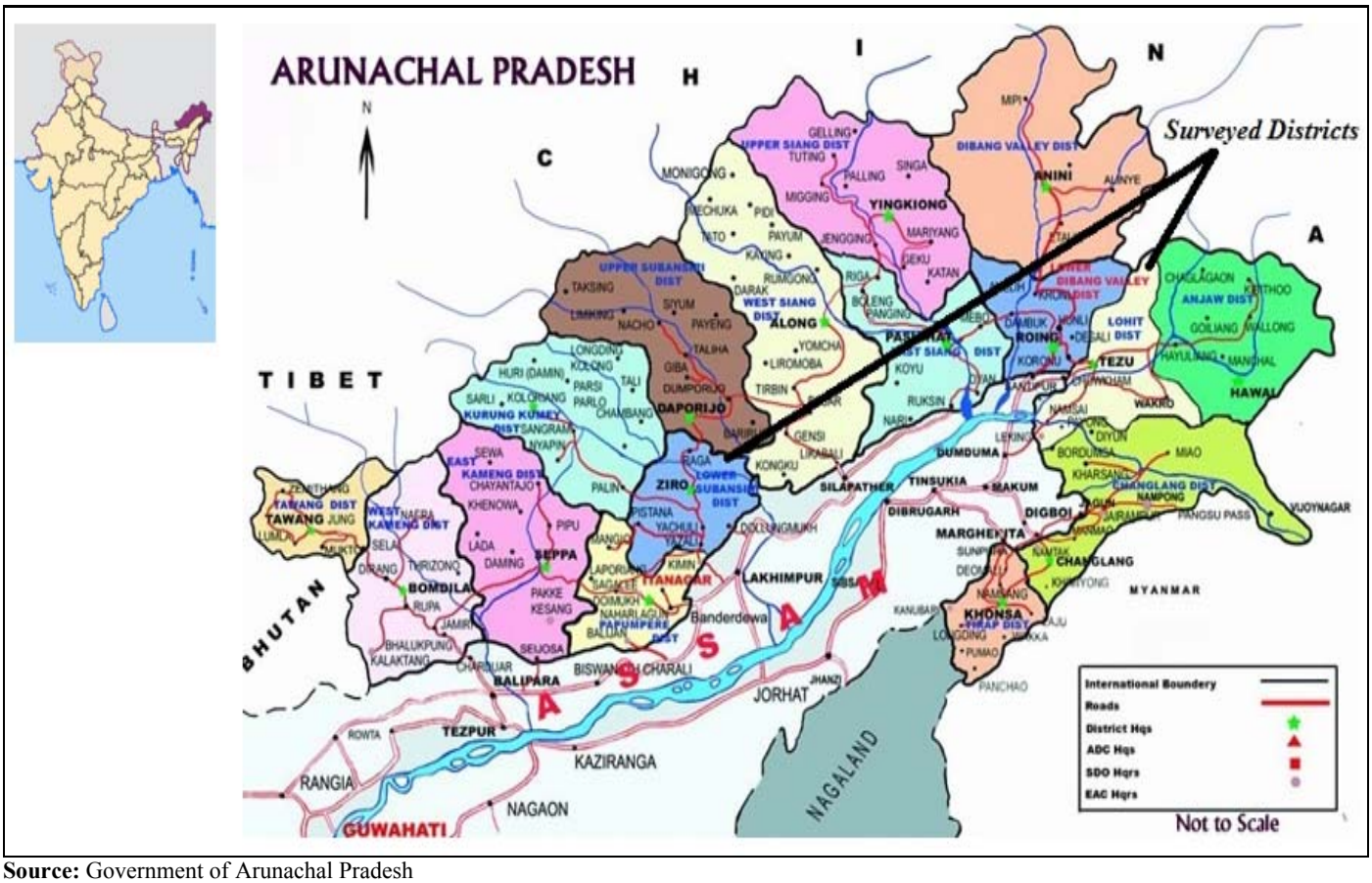
1. Introduction
Agriculture is the main source of livelihood for the majority of the people of India despite concerted industrialization in the last six decades. In fact, a majority of the farmers of India are still following traditional practices of farming which are not at all remunerative. Therefore, there is a need for diversification of agriculture and herein lies the importance of agricultural allied activities, including fishery, in rural areas of India. Fisheries, now recognized as a sunrise sector in India, recorded faster growth than any of the other agricultural and allied sectors during the last few decades. This rise in fish production was possible due to a quantum jump in inland fish production, especially pond culture, which is now growing at an average annual growth rate of around 13.87 per cent. The Twelfth Five Year Plan of India has emphasized to augment the production from fresh water aquaculture and make it a vibrant enterprise that can support rural livelihoods (Government of India, 2012) [5]. Arunachal Pradesh is richly endowed with water bodies, accounting nearly 56.48 per cent of water bodies of North East Region of India. Hence, there is great potential in the development of fishery sector of Arunachal Pradesh including the cold water fishery. In spite of large potential of inland water resources, only a minor part has been utilized by State fisheries due to a number of natural and anthropogenic factors. For example, most of the tribes of the State used to enjoy the social habits of open fishing and their fishing habits are just to meet the requirements of fish proteins at family level. However, with the growing individualization of agricultural land as well as water bodies, limited numbers of the owners of the water bodies are hold the potentiality to catch the commercial as well as ornamental market. The water bodies, as well as fishing resources, were owned by the community and clan. There was no restriction on individual fishing of a particular community or a clan for the consumption purpose (Chaudhuri, S., U. K. Sarkar and D. N. Das. 2008) [1]. However, sometimes huge catches of fish were done by the community during the festival or recreational purpose from the water bodies owned by the community. This was the common practice a few decades ago when Arunachal economy was basically a mono-economy characterized by subsistence agriculture and a few cottage industries (Mitra, 2005) [9]. In fact, in many districts of the State, most of the ponds, tanks and beels are owned by individuals. For example, fish ponds and farms owned by the people consisted of around 9200.00 hectare, as against the Government fish firms of 35.69 hectare in 2010-11 (Government of Arunachal Pradesh, 2011) [4]. Many owners of these water

