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Total Factor Productivity of Tuna Fisheries in Lakshadweep

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An assessment of total factor productivity (TFP) was carried out for tuna fisheries in Lakshadweep to evaluate its growth and economic sustainability using Divisia-Tornqvist index. The output index showed a positive growth of 7.32% and input index showed a positive growth of 5.88% when year-to-year simple growth rates were averaged while TFP showed a positive growth of 1.44% during 2000-14. Positive TFP growth in tuna pole and line fisheries during the given period is mainly due to technology development in terms of installation of FADs, mechanisation of pole and line Pablo boats, introduction of new mechanical sprayers, subsidies, training and capacity building programmes, improvement in engines, development in infrastructure facilities like cold storage and ice plants and awareness regarding potential of yellowfin tuna resources.

[**Keywords:** Divisia-Tornqvist input output TFP index, Sustainability, Pole and line fishing, *Masmin*]

Introduction

Tuna landings in Lakshadweep are 13505 tonnes; they account 15.83% of Indian total tuna landings and 86.5% of the fish production of Lakshadweep islands[1]. Livelihood opportunity for the Lakshadweep islanders is limited. Natural resources form the basis for the traditional economy of the people. In the past, this was principally associated with coconut cultivation. However, this has now been replaced by the pole and line tuna fishery, which is considered as the mainstay of the island economy.

The estimated total fish catch in 2012 by pole and line, troll line, drift gill net, encircling gill nets, hand lines and long line was 7683 tonnes against 6428 tonnes in 2011. Tuna constituted 71.5% (5493 tonnes) while the other fishes and elasmobranches, 28.5% (2189 tonnes). The catch of yellow fin tuna in Lakshadweep Sea maintained its upward trend during 2012 also. The declining trend in total marine fish and skipjack tuna landings reversed during 2012 due to improvement in catches of skipjack tuna[2]. About 50% of the tuna landing is used for *masmin* (dried and smoked product of tuna) production, 20% for Canning and remaining 30% consumed fresh[3].

It is estimated that about 13% of the total population of Union territory of Lakshadweep are active, full time fishermen and fisheries sector provide a livelihood for about 60% of the people of Lakshadweep[4]. Consequently, the Union Territory of Lakshadweep Administration has devised several promotional programmes for the sector. The major programme is for the supply of Pole & Line boats (Pablo boats) and country crafts to the fishermen on hire-purchase basis. The development programmes also include supply of fishing implements and inputs at a subsidized rate. The department also imparts training in Fishing Gear Technology, Navigation, and

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Fishing Technology etc. It is estimated that the exploitable potential of tuna from the Union territory of Lakshadweep waters is 150000 tonnes. The total fishable potential of non-tuna resources of Union territory of Lakshadweep waters is 100000 tonnes, provided, there is significant development in the introduction and use of non-traditional fishing techniques like Trolling, Long Lining, Perch Traps, etc.

The real growth in the fish landings of the Union territory of Lakshadweeep was from the year 1980 with large scale introduction of mechanised / motorised boats fitted with bait tank[5]. The total fish production had increased from 1760 tonnes in 1980 to the present level of 15612 tonnes[1]. During the same period, the number of specialized fishing crafts had also increased from 194 to 752[2].

The main fishing method practiced in Lakshadweep islands is pole and line except Androth[3]. Pole and line for tuna using live bait are the most important gear for tuna fishery with a contribution of 92.8% followed by troll line, drift gill net and handline, contributing 3.3%, 2.1% and 1.9%. In Androth, troll line is the major fishing method[6]. As per the basic statistics 2012[7], there are about 2017 fishing boats in Lakshadweep. Non-mechanized forms about 52% of the fleets, followed by mechanized boats (28.11%) and motorized boats (19.8%).

A systematic study targeting the exploration of significant developments can be made possible by technological progress and policy changes that can be measured by Total Factor Productivity to establish Indian tuna fishery in general and for Lakshadweep in particular on a sound footing aiding planners to allocate resources to R and D, infrastructure etc.

Inputs consist of two components – one is quantity, and the other is technology component. Even though, only quantity and corresponding value for each input considered are utilized for computing input index, what proportion and why such a quantity is being used for a particular system is decided apriori depending on the best management practices and knowledge available for that system that can be termed as the technology component. Hence, the output growth depends not only on input growth over years but also the growth of technology over the same period in an additive fashion. Hence, technology growth (measured in terms of TFP subsequently) can be obtained as output growth minus input growth.

