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Value chain analysis of farmed shrimp sector in Tamil Nadu, south India

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ABSTRACT

Shrimp farming in India has grown considerably and has emerged as a major commercial enterprise owing to the introduction of specific pathogen free (SPF) stocks of *Penaeus vannamei*. The complexity and limited transparency of the shrimp value chain, make it difficult for buyers to take action on cost optimisation. Against this background, a study on value chain analysis of farmed shrimp sector in Tamil Nadu was undertaken with the objectives of analysing different input market channels, inbound and outbound logistics, value chain management (VCM) practices being adopted in shrimp farming, key challenges and finally to suggest a cost effective value chain model for shrimp farmers. Four coastal districts in Tamil Nadu, namely Nagapattinam, Thanjavur, Ramanathapuram and Cuddalore were selected for the study. From each district, 50 shrimp farmers registered with Coastal Aquaculture Authority (CAA) were selected randomly with a total sample size of 200. Descriptive statistics, multiple regression and factor analysis were employed for data analysis. The annual per hectre yield and income were estimated at 7.42 t and ₹64.23 lakhs, respectively. The overall distribution of inbound logistics revealed that almost all the inputs were transported through trucks, autorickshaws and motor cycles. The channels of distribution of various inputs were also documented. The overall farm gate price was estimated at ₹433.70 kg^{-1}. Among the VCM practices, feed and feeding management contributed the highest (42.95%). The results of regression model (performed on cost contribution of value chain processes to final price) and factor analysis (frequency of performing VCM processes) concluded that the shrimp farmers regularly perform VCM operations such as feed and feeding management, energy usage, application of probiotics, chemicals and minerals, check tray monitoring and sampling, while they poorly practise VCM processes of waste water management, disinfection protocol, disease management and water quality management. Suitable recommendations for better yield and final price are also suggested.

Keywords: Adoption, Shrimp farming, Value addition, Value chain management

Introduction

Wild fish stock depletion and a growing demand for seafood are major reasons for reliance on aquaculture (Naylor *et al*., 2000) and presently aquaculture is widely heralded as world's fastest growing food production sector (Galappaththi *et al*., 2016). India contributes 6.3% to the total global aquaculture production and ranks 2nd after China (Paul, 2017). Brackishwater aquaculture sector of India majorly comprises the culture of shrimp varieties predominantly the exotic white leg shrimp *Penaeus vannamei* owing to the high export potential (Ayyappan *et al*., 2011), with a contribution of 76% to the total cultured shrimp export during 2016-17 (Paul, 2017).

Value chains are usually defined as the full range of processes that are required to bring a product from its conception to its end use (Kaplinsky and Morris, 2001; Alexander *et al*., 2018). Co-ordination in a value chain is defined as the efforts or measures that players make in a market system to act in a complementary way towards a common goal (Poulton *et al*., 2004). Value chain analysis (VCA) is one of the managerial strategies that can help to reduce costs associated with production and distribution (Kotni, 2014), thereby improving productivity.

Coastal Aquaculture Authority (CAA), Govt. of India, established under the Coastal Aquaculture Authority Act, 2005 is regulating coastal aquaculture activities in the country, in order to endure sustainable development without causing damage to the coastal environment. The authority is empowered to make regulations for the construction and operation of aquaculture farms in coastal areas, inspection of farms to ascertain their environmental impact, registration of aquaculture farms, fixing standards for inputs and effluents as well as removal or demolition of coastal aquaculture farms, which cause pollution (www.caa.gov.in). Tamil Nadu is blessed with an estimated brackishwater area of 56,000 ha, out of which 6115.68 ha is under coastal aquaculture production, particularly shrimp aquaculture (GoTN, 2018). To supplement the activities of CAA, dissemination of information on value chain management (VCM) in farmed shrimp sector becomes essential that helps the CAA registered shrimp farmers in achieving higher value at minimum cost. Moreover, for better price realisation, the farmer should have a thorough knowledge on various aspects related to market demand and supply of cultured shrimps, various value chain participants, inbound and outbound logistics, input supply market, production technology, trading, cost, price addition and frequency of each VCM process, supporting products and services as well as constraints involved. Hence, research in this line will definitely throw light on developing cost effective value chain model and provide valuable suggestions for all the stakeholders concerned. In this context, this study presents the different input market channels, inbound and outbound logistics, VCM practices adopted, key challenges and finally with a cost effective value chain model with suitable recommendations.