bodies hold the potential to catch the ornamental as well as commercial market (both domestic and international) if their culture methods are developed (Das, 2005) [3]. So, it is high time to examine the productivity of fisheries, resource use efficiency as well as the marketing structure of the fisheries of Arunachal Pradesh. However, no study on economics of fishery in this direction is done till today in the State. Hence, the present study is an attempt to fill this gap in knowledge.

2. Sample Design And Analytical Framework

2.1 Sample Design and Methodology

The present paper is empirical in nature. The paper used both primary and secondary data. The collection of primary data was based on multistage sampling technique. In the first stage two districts namely Lohit and Lower Subansiri were selected by purposive sampling since almost 20 per cent of the total fish produced in Arunachal Pradesh comes from these two districts. In fact, Lohit is the largest producer of fish in the State and Lower Subansiri district is one of the largest producers of fish among the hilly districts of Arunachal Pradesh. Further, the *Apatani* plateau of Lower Subansiri district is a unique example of the paddy-cum-fish culture of the State. In order to have a clear picture of the study area, a location map of Lohit and Lower Subansiri districts of Arunachal Pradesh is shown in Figure 1.



Source: Government of Arunachal Pradesh

Fig 1: Location Map of Arunachal Pradesh Showing the Surveyed Districts

In addition, these two districts were selected as representative of three out of four agro-climatic zones existing in Arunachal Pradesh. Lohit district represented tropical zone (0-900 meters) and Lower Subansiri district represented sub-tropical zone (901-1800 meters) and temperate zone (1801-3500 meters). In the second stage, three blocks namely Tezu, Namsai-Chongkham and Lekhang from Lohit district and one block i.e., Ziro-I from Lower Subansiri district were selected by purposive sampling on the basis of extent of fish cultivation. In the third stage, four villages from Tezu block, seven villages from Namsai-Chongkham block, three villages from Lekhang block and six villages from Ziro-I block were selected purposively where fish farming was carried on a large scale. In the final stage, the fish farmers were selected randomly. The unit of observation is the fish farmer's household. Twenty fish farmer were selected from those villages where fish farming is carried out comparatively in large scale and ten fish farmer household were selected from those villages were fish farming is done comparatively in small scale.

The secondary data were collected from various published and unpublished sources.