Materials and Methods

The increased use of inputs, to a certain extent, allows the fisheries sector to move along the production surface, the use of progressive inputs may also induce an upward shift in the production function to the extent that a technological change is incorporated in them. TFP measures the amount of increase in the total fish output, which is not accounted for by the increase in the total inputs. Divisia-Tornqvist index was used for computing TFP for tuna pole and line fishery in Lakshadweep islands (Fig. 1) of India[8].

The Input, Output and TFP indices were computed as follows:

$$\text{Input index}_t = \prod_i (X_{it} / X_{it-1})^{(S_{it} + S_{it-1})^{1/2}} \quad \ldots\ldots\ldots\ldots(1)$$

where X_{it} and X_{it-1} are the quantities of input i at time t and t-1; S_{it} and S_{it-1} are the share of input i in total cost at time t and t-1.

$$\text{Output index}_t = \prod_j (Q_{jt} / Q_{jt-1})^{(R_{jt} + R_{jt-1})^{1/2}} \quad \ldots\ldots(2)$$

where Q_{jt} and Q_{jt-1} are the quantities of resource j at time t and t-1; R_{jt} and R_{jt} are the share of resources j in total revenue at time t and t-1; t in the number of years.

Total input and output index in period t was computed from equation (1) and (2) as follows:

Total Factor Productivity index (TFPt) = (Output indext)/(Input indext) -------- (3)

Equations (1) to (3) provide the index of total input, total output and TFP, respectively for the year 't'.

Total Factor Productivity Growth = output index growth - input index growth

For construction of input index in tuna pole and line fisheries, quantities and cost share of labour, fuel use were considered because they account for more than 80% of the total operating costs, Similarly for calculating output index, quantity and value of fresh tuna and *masmin* were considered because in Lakshadweep around 10% of the tuna catch is sold within the islands in fresh condition while the major portion of the tuna catch is converted into *masmin*.

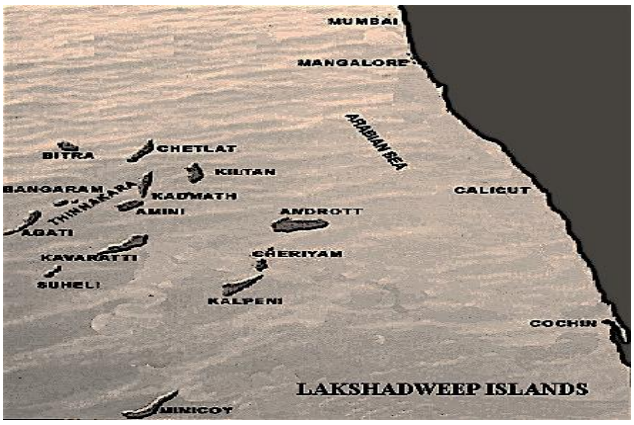

Fig. 1—map of the Lakshadweep Islands

Time series data on tuna fish production was compiled from various sources, such as report on master plan for the development of fish landing centres in the U.T. of Lakshadweep Island and basic statistics 2012[7], U.T. of Lakshadweep. Pole and line catch contributes around 90% of the total tuna landing in Lakshadweep. As per consultation with expert and fishers, 10% is consumed/ sold as fresh within the island and remaining 90% is converted into *masmin* and their price at the island level were compiled from various sources such as CMFRI Annual Report [6,9,10,14] and unpublished data observed from Department of Fisheries, Lakshadweep.

Data on diesel were collected from Department of Fisheries, Lakshadweep, because diesel is supplied from the fisheries department to the fishing boats. The data on lubricants is obtained from oil companies and Department of Fisheries, Lakshadweep.

The quantity of diesel used has been worked out by taking into account the number of pole and line fishing vessels, number of fishing days, hours of work/day with the norms that 200 milliliters (ml) of diesel are used per Hp per hour referred in (Kumar et al, 2004)[8]. The total Hp utilization was worked out in consultation with experts. The quantity of lubricants used has been worked out by expert opinion that 10 litres of lubricant had to be used after 4-5 barrels (1 barrel=200 litres) of diesel consumption.