Materials and methods

Sampling design

Out of the 13 coastal districts in Tamil Nadu, four districts *viz*., Nagapattinam, Thanjavur, Ramanathapuram and Cuddalore (Fig. 1), having more of CAA registered shrimp farms (www.caa.gov.in/farms.html) were selected for the study. Purposive sampling technique was adopted and from each of the selected district, fifty CAA registered shrimp farmers were randomly selected to collect primary data during 2016-17, with a total sample size of 200.

Data source

Two pre-tested structured survey schedules were used as primary instruments for farm based data collection, whereas secondary data were collected from online and print sources. Schedule I detailed on socio-economic characteristics of the shrimp farmers and general characteristics of farms in the study area. It also focussed on identification of channel of distribution (marketing channel) of farm inputs namely seed, feed, fertiliser, probiotics and chemicals, by describing its type, ownership and frequency of purchase. Inbound logistics in this study refers to the transport, storage and delivery of inputs into the shrimp farming business and outbound logistics refers to the same but for the produce *i. e.,* cultured shrimps going out of the farm. The information pertaining to value

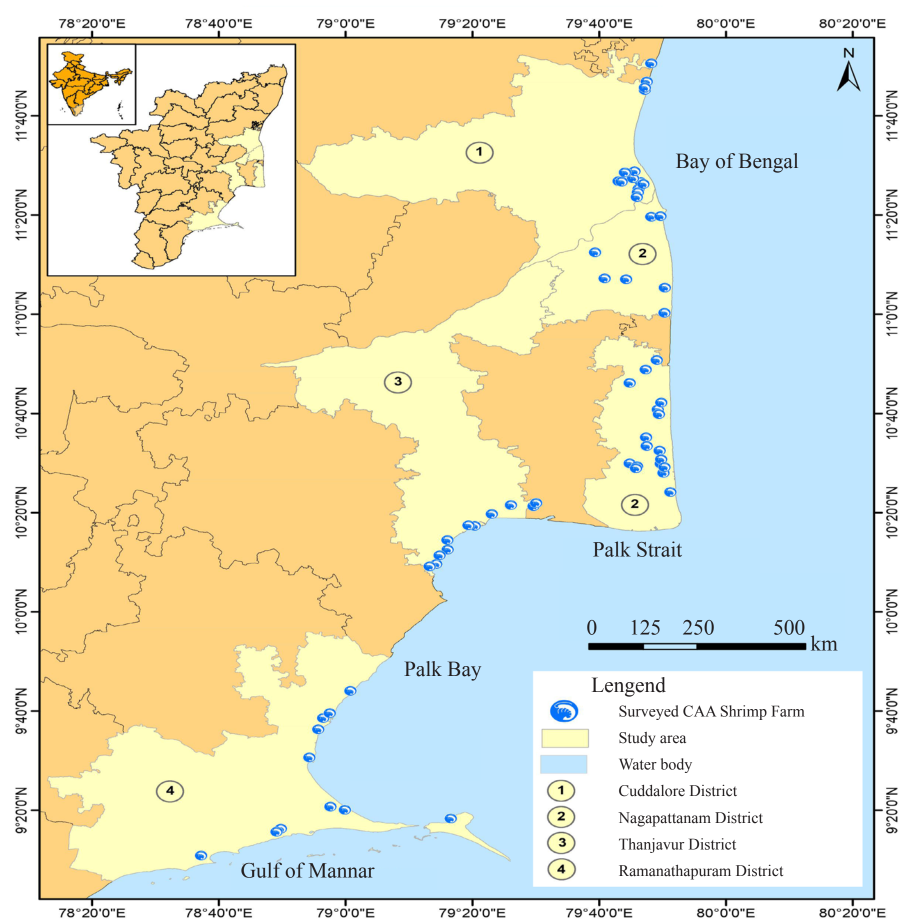

Fig. 1. Map showing CAA registered shrimp farms selected for the study in Tamil Nadu

chain management (VCM) processes practiced in shrimp farming was collected using Schedule II, wherein pre-stocking operations like pond preparation, manuring and fertilisation, installation of biosecurity measures and post-stocking management operations *viz.,* seed stocking and management, feed and feeding management, check tray monitoring, sampling, water quality management and disease management were detailed. The key challenges in shrimp farming sector were documented through focus group discussions (FGD) with CAA registered shrimp farmers in the surveyed districts as well as with officials of Department of Fisheries, Government of Tamil Nadu.

