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Diversification of Fish Culture and Exports among Major Shrimp-producing Countries of Asia: A Spatial and Temporal Analysis

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Abstract

Asian countries contribute nearly 90 per cent to global production of culture fisheries. Diversification of species is not happening in fish culture because of the high value shrimp commands in the export market. Shrimp farming is on the increase in all the major shrimp-producing Asian countries. Higher the growth in shrimp production, higher is the instability in production due to production risks associated with ecosystem complexities and disease incidences. Most of the shrimp-producing countries have been moving towards specialization of shrimp production for export because of the high price that the shrimp asserts in the international market. A comparison between the Asian countries for the period 1976-2002 has revealed that Malaysia has maintained low growth and low instability and higher diversification, and Bangladesh and Vietnam have diversified in fish exports. In a country-level comparison, India, Indonesia, Thailand and Philippines have shown moderate growth in production and export of shrimp. The instability associated with their shrimp production has also been moderate. Diversification in fish production as well as exports has been suggested for assured income to farmers and the country. It has been pointed that replacing, supplementing or rotating the shrimp farming with culture of other high-value fish species like Asian sea bass (*Lates calcarifer*), grouper (*Epinephelus* spp), mullets (*Mugil* spp) and milk fish (*Chanos* spp) culture may ease the risks in mono-cropping of shrimp.

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This paper has been drawn from the Institute Research Project, *Socio-economic Appraisal of Traditional and Diversified Coastal Aquaculture in India*.

Authors thank the referee for his suggestions and Dr P. Ravichandran, Director, Central Institute of Brackishwater Aquaculture, Chennai, for the guidance.

Introduction

Aquaculture has a long history in the Asian countries dating back to 500 BC. These countries contribute nearly 90 per cent to global production of culture fisheries. Though fish culture started with fin fish, viz. common carp (*Cyprinus carpio*), the recent trend in most of the tropical countries of Asia is to culture shrimp (*Penaeus* species), basically belonging to the shell fish¹ group, because the premium price it commands in export markets, although the risks associated with monoculture of shrimp are also many. On the other hand, it was observed that even culture of milk fish (*Chanos* spp.) — a choiced fin fish, was coming down in Indonesia, the Philippines and Taiwan after the early-1990s. The FAO year book (1998) has listed about 100 fin fishes that are cultured in tropical Asia. Hence, the Asian region is suitable for diversification of fish culture for stabilizing the income. The estimates from FAO and Official Taiwanese Statistics (Pullin, 1996) show that 95 per cent of farmed aquatic produce comprises sea weeds (6 species), molluscs (43 species), crustaceans (27 species) and fin fish (125 species). The Asian countries have a vast biodiversity, varying climates, terrains and ecosystems which could support diversified culture of many species. But the estimate of Biodiversity Utilisation index (BUI) was very small for India (0.13 on a scale of 0 to 1); it was 0.5 for Taiwan and 0.34 for Thailand (Kutty, 1999). Though the BUI estimate is a crude measure, it does reflect the insufficient efforts of farmers for diversification of fish culture.

Economists advocate the diversification as a tool of risk management. Farm planning is done with diversified enterprises to reduce income variability. Viability of fish culture will be more with diversification, mitigating the risks associated with the dependence on a couple of high-value species. There are two aspects of diversification. One is that of planning under an assumption of perfect knowledge about production and price factors and the other is to minimize the variability in farm income. Farmers or farm managers select a combination of enterprises to reduce the income variability. Diversification is mostly considered as a risk management strategy that involves performing more than one activity at any given time. It facilitates in mitigating price risk as well as production risk of falling output. Agriculturists normally mix crop husbandry with livestock or poultry farming to reduce the income variability. Most farmers choose a crop mix to tide over the production risks.

¹ “Shellfish” means an aquatic, invertebrate species having a shell. These species include, but are not limited to, oysters, clams, crayfish, shrimps, crabs, and other molluscs and crustaceans and “Finfish” means any of the numerous cold-blooded aquatic vertebrates that characteristically swim with fins, breathe with gills and are covered with skin or scales.

