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Risk perception and assessment in pacific white shrimp farming: An exploratory study

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Abstract

Shrimp farming is a commercial aquaculture model therefore subject to risks. A study conducted among 240 randomly identified shrimp farmers indicated that shrimp farming is being operated at moderate to higher level of risks. Low market price and diseases with its causes were the major risks perceived and respondents differ in their risk perception based on their personal and farming characteristics. Modifications in crop planning and size at harvest in tune with market scenario, price insurance and promotion of domestic consumption are suggested as adaptations for market risk. Similarly quality seed selection, carrying capacity based stocking densities and adoption of farm biosecurity and good aquaculture practices were advocated as disease risk mitigation measures. In addition strengthening farmer associations and formation of fish farmer producer organizations are expected to empower farmers to deal with market forces, as well as enforce collective compliance for disease preventive and management practices at the shrimp clusters. Therefore, policy support for insurance, intuitional credit support and strengthening of farmer institutions as well as capacity cum skill development of shrimp farmers on risk identification, prevention and adaptation by the extension agencies are important for the profitable and sustainable shrimp farming in India.

Keywords: Risk perception, risk assessment, risk prevention and management, farmer profile, shrimp farming

Introduction

Aquaculture is one of the fastest growing food production sectors and shrimp aquaculture is a popular success story promoting small-scale farming entrepreneurs in the coastal agro-ecosystem. Despite its seminal contributions for fish production, livelihoods, employment generation, high export earnings worth INR 45000 crores, village economy and rural development, shrimp farming is subject to on and off-farm risks. Shrimp farming systems are heterogeneous practiced with different scale of technology, intensification under varying production systems by different strata of farmers. Shrimps are delicate organisms sensitive to changes in the pond environment and therefore susceptible to production related risks. Shrimp farming is mostly operated as cluster of farms along a common water source hence, the on-farm risks are 'compound' in nature as they are transferable from one farm to the other through cross contamination and their impact is disproportional. Shrimp aquaculture is exposed to specific production risks as most of the farms are operated in an open environment along the coastal hinterland which is naturally a risk prone environment. Hence, identification of potential risks and evaluating their consequence on production and farmers income is important to have a risk prevention and management plan. Risk perception and assessment is a pragmatic approach in shrimp farming which would pave the way for the adoption of risk preventive and management practices (Lestariadi and Yamao, 2018; Joffre *et al.* 2018; Kumaran *et al.* 2021) [19, 14, 12].

Risk assessment is a process of identifying risk hazards associated with the shrimp value chain, their probability of occurrence and analyze their impact on production and income. Risk perception includes evaluation of the probability as well as the consequences of a negative outcome (Sjoberg *et al.* 2004) [28] as risk is the product of magnitude and likelihood of harm (Patt and Schroter, 2008). Risks in shrimp farming are at different level which includes production risks (eg. poor pond management), disease risks (Existing and emerging pathogens), market price risks (e.g. market price fluctuation, changes in market requirements) and climate risks (e.g. sudden temperature changes, drought or unpredictable rainfall (Kumaran *et al.* 2021; Muralidhar *et al.* 2021) [22]. Risks influence risk management strategies and adoption of new technologies (Aguilar-Gallegos *et al.*, 2015; Case *et al.*, 2017; Joffre *et al.*, 2018; Lestariadi and Yamao, 2018) [1, 5, 14, 19]. The pioneering risk assessment study in aquaculture was done in salmon fish farming in Norway (Bergfjord, 2009) [4] which was followed subsequently in shrimp farming in Bangladesh (Ahsan, 2011) [2], Vietnam (Joffre *et al.* 2018) [14] and India (Kumaran *et al.* 2021) [22]. However, risk assessment need to be continuous especially in shrimp farming where the risks are constantly emerging with high impacts and to develop risk management practices to mitigate and adapt to them. In

this context, the present study was undertaken to identify the on and off-farm risks in shrimp aquaculture and assess its potential impact on the production process and income.