Tools of analysis

Empirical analysis was undertaken employing simple percentage and descriptive statistical analyses for variables with respect to Schedule I. Multiple regression and Factor analyses were attempted for Schedule II. Multiple regression technique (Maheshwari *et al.,* 2012; Kotni, 2014) estimated the effect of each factor and the impact of costs of all value addition processes in shrimp farming (Independent variable) upon the final price of shrimp (Dependent variable). The estimated correlations thereafter facilitated to analyse the contribution of each value addition process in increasing or decreasing the final price of shrimp. Similarly, Factor analysis (Krishnaswami and Ranganatham, 2007; Kotni, 2014) was performed on the data of frequency of identified VCM processes to identify more frequently performed and less frequently performed VCM processes based on the factor loadings and thereafter ranked based on the frequency of VCM processes performed.

Test of data reliability

Kaiser-Mayer-Olkin measure of sampling adequacy (Hair *et al.,* 1998; Kotni, 2014) was carried out in factor analysis to determine the factor to be considered for further analysis (KMO measure > threshold value of 0.5). In order to find out the appropriateness of factor analysis for the set of variables identified, Barlett's Test of sphericity (Kotni, 2014) was used that measures the correlation of variables, where $p<0.05$ is acceptable

Chi-square test and Eigen values

Using the information provided in each grouped factor, Chi-square test was used to test the significance of the cumulative explanation of variance and the factors with estimated Chi-square value greater than table value were considered as proper and used the factor scores as indices for further analysis. The Eigen value for a given factor reflects the variance in all the variables, which is accounted for by that factor and it is the sum of squared values of factor loadings relating to a factor (Krishnaswami and Ranganatham 2007; Kotni, 2014). All the above analyses were done using SPSS version 22 (SPSS Inc., Chicago, USA).

Results and discussion

Socio-economic characteristics of shrimp farmers in Tamil Nadu

The average age of the surveyed respondents was estimated as 47 years with a maximum educational level of higher secondary (51%). The gender composition of the surveyed shrimp farmers showed 89.5% males and 10.5% females. About 99.5% of the farmers are practising shrimp farming as their primary occupation and mostly associated with Shrimp Farmers Association (SFA). Almost half of the shrimp farmers (58.5%) were with 13 years of hands-on experience in shrimp farming with sound knowledge on culture aspects and disease preventive measures as well (54%). Predominantly, sharing of information happens with the fellow farmers and availing comparatively greater support from input suppliers rather than processors.

General characteristics of shrimp farms in Tamil Nadu

The average farm size recorded was 2.76 ha from a total surveyed area of 552.66 ha. On an average, the shrimp farmers need to travel 220 km from hatchery to the respective farms which scored the highest value when compared to other procurement points. Most (58%) of the farmers were found to adopt semi-intensive farming system and about 44.5% of the farmers depend on creeks as source of water. The number of crops was restricted to two per annum with a mean culture period of four months, wherein both complete (74%) and partial (26%) harvests were followed. The stocking density (PL 12) ranged from 20 to 60 nos. m^{-2} with a record mean survival rate and yield per ha of 73.13% and 7.43 t , respectively. While the annual mean income per ha was estimated as ₹58.81 lakhs, Viswakumar (1992) stated that under extensive systems with supplementary feeding, shrimp farming in Andhra Pradesh yielded an annual net returns of ₹30,000 ha^{-1} and with improved extensive and semi-intensive systems of production, the returns were estimated as ₹0.90 lakhs and ₹1.94 lakhs, respectively. Jayaraman (2017) reported that with the production levels of 10-12 t ha^{-1} $crop^{-1}$ in 3-4 months, the production of *P. vannamei* has attained phenomenal levels. By engaging trained personnel for shrimp culture activities, the number of workers varied with farm size with an average wage rate of ₹460.51 per day.

Inbound and outbound logistics

While polythene bags were used for seed transportation, single trailer trucks, heavy-duty pickup trucks, medium trucks, autorickshaws and motor cycles were used for transportation of other farm inputs. Except fuel which is stored in barrels, all other farm inputs were stored in store rooms. The farm labours alone were engaged in distributing all types of farm inputs and the harvested shrimps were preserved in slurry ice in barrels (54%) and tubs (46%); which were then transported to processing plants by human resources specifically engaged for this purpose. Insulated single trailer trucks (63%), insulated medium trucks (31.5%) and insulated containers (5.5%) were commonly used for transporting the harvested shrimps from farm gate to the processing plants.