Apart from similar considerations as in agriculture, fish culture systems call for diversification for some more reasons like changes that occur in food web of the ecosystem consequent to specific species being chosen for aquaculture, imbalances in population size of other species which co-inhabit the ecosystem, cross-breeding possibilities with locally available wild stock and capture fisheries, and effects of aquaculture species on indigenous flora and dependent fauna. Hence, fish culture should be done with more species of fish to have a sound and viable culture system in the long-run. Even then, diversification of species is not happening in fish culture because of the high price realised for cultured shrimp. With this in the back drop, the present study was conducted with the following objectives: (i) to examine the recent trends in growth and instability associated with shrimp culture for the major shrimp producing countries of Asia, (ii) to assess the trends in diversification in the fish exports from these countries quantitatively, and (iii) to suggest policy options for diversification in aquaculture.

Methodology

Sources of Data

The data on shrimp production from 1976 to 2002 were collected from the annual yearbooks of FAO Fishery Statistics for the major shrimp-producing countries, viz. Bangladesh, China, Indonesia, India, Malaysia, Thailand and Vietnam of the Asian region. It may be noted that following FAO's classification, data on China do not include Hong Kong Special Administrative Region (SAR) and Taiwan Province of China. FAO has revised the data on Chinese fish production couple of times, as original data was found to overstate the production. Contrast between production data and household consumption survey data, has raised suspicions about the accuracy of reported totals. Possibly because of institutional incentives, the production data might have been overstated (Delgado *et al.*, 2003).

Export data from 1976 to 2002 were arranged into groups of major commodities, viz. shrimps, crabs, other crustaceans, fin fishes and aquatic plants and sea weeds, and were obtained from Fish Stat + Version 3.1. The commodities, not included in any of these groups, were grouped as 'others' for developing the diversification index. Export figures on aquatic plants and sea weeds were converted to and expressed in wet weight basis. For the present study, the data points that were reported as negligible/not available were assumed as zero values.

Methods of Measuring Diversification

For measuring diversification, specialization or concentration and inequalities in resource allocation, several indicators have been employed

(Hall and Tideman, 1967; Atkinson, 1970; Berrebi and Jacques, 1985; Joshi *et al.*, 2003 and Foldvary, 2004). In the present study, Simpson Index of Diversification was used because it was considered as the most suitable index for measuring dispersion of enterprises in a particular geographical region (Joshi, 2003).

$$\text{Simpson Index of Diversification (SID)} = 1 - \sum a_i^2 \quad \dots (1)$$

where, a_i is the proportion of export of the i^{th} commodity to total exports.

The SID ranges from 0 to 1. If the estimated SID is near zero, it indicates that the country is near to the specialized export of particular commodity. If the SID is close to one, the country is fully diversified in the commodities that it exports. The decennial averages were worked out for the SIDs computed annually for all the countries to track their average movement towards diversification or specialization.

Results and Discussion

Growth in Shrimp Farming

The shrimp production from the major producers of Asia has been presented in Table 1. The compound growth rates for the period 1976 to 2002 have been as small as 1.33 per cent in Malaysia to as large as 12.00 per cent in Bangladesh. Other countries that exhibited high growth rate were China (8.93 %) and Vietnam (6.77 %). The rest of the countries were classified as medium growth countries, viz. India (3.94 %), Indonesia (5.36%), Philippines (5.33%) and Thailand (5.19%). The stagnation in Malaysian shrimp production was due to stabilization of shrimp production at about 1 lakh tonnes from the year 1986 onwards. As in the case of other countries of the Asian region, Malaysia also faced stiff opposition from environmentalists and viral epidemics that blocked adoption of intensive culture methods and arrested the growth of average productivity per hectare (Ling *et al.*, 1996).

Instability in Shrimp Farming

Shrimp culture is classified as a risky enterprise by entrepreneurs in the Asian region. The reason is epidemic attacks of devastating viral diseases that have occurred in the cultured shrimp after late-1980s, in Thailand, India and Philippines. Even if the shrimps could manage to survive, the growth was slow, reducing the price realized in the export market. The price offered for smaller size of shrimps is unremunerative and the size decides the premium in price. It falls by 20 to 35 per cent if the size is below 30 counts standard (30 pieces of headless shrimps for a kilogram).