Materials and Methods

The methodology used in the study includes identifying potential production hazards, their probability of occurrence, and their impact on shrimp production and income. A hybrid approach consists of qualitative and semi-quantitative assessment or expert opinion as done in previous studies was followed (Anon, 2006; GESAMP, 2008; Kumaran and Ponniah, 2013; Taranger *et al.* 2015) [3, 12, 17, 30]. Thirty five (35) parameters under nine heads covering all the possible risks that may occur in shrimp production and associated with shrimp farming *viz*., farm biosecurity and infrastructure, pond preparation, seed selection and stocking, feeding and feed management, water quality and climate change, diseases, market, social and institutional parameters were identified, validated and included based on the available literature and expert opinion of the subject matter specialists. The respondents were asked to identify whether the particular item from the list is a risk factor on a dichotomous response as Yes or No. If yes, then its likelihood of occurrence was measured through a Likert-type 5-point rating scale: Very High (80-100% chance = 5); High (60-80% chance = 4;); Likely – (40-60% chance = 3); Low – (20-40% chance = 2;) and Very Low - (0-20% = 1) and scored accordingly. Similarly the impact of the risk factor was also measured through a 5-point rating scale: Disastrous (Crop failure & 100% loss of production = score 5); Extremely negative (More than 50% loss in production OR 50% increase in cost of production = 4); Moderately negative (25 to 50% of loss in production OR 25-50% increase in cost of production=3); Minor negative (10-25% of loss in production OR 25% increase in cost of production= 2) and Little negative (Less than 10% loss in production OR 10% increase in cost of production =1). The scores of risk probability of occurrence and impact were multiplied to obtain the risk score of a particular risk. Likewise the risk scores of all the 35 items were added to get a respondent's risk perception score and categorized them into low, moderate, high and very high risk using the range divided by class interval procedure suggested by Kumaran *et al.* (2021) [22].

Primary data for the study were collected from a sample of 240 shrimp farmers and 60 extension professionals by direct contact, adopting a proportionate random sampling design in East Godavari, West Godavari and Guntur districts of Andhra Pradesh (Fig-1) state, India. A comprehensive questionnaire pre-tested in a non-sampling area for its format, reliability, and validity was used for data collection. In addition to farm surveys, three focus group discussions (FGD) involving 12–15 progressive farmers and field level aqua professionals were conducted at appropriate locations to crosscheck the data obtained through the survey and had detailed discussion on the risks identified, their probability of occurrence and their impact on shrimp farming. FGDs as a methodology have also been used to identify the risks and their management in earlier studies (Edmund *et al.* 1999; McLafferty, 2004) [7, 21]. Mean and standard deviation were used to prioritize the risks. Primary data on personal profile of the farmers' *viz*., education, farming experience, participation in farmer institutions, training attended, type of production system, farm size, cropping intensity, perceived success rate, information source utilization and farm average productivity was also collected to understand the farming profile of farmers and their relative influence on risk perception was done using non-parametric Mann-Whitney-U and Kruskal Wallis tests.

Results and Discussion

Profile of shrimp farmers: Results on personal and farming profile of farmer's respondents indicated 40% of them had pre-graduate level education and about 20% each were graduates and had matriculate level education respectively. It indicated that most of them were basically agriculture farmers and diversified in to shrimp farming. About half (51.70%) of the respondents had more than 10 years of farming experience and the remaining half (48%) had less than 10 years of experience in shrimp farming. Majority of the respondents (65%) were members of the cluster based farmer association an institution formed to implement a common crop calendar and enforce adoption of good aquaculture practices by the farmers as an adaptive measure to prevent disease outbreaks in the cluster as they are waterborne. Joffre *et al* (2018) [14] reported that farmer institution influences adoption of farming practices via two underlying processes: frequency of interaction with public and private sector's actors, and perception of market risk, both of which ultimately promote the adoption of practices. Pacific white shrimp (*Penaeus vannamei*) was the species farmed by the respondents and 80% of the farmers farmed this species in low saline waters as this shrimp species is euryhaline can adapt to wider salinity range (FAO, 2020) [8]. About three fourths of the farms were more than 3 ha size and in that 41.60% of them were above 5 ha. Considering the economy of scale and adoption of certain regulatory guidelines like reservoirs and drainage treatment ponds in the farm for that 30-40% of farm area is required, farm size of 3-4 ha is an optimal farm size. Majority of the farmer respondents (60%) did not attend any formal training on shrimp farming and 40% of respondents attended one or other training programmes conducted by the fisheries departments and inputs companies at the village level as part of their extension education activities. Most of the respondents practiced two crops in a year, one summer crop (February-March to May-June) and one post monsoon crop (August-September to November-December). About 50% of the respondents informed that their probability of getting a successful crop free from production risks was 50-75%. Shrimp farming is highly technology driven therefore, majority of the shrimp farmers availed farm advisory services from more than once source dominated by private sources: inputs companies (89%) fellow farmers and publications of companies/institutions (68%). Kumaran *et al.* (2012) [20] reported that 90% of shrimp farmers in India depend on private extension sources for technology advisory information. Majority of the farms were earthen pond based and majority of the farmer respondents (84%) produced 5 to 8 tonnes of shrimp per ha which was on par with the national average productivity of *P. vannamei* farms in India.