Cost of each value addition process and value (price) added to the farmed shrimp

In this study, pre-investment was calculated based on depreciation charges (@12% of the total value), interest on fixed capital (@ 10% on par with crop loan bank interest rate), repairs and maintenance and consulting charges (@ 2 to 3%) (Table 1). While the cost of pond preparation accounted to ₹2.64 per kg, the cost towards manuring and fertilisation as well as establishment of biosecurity measures were ₹1.58 and ₹2.48 per kg, respectively on an average. The average cost from the stage of seed stocking to grading and packing was estimated at ₹293.02 per kg and finally with the value added cost *i.e.,* the farmer's profit margin of ₹114.25 (26.33%), the final farm gate price was ₹433.70 per kg. Thus, the final average price per kg increased from ₹26.43 to ₹407.27 with an increase of 93.91% after performing value chain management operations (Table 1). The results are well confirmed with the study undertaken by Kotni (2016) in marine fisheries, determining the value addition operations by different intermediaries stating that 12% value is being added to fish if subjected to value addition processes. Hence, it is strongly suggested that the shrimp farmers need to adopt value chain management operations for better price realisation.

Identifying the correlations among value chain processes and their contribution to final price of farmed shrimp

Multiple regression analysis was carried out with the final price of farmed shrimp as dependent variable and cost of value chain management processes (19 nos.) as independent variables. The regression model was statistically significant at 1% level with F value of 6.548 and 74.8% variation in the cost of value chains in shrimp farming was explained by final price as indicated by the R^2 value. Out of 19 independent variables**,** feed and feeding management, profit margin, pre-investment and power and fuel (energy usage), application of probiotics, chemicals and minerals and labour management were found to be most significant at 1% level as they were the highest contributors to final price (Table 2). Based on t test values, pond preparation, sampling, waste water management, harvesting, disinfection and disease management were found as next level value adders and management processes *viz.,* manuring and water quality management showed negative correlation with final price.

Analysis of frequency of VCM processes

The shrimp farmers were asked to respond on a five point Likert scale (every time [5], frequently [4],

Table 1. Cost of each value chain and addition of value to final price

Particulars	Average price (₹ kg^{-1})	Contribution to final price (%)
Pre-investment	19.73	4.55
Pond preparation	2.64	0.61
Manuring and fertilisation	1.58	0.36
Biosecurity measures	2.48	0.57
Value chain management operations performed by shrimp farmer at farm level		
Seed and seed stocking	14.93	3.44
Feed and feeding management	186.39	42.95
Check tray monitoring	0.83	0.19
Sampling	0.72	0.17
Application of probiotics, chemicals and minerals	20.51	4.73
Water quality management	1.27	0.29
Disease management	1.16	0.27
Disinfection	1.14	0.26
Farm hygiene management	1.53	0.35
Waste water management	0.88	0.20
Labour management	16.15	3.72
Power and fuel	44.79	10.32
Harvesting	2.40	0.55
Grading and packing	0.30	0.07
Profit margin	114.25	26.33

sometimes [3], rare [2], never [1] with regard to the 13 identified VCM processes. The Kaiser Meyer Olkin (KMO) measure was observed as 0.571 and Barlett's Test of Sphericity was found significant (X^2 = 469.671, p<0.001, df = 78). Factor analysis was performed using principal component extraction method with varimax rotation and it was found that all thirteen variables were reduced to five-factor dimensions, which explained 62.43% of cumulative variance (Table 3). The factor scores matrix of frequency of VCM processes showed the associated variables in all the five factors and their relative factor scores. The factor scores in the factor scores matrix represent the priority of performing VCM processes (Table 4). A study in the same line was undertaken for marine capture fisheries in Andhra Pradesh, wherein a cost effective value chain model was proposed (Kotni, 2014).