2.2 Analytical Framework

2.2.1 Cobb-Douglas production function

The Cobb-Douglas production function is given in equation 1 is used, which is a purely technical relationship between input and output that is applicable in economic content.

$$\mathbf{Y= \alpha X_i^{\beta i} u_t} \quad (1)$$

or, $Y = \alpha X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} U_t$

Where,

Y= Value of gross fish production *(in $)*

α = Intercept *(constant)*

X_1 = Fish seed *($/50 nos.)*

X_2 = Fish feed *($/kg)*

X_3 = Manure, fertilizers, lime, etc *($/kg)*
X_4 = Labour cost *($/acre)*
u_t = Error term*(assumed to have a zero mean and constant variance)*
β_1 to β_4 = Regression coefficient or production elasticities of respective variables
The analysis is based on the cross-sectional pond-wise per acre values of output and the values of all the four independent variables as explained above. The Marginal Value Product (MVP) of a variable is given by equation 2:

$$MVPx_i = \frac{\partial Y}{\partial Xi} \quad (2)$$

$$= \beta i \frac{\overline{Y}}{\overline{Xi}}$$

Where;
Y = Value of gross fish production;
$\overline{Y}$ = Geometric mean of the value of gross fish production;
X_i = ith input;
$\overline{Xi}$ = Geometric mean of the i^{th} input; and
β_i = Elasticity of production of the i^{th} input. / Regression coefficient of i^{th} input.

2.2.2 Marketing structure
Marketing structure and its efficiency of the fish products in the study area was also studied by finding different marketing channels operating in the surveyed districts and marketing efficiency was also calculated with the help of the following formula:

$$ME = \frac{V}{I} - 1$$

Where;
ME = Index of marketing efficiency
V = Value of goods sold (consumer's price)
I = Total marketing cost.

3. Status of Fisheries in Arunachal Pradesh
Arunachal Pradesh is located in the extreme north eastern corner of India. The State is well endowed for inland water fisheries. It is situated in the monsoon belt. It received an average annual rainfall of around 2721.80 mm (Government of Arunachal Pradesh, 2011). The State has extensive inland water resources in the form of rivers, hill streams, wetlands, lakes, ponds etc. The details are given in Table 1.

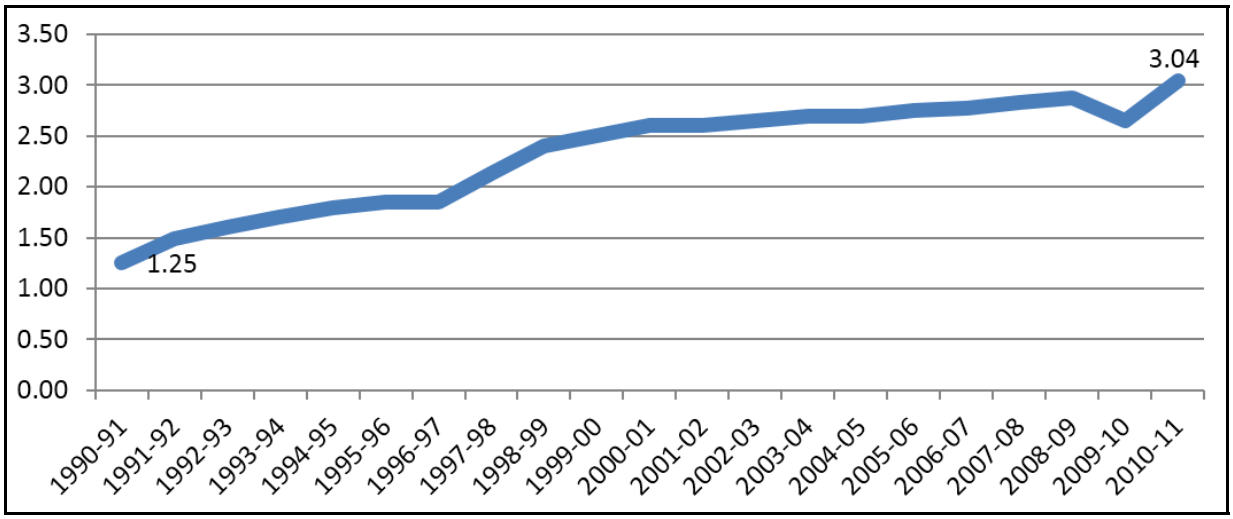
Table 1: Inland Water Resources of Arunachal Pradesh