Table 1. Growth and instability of shrimp production in the selected Asian countries

Country	Compound growth rate ,%	Mean tonnes	Standard deviation	Coefficient of variation, %
Bangladesh	12.00	24273.33	19185.26	79.04
China	8.93	557513.63	357259.99	64.08
India	3.94	294319.96	98554.18	33.49
Indonesia	5.36	251771.07	102664.35	40.78
Malaysia	1.33	94475.04	16742.09	17.72
Philippines	5.33	71582.19	31935.09	44.61
Thailand	5.19	239115.30	102668.38	42.94
Vietnam	6.77	84420.67	45068.75	53.39

The instability in shrimp farming was assessed using standard deviation (SD) and coefficient of variation (CV), and the results of analysis have been presented in Table 1.

The results of analysis for instability in shrimp production, as measured by SD in relation to mean values and CV, were found to be identically related to the computed growth trends. Though variations were found annually, the technological inadequacies and production vagaries had affected the long-term trends in level of production during the period 1976-2002, in all the studied Asian countries. The instability in shrimp production was the least in Malaysia (17.72%) and the production instability was medium (25 to 50%) in India, Indonesia, Philippines and Thailand. The other countries which exhibited high instability in production of shrimps were Bangladesh (79.04%), China (64.08%) and Vietnam (53.39%).

This analysis clearly revealed that faster the growth in shrimp production, higher will be the instability in production. Moreover, shrimps are mostly exported by these Asian countries to the USA, Japan, European Union and the gulf countries. Hence, changes in income, price of substitutes and tastes and preferences of the consumers in these importing countries will adversely affect the demand for shrimps in general, and the cost-price relationships may reverse, making the shrimp production not worth the investments. Hence, it will be safer to have a more diversified basket of commodities for export, and earning foreign exchange.

Diversification in Fishery Exports

The limitations in land-based food production systems such as agriculture, horticulture, forestry, etc. and the fear of operation of Malthusian presumptions make water-based production systems more dependable in meeting the food and nutritional requirements of the growing population of the globe (Kutty, 1999). Table 2 depicts the percentage composition of fishery exports of the selected Asian countries during the period 1976-2002.

Table 2. Percentage composition of fishery exports of selected Asian countries: 1976-2002

Country	Period	Shrimp	Crab	Other crustaceans	Fin fishes	Aquatic plants	Others
Bangladesh	1976-85	86.4101	0.0056	0.3000	13.2843	0.0000	0.0000
	1986-95	76.0341	0.0355	2.5221	21.4083	0.0000	0.0000
	1996-2002	72.6579	0.7650	1.7075	24.8634	0.0000	0.0061
China	1976-85	2.0244	0.6882	39.8947	57.3927	0.0000	0.0000
	1986-95	22.5033	3.7261	26.8071	45.3760	1.1181	0.4694
	1996-2002	6.2680	1.9840	19.5242	66.7806	4.5106	0.9326
Indonesia	1976-85	48.4850	2.8173	7.3005	39.3797	0.0000	2.0175
	1986-95	27.5286	1.7011	6.0993	60.4504	2.5552	1.6655
	1996-2002	18.9251	1.5763	5.1253	68.0216	4.4464	1.9052
India	1976-85	70.2387	0.0768	5.8929	21.6539	0.0000	2.1376
	1986-95	46.3944	0.6644	20.7091	31.4333	0.0009	0.7979
	1996-2002	30.7977	1.1046	13.8754	53.6783	0.0151	0.5289
Malaysia	1976-85	23.7668	0.5325	28.7253	43.5020	0.0000	3.4734
	1986-95	15.7462	1.1322	36.6342	42.4127	0.0003	4.0744
	1996-2002	18.0030	0.7276	26.0209	42.2347	1.3254	11.6883
Philippines	1976-85	10.3396	0.0201	6.2164	82.4418	0.0000	0.9821
	1986-95	20.4389	0.5280	9.0239	60.6006	8.2101	1.1985
	1996-2002	10.1825	1.9161	9.6020	58.7417	18.1042	1.4534
Thailand	1976-85	9.0681	0.3952	16.6137	32.0534	0.0000	41.8696
	1986-95	16.7263	1.3285	9.6642	65.2674	0.0074	7.0063
	1996-2002	21.2116	1.0532	8.7256	67.9282	0.0177	1.0636
Vietnam	1976-85	23.0871	0.0009	40.8669	6.0126	0.0000	0.0326
	1986-95	68.8622	0.9695	16.8646	12.8826	0.0000	0.4212
	1996-2002	28.5569	1.7985	24.8270	41.1174	0.2051	3.4951