Table 2. Regression co-efficient for surveyed shrimp farms

Variables	Regression co-efficient	Significance level
Constant	242.730	0.000
Pre-investment	0.483	0.000*
Pond preparation	0.090	0.161
Manuring and fertilisation	-0.108	0.183
Biosecurity measures	0.036	0.715
Seed and seed stocking	0.037	0.570
Feed and feeding management	0.633	0.000*
Check tray monitoring	0.069	0.442
Sampling	0.079	0.124
Application of probiotics, chemicals and minerals	0.247	0.002*
Water quality management	-0.010	0.919
Disease management	0.098	0.428
Disinfection management	0.085	0.403
Farm hygiene management	0.039	0.569
Waste water management	0.139	0.211
Labour management	0.265	0.002*
Power and fuel	0.310	0.000*
Harvesting	0.063	0.398
Grading and packing	0.070	0.514
Farmers' profit margin	0.826	0.000*

*1% level of significance

Table 3. Factors: Frequency of performing VCM processes

Factor	Eigen value	Total variance (%)	Cumulative variance (%)
FACTOR 1	2.567	19.747	19.747
FACTOR 2	1.890	14.538	34.285
FACTOR 3	1.325	10.191	44.476
FACTOR 4	9.143	9.143	53.619
FACTOR 5	1.145	8.808	62.426

Table 4. Factor scores matrix - Frequency of performing VCM processes

Variables	Factor				
	1	2	3	4	5
Feeding management	0.834				
Power and fuel	0.815				
Application of probiotics	0.768				
Check tray monitoring		0.692			
Sampling		0.676			
Water quality management			0.760		
Disease management			0.717		
Waste water management				0.677	
Disinfection					0.492

Variables removed: Labour management, Farm hygiene management, Harvesting, Grading and packing

It was concluded that VCM enabled the fishermen to get more value for the same product and an effective VCM encourages value added services and discourages non-value added services in processing and help to identify the value added activities to be performed frequently and not to or to perform less frequently.

Analysis of results of regression model and factor analysis

According to the regression model, feeding management, power and fuel were the most significant contributors to the final price followed by labour management and application of probiotics. But the results of factor analysis revealed that labour management was eliminated *i.e.* the frequency of employing labourers was not regular and hence the shrimp farmers were suggested to employ other state people as labourers on contract to reduce the labour cost contribution to the final price. The processes like feed and feeding management, power and fuel and application of probiotics are recommended to perform regularly to get better final price as they were the most frequently performed and the most significant contributors to the final price.

The results of factor analysis indicated that check tray monitoring and sampling were the frequently performed VCM processes. Though check tray monitoring had less influence on the final price, sampling was significant in the regression model. Check tray monitoring and sampling are the effective controlling/deciding factors of feed conversion ratio (FCR) and animal health and hence need to be performed regularly. Though disinfection, harvesting and waste water management showed significance in regression model, the results of factor analysis clearly depicts that waste water management and disinfection were poorly performed, and harvesting was eliminated. It could be interpreted that the farmers were not regularly performing some of the VCM practices, and hence it is recommended that the farmers need to properly and strictly adopt the disinfection processes and waste water disposal promptly and regularly.

In the regression model; disease management, grading and packing as well as farm hygiene management were not significantly contributing to the final price while water quality management was eliminated. In factor analysis, while water quality management and disease management were found to be moderately performed by the shrimp farmers, farm hygiene management, grading and packing were eliminated. Thus, it is clearly stated that irrespective of the farm size, the shrimp farmers are insisted to perform the said processes regularly and also to check all the water quality parameters as prescribed by CAA in order to get more yield and better final price. Based on Michael Porter value chain model, an adapted shrimp value chain model (Fig. 2) is proposed here based on the field observed primary and secondary attributes and the cost effective value chain model for shrimp farmers is depicted in Fig. 3.