	Arunachal Pradesh	North Eastern Region (NER)	Arunachal's Contribution to NER *(in per cent)*
Rivers and Canals *(in km)*	2000	20875	9.58
Reservoirs *(in lakh ha.)*	0.00	0.33	0.00
Tanks and Ponds *(in lakh ha.)*	2.76	3.71	74.39
Floodplain, Lakes and Derelict Water *(in lakh ha.)*	0.42	1.59	26.42
Total Water Bodies *(in lakh ha.)*	3.18	5.63	56.48
Total Geographical Area *(in sq. km.)*	83,743	2,62,179	31.94

Sources: 1. Annual Report 2011-12, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India & 2. Basic Statistics of North Eastern Region, 2006

Table 1 shows that Arunachal Pradesh consists of around 31.94 per cent of the total geographical area of the North Eastern Region of India but it contains 26.42 per cent of flood plain, lakes and derelict water, 74.39 per cent of tanks and ponds and 56.48 per cent of total water bodies of the region. Thus the State has enormous potential for development of fisheries in the region. In fact, fish, from time immemorial, has been an important dietary food of the people of the State. In addition, paddy-cum-fish cultivation is an important component of fisheries in general, and culture fisheries in particular, of the State.

4. Trends of Production of Fishes in Arunachal Pradesh
The fisheries programme was first initiated in the year 1958-59 in a very modest scale. However, with the passage of time and expansion of fisheries development activities, pisciculture has taken a firm root in the State. The people are presently looking forward to fisheries as a means of additional income and seeking more and more Government intervention for this purpose. This is attributed by the fact that the people are basically farmers taking fishery as a subsidiary occupation and no 'fisherman' exists by caste in the State (NEDFi Data Bank, 2007) [15]. In fact, the problems of flash flood, underutilization of aquatic resources, unscientific methods of culture and low level of people's participation are some of the important factors in lowering the production up to a minimum level. However, there was a steady increase in production of fish since the nineties. The details are shown in Figure 2.



Source: Department of Fisheries, Government of Arunachal Pradesh, Itanagar. (*In '000 tonnes)*

Fig 2: Fish Production in Arunachal Pradesh during 1990-91 to 2010-11

Figure 2 shows that fish production in Arunachal Pradesh increased from 1250 tonnes in 1990-91 to 3040 tonnes in 2010-11 (i.e., 2.4 times). An attempt was made to estimate the exponential growth of fish production during 1990-91 to 2010-11 as follows:

$$InY = 3.171 + 0.017\,t$$

$$R^2 = 0.859,\ \overline{R}^2 = 0.851 \text{ and } n = 21$$

Where Y is the total fish production of Arunachal Pradesh, t is the time measured in years, with origin at 1990-91 and the period covered is 1990-91 to 2010-11, with 21 observations (value of n). The average annual exponential growth rate was found to be 1.7 per cent, which is significant at 0.01 per cent level. Thus, the production of fish in Arunachal Pradesh grew at an average rate of 1.7 per cent during 1990-91 to 2010-11 which is higher than that of the North Eastern Region as a whole (1.3 per cent).

5. Results

5.1 Productivity Analysis of Surveyed Fish Ponds

In this section, an attempt is made to estimate the productivity of fish pond on different size classes. Firstly, the surveyed ponds were divided into three different size classes i.e., small (up to 0.29 acres), medium (0.30 to 1.99 acres) and large (2.00 acres and above). Then the productivity was measured in terms of kg of fish catch per acre per year in the three different categories of ponds.