Results

Tables 1 and 2 give the quantity and value share of various items in the total cost and total revenue respectively for computation of input/output indices for in turn calculating Total Factor Productivity (TFP). Note here that these values have been only given for two years 2000 and 2014; similar values were arrived at for intermediate years as well but not given here for brevity. The steps involved in computing these values have already been discussed in the methodology section.

In the computation of input index, the quantity of fuel consumption for fishing has been drastically increased from 27.43 lakh liter to 96.24 lakh liter and simultaneously the value of expenditure has also increased from 401.94 lakhs to 5741.10 lakhs during 2000 to 2014. The total labour man-days increased from 7.08 lakhs to 11.08 lakhs during 2000-14.

The share of fuel increased from 26.99% in 2000 to 37.55% in 2014 whereas the share of labour declined from 58.87% to 44.60% with a reduction in the crew share.

Analysis of the shares of different revenue components in the gross revenue showed that the share of *masmin* increased from 78.26% in 2000 to 80.19% in 2014. The share of fresh tuna declined from 21.73% to 19.80%.

TFP showed a positive growth of 1.44% in Lakshadweep during 2000-14 (Table 3). The output index showed a positive growth of 7.32% and input index showed a positive growth of 5.88% when year-to-year simple growth rates were averaged.

Table 1—Quantity and value share of various items in the total cost for computation of input index in TFP

Cost components	2000			2014		
	Quantity	Value (Rs. in lakh)	Share (%)	Quantity	Value (Rs. In lakh)	Share (%)
Fuel (l)	2742998.40	401.94	26.99	9624088.00	5741.10	37.55
Labour mandays	708480.00	876.76	58.87	1108000.00	6820.02	44.60
Other costs		210.54	14.14		2729.01	17.85
Total		1489.24	100		15290.13	100

Table 2— Quantity and value share of various resources in the total revenue for computation of output index in TFP

Revenue components	2000			2014		
	Quantity (kg)	Value (Rs. in lakh)	Share (%)	Quantity (kg)	Value (Rs. in lakh)	Share (%)
Masmin	1235088.00	1235.08	78.26	2187810.00	9845.14	80.19
Fresh tuna	686160.00	343.08	21.73	1215450.00	2430.90	19.80
Total	1921248.00	1578.16	100	3403260.00	12276.04	100

Discussion

Positive TFP growth in tuna pole and line fisheries during the period 2000-14 is mainly because of technology development in terms of installation of fish aggregating devices, mechanization of pole and line Pablo boat and improvement in the engine (in terms of Hp) and regular training programs to the fishers.

The result shows that, the tuna pole and line fishing is sustainable, and it was estimated that the exploitable potential of tuna from the Union Territory of Lakshadweep waters is 1.5 lakh tonnes[4] and currently they are exploiting around 9% of the exploitable potential.

Fish Aggregating Devices (FADs) were introduced in Lakshadweep waters in 2002 in the open sea as well as in the lagoon to aggregate fishes by the CMFRI under World Bank Programme. Data buoys for Arabian Sea Monsoon Experiments - Phase 2 deployed by National Institute of Ocean Technology (NIOT), 16-26 nautical miles off Minicoy and Kavaratti are functioning as FADs aggregating tunas as well as other fishes[11]. Again during 2005-09, the Lakshadweep Administration has installed 30 FADs with the help of NIOT, CMFRI and the Department of Fisheries Lakshadweep. In 2011, redeployment of 10 FAD took place in Lakshadweep at an investment of 1 crore[1]. Introduction/deployment of FADs is helpful in the augmentation of fish catch particularly of the migratory pelagic fishes like tunas. As a result, the catches and catch rates tend to be higher. Also, the FADs help to reduce the scouting time and fuel consumption.

Another major technological innovation is the introduction of mechanical spraying of seawater in the aft portion of the pole and line fishing boats to enhance the chumming action to increase the catch that reduced the number of fishers per boat from 11 members to 9 members[12].

Improvement in satellite and communication technology and its subsidized dissemination to fishers in last decade has a considerable positive bearing on fish production and profitability in pole and line fisheries.