A clear trend of increasing proportion of shrimp in total fish exports over the years could be noted with Thailand and reducing proportions of shrimp in total fish exports could be seen in Bangladesh, Indonesia and India. The mixed trend of ups and downs in proportion of shrimp in total fish exports was found in China, Malaysia, Philippines and Vietnam. While crabs constituted an insignificant portion of exports in all the countries, fin fishes depicted an increasing proportion of fish exports in all the countries. Philippines, China and Indonesia have made a steady progress in popularisation of aquatic plants production (seaweeds).

The degree of diversification in fishery exports from the major shrimp producing countries of the Asian region was computed using SID and the results have been presented in Table 3. The average values were also computed for the periods 1976-1985, 1986-1995 and 1996-2002 to track

Table 3. Decennial average of Simpson index

Country	1976-85	1986-95	1996-2002
Bangladesh	0.226	0.370	0.402
China	0.503	0.657	0.504
India	0.446	0.621	0.593
Indonesia	0.574	0.535	0.489
Malaysia	0.655	0.650	0.694
Philippines	0.300	0.562	0.599
Thailand	0.675	0.515	0.485
Vietnam	0.186	0.464	0.667

the average movement of SIDs. Fishery exports from Bangladesh, Malaysia, Philippines and Vietnam had become more diversified in the past with steadily increasing SID values during these periods. Thailand and Indonesia had become more specialized fishery exporters in the Asian region. China and India had started as specialized producers, diversified till 1995 and again moved towards specialization. Particularly, China had more increased the total fish production as well as proportionate production of fin fishes, aquatic plants and crabs. India had quadrupled shrimp production during the reference period, while stagnating in the proportionate growth of 'other' commodities. The culture of aquatic plants/seaweeds and crabs are yet to get impetus in India. The popularisation of shrimp farming and increase in shrimp exports had reduced diversification in fisheries of these nations.

The analysis has clearly brought out three major inferences. Firstly, shrimp farming is on the increase in all the major shrimp-producing Asian countries. Secondly, the high growth in shrimp production is concurrent with higher instability in production. Thirdly, most of the shrimp-producing countries have been moving towards specialization of shrimp production for export because of the high price that shrimp asserts in the international market.

A comparison between these Asian countries for the period 1976-2002 has revealed that Malaysia maintained low growth and low instability and higher diversification, and Bangladesh and Vietnam diversified in fish exports. In the country level comparison, India, Indonesia, Thailand and Philippines showed moderate growth in production and export of shrimp. The instability associated with their shrimp production was also moderate. While Indonesia and Thailand have been found specializing, Philippines was moving towards diversification during this period. India, along with China had ups and downs in diversification during this period.

Conclusions

Diversification in fish production as well as exports has been advocated for assured income to the farmers. Diversification of fish culture helps in avoiding disease incidences and aids in better utilization of resources. The Asian countries could take advantage of their rich endowments of resources and become more diversified in their fish production and exports. The governments and research institutions addressing the requirements of these countries should strengthen their efforts on diversification of fisheries. The disease problems associated with shrimp farming make it a risky enterprise to carry on with continued monoculture of shrimp. Though technology development has been done in many alternate culture systems like finfish culture, mollusc culture, seaweed culture, etc. these are yet to take off commercially.

Replacing, supplementing or rotating the shrimp farming with culture of other high-value fish species like Asian sea bass (*Lates calcarifer*), grouper (*Epinephelus* spp.), mullets (*Mugil* spp.) and milk fish (*Chanos* spp.) culture may ease the risks in mono-cropping of shrimp. To facilitate this, research should be conducted on the breeding and hatchery seed production of the specific species in the Asian countries on priority. Diversification in fish production can become effective only when supporting facilities like hatcheries, feed mills, disease management techniques and packaging techniques for these species were established.

Specialized and hygienic processing and adoption of Hazard Analysis and Critical Control Points (HACCP) from aquaculture production to processing will help the aquaculturists to fetch better prices for alternate species comparable to that of shrimp in the international markets.

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