The productivity of small size pond was found to be 506.14 kg/acre/year followed by medium size (422.13 kg/acre/year) and large size (304.54 kg/acre/year). Thus, it was observed that there was an inverse relationship between the size of pond and productivity. The inverse relationship was found to be more specific in the case of Lohit district where the productivity of the small size pond was found to 509.30 kg/acre/year whereas the productivity of medium size pond was 416.69 kg/acre/year and that of large size pond was 304.54 kg/acre/year. On the other hand, the inverse relationship was not very specific in the case of hilly districts of Lower Subansiri where the productivity of small size pond was found to be 503.24 kg/acre/year and that of medium size pond was 490.16 kg/acre/year. The large size pond was not found in the surveyed area of Lower Subansiri district. The productivity of small size pond was much higher than that of the medium and large size pond because of the fact that the water bodies of smaller size enjoy the benefits of close supervision, intimate monitoring and sincere regulation by the family members themselves. The details are given in the Table 2 below:

Table 2: Distribution of Productivity by Size of Pond *(in kg/acre/year)*

Pond Size	Lohit	Lower Subansiri	Aggregate Productivity
Small	509.30	503.24	506.14
Medium	416.69	490.16	422.13
Large	304.54	--	304.54
All	420.00	502.24	444.76

Source: Field Survey, 2010-2012.

It was observed that between the two surveyed districts, on an average the productivity of fish in Lohit district (420 kg/acre/year) was found to be much lower than that of Lower Subansiri district (502.24 kg/acre/year). However, in the case of small size ponds, the productivity of fish in Lohit district was marginally higher than that of Lower Subansiri district.

Another important observation of the surveyed pond was that there was a decline in productivity of the pond as the number of shareholders increased. The productivity of sole owner pond was found to be 496.02 kg/acre/year, followed by two owners (364.97 kg/acre/year) and more than two owners (311.64 kg/acre/year). From Table III it is found that in the case of Lohit district the productivity of one owner, two owners and more than two owners pond were found to be as high as 496.32 kg/acre/year, 308.52 kg/acre/year and 254.39 kg/acre/year respectively. But it was interesting to observe that the trend is 'U'-shaped in the case of Lower Subansiri district where productivity of one owner, two owners and more than two owner ponds were found to be 502.24 kg/acre/year, 499.36 kg/acre/year and 507.26 kg/acre/year respectively. It showed that as the number of owners increased the productivity first declined in Lower Subansiri district and then it increased. However, there was a variation in the relationship of productivity and number of pond owner in the case of the surveyed districts. The details are given in Table 3.

Table 3: Distribution of Productivity by Number of Owners of Pond *(in kg/acre/year)*

Number of Owner	Lohit	Lower Subansiri	Aggregate Productivity
One	496.32	502.24	496.02
Two	308.52	499.36	364.97
More than Two	254.39	507.26	311.64
All	420.00	502.24	444.76

Source: Field Survey, 2010-2012.

This variation in the two districts may be due to two factors. Firstly, Lower Subansiri is basically a hilly district and Lohit is a comparatively plain district and both the districts are from two different agro climatic zones of the State. Secondly, in Lower Subansiri district, paddy-cum-fish culture is practiced on a very large scale.

The production of fish depends on various factors. Hence, it is necessary to identify the key input factors and their contribution to fish production in the study area. Thus, with the help of production function analysis an attempt was made to establish a relationship between production of fish and different inputs like fish seeds, fertilizers, supplementary fees, manures, labour etc. The Cobb-Douglas production function was used for the estimation of elasticities of production and returns to scale.

With the help of the above mentioned production function an attempt was also made to estimate production elasticities and marginal value product of two surveyed districts separately. The details are given in Table 4.

Table 4: Production Elasticities and Marginal Value Products of Various Inputs

Input Variables	Lohit		Lower Subansiri	
	Production Elasticities	MVPs *(in $)*	Production Elasticities	MVPs *(in $)*
Fish Seeds (X_1)	0.63** (3.601)	0.04	0.54** (4.516)	0.04
Fish Feed (X_2)	0.52*** (2.132)	0.03	0.69** (4.069)	0.04
Manure, fertilizers, lime, etc. (X_3)	0.23 (0.250)	0.03	0.46*** (2.304)	0.02
Labour (X_4)	0.39*** (2.018)	0.03	0.19 (0.557)	0.03
	R^2 = 0.689, $\overline{R}^2$= 0.684, N = 200 and F = 12.352*		R^2 = 0.664, $\overline{R}^2$ = 0.661, N = 100 and F = 10.326*	

Note: 1. Figure in Parentheses indicates the t-value of respective coefficients
2. *, ** and *** denote that the coefficient are significant at 1%, 5% and 10% level of probability respectively
3. Exchange Rate $1 = INR59.29
Source: Field Survey, 2010-2012