<table>
<tr><td rowspan="4">Support activities</td><td colspan="6">Infrastructure
Well-developed feed mill and cold storage at district level
Establishment of well-equipped seed & water quality testing and PCR labs</td><td rowspan="7">Profit margin</td></tr>
<tr><td colspan="6">Human Resource Management
Capacity building (Training / Awareness / Advisory programmes) in VCM operations, costing, marketing skills</td></tr>
<tr><td colspan="6">Technology development
Rearing of PL in nursery ponds (1 month) before stocking
Automation in feeding, harvesting and packaging
Blowers for aeration, DO depletion SMS alert, partial replacement of electricity by solar energy, CC TV for farm surveillance,
Underwater camera for animal health surveillance, central sludge removal system</td></tr>
<tr><td colspan="6">Procurement
Minimum Supporting Price fixation of farmed shrimp
Provision of less cost transportation facilities for farm inputs</td></tr>
<tr><td rowspan="3">Primary activities</td><td rowspan="2">Inbound logistics</td><td colspan="2">Operations</td><td rowspan="2">Outbound logistics</td><td rowspan="2">Marketing and sales</td><td rowspan="2">Services</td></tr>
<tr><td>Pre-stocking</td><td>Post-stocking</td></tr>
<tr><td>• Transportation of farm inputs
• Storage of farm inputs
• Distribution of farm inputs
• Ponds for shrimp culture</td><td>• Pond preparation
• Manuring and fertilisation
• Bio-security measures</td><td>• Seed stocking
• Feeding management
• Check tray monitoring
• Sampling
• Application of probiotics
• Water quality management
• Disease management</td><td>• Transportation of shrimps
• Disposal of farmed shrimps to buyers</td><td>• Local marketing
• Whole sale marketing</td><td>• Services to buyers
• Farm input services
• Financial services
• Extension and information services</td></tr>
</table>

Fig. 2. Adapted shrimp value chain model

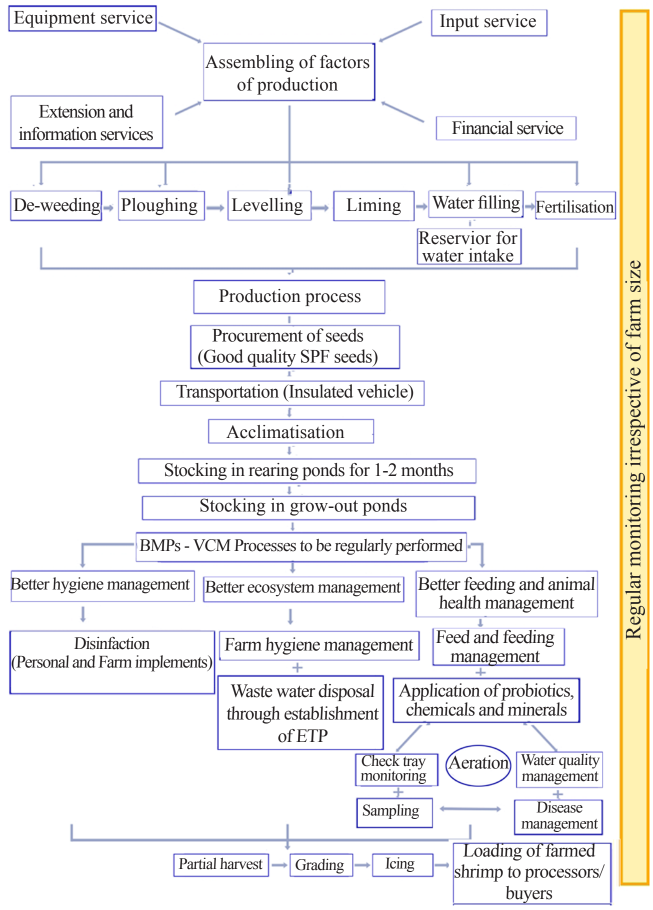

Fig. 3. Cost effective shrimp value chain for farmers

Key challenges in shrimp farming industry

The key challenges facing the shrimp farming industry are disease prevalence (100%), price and quality volatility (91%), ineffective implementation of industry standards (86%), pollution (82%), problem of middlemen (81%), government embargoes and tariffs (80%), ecosystem disruption from introduction of non-native species (76%), sustainability of supply and food security (63%), primary concerns of value chain (60%), risks to business such as reputational risks (58%), worker protest (53%), consumer health and food safety (47%) and land grabs (26%).

Shrimp farming dominated with male farmers is a lucrative sector in Tamil Nadu with the farmers being socially and economically well off. Inbound logistics are sound enough in performing the business successfuly and outbound logistics are predominantly in the hands of the buyers. Irrespective of credit and cash transactions, the channel of distribution of inputs varies with farmers. The value addition management processes performed at farm level increase the value of shrimps to make it marketable for direct consumption, processing and value addition. The present study made an attempt to correlate the contribution of VCM processes to the final price of shrimps and the frequency of adoption of VCM practices revealed that the shrimp farmers need to pay more attention on selected practices for better price realisation.

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