Risk perception and assessment

It may be noted from the Fig-2 that shrimp farmers

perceived that farming is surmounted with risks and about 48% and 38% of farmer respondents respectively felt that shrimp farming was exposed risks related to production and income at moderate to high level with extremely negative impact causing 50% production or revenue loss if not prevented or managed appropriately. Similarly 55% extension workers also perceived that shrimp farming was highly risky. Previous studies also reported that shrimp farming is risk-intensive on the account of seed quality, the complex interplay of pond production parameters, susceptibility to diseases, climatic variability, high operational investments, volatile export market, and higher variability in production and revenues (Flaten *et al*. 2005; Joffre *et.al* 2018; Kumaran *et al.* 2021) [10, 14, 22]. The respondents ranked that low market price, poor seed quality and disease were major three risks in shrimp farming (Table-2) and risks like poor seed quality, poor pond preparation, lack of biosecurity and poor management indirectly contribute for disease risk. Whereas, the extension workers felt that poor seed quality and lack of biosecurity which led to disease outbreaks in shrimp farming were the key risks in shrimp farming followed by market price. Their perceptional difference was due to obvious reasons. For a farmer assured income was the main objective and extension workers might think about the larger perspective of disease free shrimp farming, increased fish production and its sustainability. Therefore, there is a significant difference in the perception of these two stakeholders (p<0.05). It was observed from the farm records that the farm gate price of shrimp had shown decreasing trend across years whereas the production costs were constantly increased during the period. This cost and price gap erodes the profitability of shrimp farming, prevents further investments in farming and challenges its sustainability.

The risk matrix prepared (Table-2) indicated that market price and diseases were of very high probability with disastrous impacts whereas the poor seed quality, poor biosecurity and poor pond preparation which are the main causes for disease occurrence were assessed with extremely negative impacts. Further to market price, inadequate bargaining power of farmers against the buyers, oligopsony nature of the shrimp market together with poor domestic consumption were contributed for the market price risk. Studies reported that volatility of farm gate prices and increasing production costs decrease the profitability of shrimp farmers over the years worldwide (Kabir *et al*., 2020; Joffre *et al*., 2018; Khiem *et al*., 2021; Ordoñez Celi *et al*. 2021) [15, 14, 16, 24]. Diseases were the second major risks reported by the farmer respondents. It was reported earlier that diseases are the major production risk in shrimp farming (Thitamadee *et al*. 2016; Patil *et al*. 2021; Kumaran *et al.* 2021) [31, 25, 22]. Shrimp diseases, price and availability of quality shrimp seeds, exploitation by intermediaries and uncertainty about the future demand for shrimp in foreign markets were perceived as the most important sources of risk perceived by the Bangladesh shrimp farmers (Ahsan, 2011) [2]. Shrimp farmers in Vietnam faced risks related to disease, market and climate, which influence risk management strategies and the adoption of new technologies. The average loss at farm-level due to White Fecal Disease alone was estimated at ₹61,778 (US$ 813) ton^{-1} with an average estimated reduction in gross returns was 19.83% (Geetha *et al.* 2022) [11]. Lack of cooperation among the farmers where the farmer associations were not there and labour scarcity were the social risks reported by the respondents. Similarly prolonged temperature variations particularly diurnal temperature variations, unexpected cloudy weather and water quality issues like high load of metabolites, low mineral and alkalinity levels were the climate and water quality risks perceived by the farmer respondents. Climate-related risks increase production costs by making it difficult to manage the farm efficiently, resulting in direct production losses (Sulit, 2005) [29]. Full adoption of farm biosecurity measures and better management practices by the farmers together with a strong farmer association to enforce these practices could minimise the disease risk in shrimp farming.