Regular training related to fisheries and allied activities was started in the 1970s and is still functional and currently operational at Androth. It could possibly be one of the continuous force driving pole and line fisheries in the positive direction[1].

Several training programmes related to capacity building in the field of repair and maintenance of marine diesel engine, running and maintenance of ice plant and boat building since 2003, 2012 and 2013 respectively to the ITI students of the Island. This has led to the development of local expertise that have been given substantially reduces time and money involved in repair and maintenance which was earlier possible only on the mainland[1].

Subsidies play a major role in augmenting any food production sector and pole and line fisheries are not an exception to it. 40% subsidy on the construction of the boat, 40% or maximum of 10 lakh on purchase of Maldivian type pole and line boat above 50 feet and 50% subsidy on purchase of new engine are among the major factors responsible for the improvement in fish production and socio-economic status of fishers of Lakshadweep. Subsidies on icebox and construction of kiln have also improved storage and processing. Even subsidies are available for repair and renovation of the open type of fishing boat. It is worth mentioning that most of these subsidies have been in operation only during last decade[1].

Introduction and upgradations of infrastructure facilities supporting fisheries sector does play a significant part in the development of organized fisheries in an area. The establishment of block ice plant of 10 tonnes capacity in Kavaratti and Androth (2006), Kalpeni (2011-12) and Kadmath (2013-14) and flake ice plant of 1 tonne capacity in Agatti (1999-2000) are major initiatives taken to meet the onboard ice requirement of tuna fisheries of the

island. Tunnel freezer of 3 tonnes capacity at Minicoy and 5 tonnes capacity each at Agatti and Chethlath along with cold storage facility of 15 tonnes at Minicoy and 5 tonnes capacity at Androth are among major post-harvest facilities made available in recent times in Lakshadweep Islands. *Masmin* is the traditional fish product in Lakshadweep and introduction of *masmin* packing unit in Agatti is a real boost to the sector[13].

Table 3— Input, output and TFP indices of tuna pole and line fisheries in Lakshadweep

Year	Input index	Output index	TFP index
2000	100.00	100.00	100.00
2001	101.87	86.52	84.93
2002	102.23	171.79	168.05
2003	101.82	71.75	70.47
2004	100.00	106.80	106.80
2005	204.54	102.00	49.86
2006	137.90	114.48	83.01
2007	93.70	96.39	102.88
2008	168.72	104.73	62.07
2009	98.32	107.64	109.48
2010	105.84	115.87	109.47
2011	94.54	98.19	103.86
2012	100.00	104.32	104.32
2013	100.00	134.20	134.20
2014	101.32	129.06	127.37
Growth	**5.88**	**7.32**	**1.44**

The total financial outlay for the year 1999-2000 dedicated to fisheries sector was 225.11 lakhs which have increased to 1050 lakhs for the year 2012-13. A major momentum was observed since 2007-08. Enhanced financial outlays towards fisheries sector is the driving force behind all the developmental activities which has ultimately led to the augmentation to the fisheries production in Lakshadweep[7].

In recent years awareness towards yellow fin resources have led to its organized fisheries by pole and liners. This also has a positive effect in the profitability of the fisheries[13].

Even though there was a substantial increase in the cost of fuel and technical labour in the past decade, an increase in the catch of yellow fin tuna and skipjack tuna intern results in increased production of *masmin* and a substantial increase in *masmin* price from Rs. 100-450 during the period 2000-2014 made the system economically sustainable.

Conclusion

TFP showed a positive growth of 1.44% in Lakshadweep during 2000-14 when input growth was subtracted from output growth, suggesting that tuna pole and line fishing is sustainable. Positive TFP has been achieved mainly because of technology development in terms of installation of fish aggregating devices, mechanization of pole and line Pablo boats and improvement in the engine in terms of horsepower (Hp). Another major technological innovation is the introduction of mechanical spraying which reduced the number of fishers per boat from 11 members to 9 members. Subsidized dissemination of GPS, regular training related to fisheries and allied activities, several training programmes related to capacity building in the field of repair and maintenance of marine diesel engine, running and maintenance of ice plant may also have contributed for overall growth. A further improvement in the available technology for Tuna fishing will enhance the current production manifold paving way for positive growth of TFP, for which support from State and Central Governments is very much needed in terms of technical and financial assistance.

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