It is clear from Table 4 that the independent variable included in the study affect fish production significantly. In case of Lohit district the estimated value of R^2 is 0.689 which indicates that 68.9 per cent of total variation of fish production (Y) was explained by the four variables i.e., fish seeds (X_1), fish feed (X_2), manure, fertilizers, lime, etc. (X_3) and labour (X_4). The sum of production of elasticities of all variables under the study was 1.77, which indicates that the increasing returns to scale existed in the production of the sampled ponds. On the other hand, in case of Lower Subansiri the value of R^2 is 0.664 which indicates that the variables explained 66.4 per cent of total variation in the fish production in the sampled ponds. There is also an increasing return to scale (1.88) which is higher than that of Lohit district. This indicates that in case of Lohit district the increase in one per cent of the variables will result in 1.77 per cent increase in fish production and in Lower Subansiri district it will result in 1.88 per cent increase in production. It is also clear from the analysis that the individual production elasticities of fish seeds, fish feed, manure, fertilizers, lime, etc and labour are not only positive but also most of the variables are significant. However, a distinct pattern was observed in our sampled districts. For example, in case of Lohit district, the highest expected increase in fish production was observed due to increase in fish seeds (fingerlings) since the coefficient of fish seed was found to be 0.63 which was significant at 0.05 level. Hence, it can be said that in Lohit district an increase in investment in fish seed may help fish farmers to increase the fish production. However, in Lower Subansiri the most important factor of production was found to be fish feed with 0.69 production elasticity values which was significant at 0.05 level. Hence, it can be concluded that in Lower Subansiri district an increase in fish feed will help to increase fish production.

Table 4 also shows that Marginal Value Productivities (MVPs) of all the inputs in both the districts were found to be positive. In fact, in all the cases, the values of MVPs were more than one. This explains that an investment of one $ on any input under our study is likely to increase fish production by more than the value of one $. Specifically, in Lohit district an investment of one $ in fish seed was likely to generate an additional income to the extent of $0.04. On the other hand, in Lower Subansiri one $ investment in fish feed was likely to generate an additional income to the extent of $0.04. Of course, it largely depends also upon the price of fish. All these estimates and analysis of resource-use efficiency, gross margin and net return and profitability estimates suggest that there exists ample scope for improvement of fish production through appropriate input allocation.

5.2 Marketing Structure in the Surveyed Districts

Marketing is one of the most important aspects in fish production as it is a highly perishable commodity. The marketing activity is restricted mainly to nearby markets like Tezu, Namsai, Mahadevpur and Sunpura in Lohit district and Hapoli in Lower Subansiri district. So, an attempt was also made to analyse the different marketing aspects like identification of important channels, cost and margins involved in fish marketing in the surveyed area. It was found that there are basically three channels through which fish is marketed in the surveyed area.

Channel-I: Producer → Retailer → Consumer
Channel-II: Producer → Vendor → Consumer
Channel-III: Producer → Consumer

Table 5: Disposal of Fish through Different Marketing Channels

	Channel I	Channel II	Channel III	Total
Lohit	137 (68.50)	33 (16.50)	30 (15.00)	200
Lower Subansiri	61 (61.00)	00	39 (39.00)	100
Total	198 (66.00)	33 (11.00)	69 (23.00)	300

Note: Figures in parentheses indicate the respective percentages of total.
Source: Field Survey, 2010-12.

From Table 5 it is observed that channel I (66 per cent) was the most popular channel followed by channel III (23 per cent) and channel II (11 per cent) respectively. The channel II existed only in one district i.e., In Lohit district among the two surveyed districts, but it was the second important channel with 16.5 per cent share.
It was also observed from Table 6 that the producers share in consumer's price varied from 64.41per cent to 72.97 per cent in the marketing of fish through identified channels. The details are provided in Table 6.

Table 6: Marketing Cost, Margin and Prices in the Study Area *(in $/kg)*

Districts	Particulars	Channel-I	Channel-II
Lohit	Producer's Price	1.35 *(66.83)*	1.35 *(72.97)*
	Marketing Cost	0.20 *(10.40)*	0.16 *(8.65)*
	Marketing Margin	0.46 *(22.77)*	0.35 *(18.92)*
	Price paid by Consumer	2.02 *(100.00)*	1.85 *(100.00)*
Lower Subansiri	Producer's Price	1.52 *(64.41)*	--
	Marketing Cost	0.29 *(12.29)*	--
	Marketing Margin	0.55 *(23.31)*	--
	Price paid by Consumer	2.36 *(100.00)*	--

Note: 1. Figures in parentheses indicate the respective percentages of total i.e., price paid by the consumer.
2. Exchange Rate $1 = INR59.29
Source: Field Survey, 2010-12.

From Table 6 it was found that the marketing margin was quite high particularly in channel I. A comparatively lower producer's share in consumer's price in channel I and channel II was mainly because of the presence of agents who corner their margins by providing services in the fish marketing. Thus, though these two parameters, namely producer's share in consumer's price as well as quantum of costs and margins indicate that the existing system of fish marketing in the study area was by and large inefficient. In fact, it was found that marketing system was quite unorganized to a great disadvantage to the fish pond owners.

5.3 Marketing Efficiency in the Study Area

In order to know the degree of the market performance, it is important to know the marketing efficiency. The efficiency of various identified marketing channels in the study area was calculated through the Shepherd's formula.

Table 7: Estimates of Marketing Efficiency in Different Marketing Channels

Districts	Particulars	Channel-I	Channel-II
Lohit	Consumer's Price*(in $/kg)*	2.02	1.85
	Marketing Cost*(in $/kg)*	0.20	0.16
	Marketing Efficiency	8.63	10.75
Lower Subansiri	Consumer's Price*(in $/kg)*	2.36	--
	Marketing Cost*(in $/kg)*	0.29	--
	Marketing Efficiency	7.12	--

Note: Exchange Rate $1 = INR59.29
Source: Field Survey, 2010-12.

Table 7 represents that the estimates of marketing efficiency of fish through various channel through Shepherd's formula. It shows that the marketing efficiency is higher in channel-II in Lohit district (10.75) and lowest in the channel-I of Lower Subansiri district (7.12).

6. Discussions

The success of any production process depends on economic feasibility. The process cannot continue in the long run if it lacks economic feasibility and incurs continuing losses due to high marketing cost and middle man's share. Fish farmers generally lack organization, leadership and political support. The success of fishery an enhancement depends on the capacity of the community to coordinate and implement the practice. Fishery enhancement requires investments for producing fish seed or procuring seed from hatcheries, and fisher communities also need money to lease fishing rights and buy their gear. This will often require financial support.
On the background of the existing status, the fishery sector of the State appears to be in the infant stage of development in spite of its enormous potential. As the State is the owner of the fishery waters of diversified zones, the aquaculture packages of practices need to be refereed for adoption in the State in accordance with the available ecological zones for proper exclusion. For example, the hilly districts of the State hold the grounds from high altitude fishery development, particularly in the trout production and sports fishery. On the other hand, the flood plain fisheries of the State encompass the natural water bodies and lakes situated in the relatively plain districts where composite carp production system may be incorporated. Therefore, there is an immense scope for development of fish farming in the State to provide a source of income and employment to the people of the State. It was also found that fish farmers are not getting desired fish production in their pond due to lack of good quality of fish seed and fish feed. They have to purchase it from the market. It is imperative to popularise low cost fish farming system. Hence, the Government should encourage public private partnership for popularising as well as augmenting the production of fishes of the State.

7. Conclusions

The conventional fishing system is no longer able to address the grassroots level of reality. This calls for integrated approach of fishery with agriculture and other allied sector like piggery-cum-fish culture; duck-cum-fish culture; duck-cum-fish-cum-piggery culture. It may be noted that the role model of paddy-cum-fish culture was practiced on a very large scale in Lower Subansiri district.
It was also observed that there is ample scope for improvement of fish production through appropriate input allocation. However, the parameters like producer's share in consumer's price as well as quantum of costs and margin indicate that existing system of fish marketing in the study area was by and large inefficient. Hence, in order to enhance producer's share and to reduce the role of middleman, it is suggested to encourage the formation of fish farmer's co-operatives.

8. Acknowledgement

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