Risk prevention and management

Market price was the major risk as the farmers could not make any profit from farming and the production costs especially on feed and other inputs constantly on rise. Farmers blame processors and the latter blame the international market forces for the price instability. At present shrimp production depends on export market and hardly 20% of farmed shrimp is consumed domestically. Therefore, the immediate strategy should be that a careful trend analysis of shrimp price according to size and season wise based on available data and assess when the prices are stable for which size shrimp across the seasons. Based on that the farmers need to be sensitized re-orient their farming plan like phase wise stocking of ponds and partial harvesting of small size shrimps for local consumption which provide them the breakeven and funds for continuing the remaining stock for a larger size shrimp to fetch a niche price. Similarly, strengthening domestic markets and promotion of domestic consumption are the viable strategies to minimise the price risk in shrimps. In Brazil, shrimp farming has been rebuilt since 2010 and the internal market has reduced the productive dependence on other countries (Felipe *et al.* 2015) [9]. Many shrimp farmer respondents were of the view that the governments need to plan insurance scheme for price risk in addition to the diseases and climate change related natural perils as an adaptive measure. There is a need for new insurance products for aquaculture industry that achieves both financial gains, in terms of reduced production and revenue risk, and environmental wins, in terms of incentivizing improved management practices (Watsan *et al.* 2018) [33]. In Vietnam, the shrimp farmers expressed interest in buying insurance that covers biotic and abiotic risks faced by them (Pongthanapanich *et al.* 2019) [27]. In this contest it is to be noted that the Government of India is promoting Fish Farmer Producer Organizations (FFPOs) under the Prime Minister Fisheries Development programme (PMMSY) a flagship scheme to empower the farmers in dealing with market forces, access innovative technology and enable improved access to inputs and services thereby to increase farmer incomes (Chander, 2019; NCDC, Govt. of India, 2021) [6, 23].

Similarly to minimise the disease risks sourcing quality seed by adoption of comprehensive seed selection protocol comprised of physical, chemical and molecular screening, optimising seed stocking density as per the pond carrying

capacity and adoption of on-farm nursery to ensure supply of quality shrimp seed. In addition skill development programmes need to be conducted on priority basis for farmers on better management practices of shrimp farming and farm level biosecurity measures to fine tune their capacity to prevent and spread of disease carrying pathogens. Strengthening social capital, the farmer associations at cluster level is important to enforce the adoption of farm level bio-security measures and collective compliance of better management practices with a cluster based approach (Kumaran, 2012; World Bank Report, 2014; Joffre *et al.* 2020) [20, 13].

Influence of farmer profiles characteristics with their risk perception

Differences in profile characteristics can influence the risk perception behaviour of farmers. The results of the non-parametric testes are given the Table-3 indicated that educational level, farm size, member in farmer association and participation in training programmes shown significant influence in the risk perception of shrimp farmers. Farmers with higher education may have consulted more information sources and kept themselves updated on production risks and their prevention which might have influenced their risk behaviour. Similarly, presence of strong farmer associations facilitated in getting quality seed and negotiated with input dealers and buyers for better price, hence, it could have facilitated in risk management. Likewise larger farmers due to their wider contacts and better infrastructure facilities at farm level may have exhibited different risk perception behaviour. Therefore, promoting and strengthening group approach to shrimp farming and undertaking capacity development programmes for farmers on risk management may aid in better prevention and management of risk factors associated with shrimp farming (Umesh *et al*., 2008; Kumaran, 2009) [32, 18].

Table 1: Personal profile of shrimp farmers (n=240)

S. No	Variables	Percentage of respondents (n=240)
1	**Educational status**	
	a) Up to Middle school level	13.50
	b) Matriculation (up to 10th	19.50
	c) Higher Secondary (10th +2)	39.50
	d) Graduation	20.00
	e) Diploma	4.50
	f) Post-Graduation	2.50
2	**Farming experience**	
	a) <10 years	48.30
	b) 11 to 20 years	51.70
3.	**Member of farmers association**	
	a)Yes	65.00
	b)No	35.00
4	**Production system**	
	a) Low saline	80.80
	b) Brackish water	19.10
5.	Farm size	
	a) ≤2 ha	20.80
	b) 3 to 5 ha	37.50
	c) > 5 ha	41.60
6.	**Training in shrimp farming**	
	a) Yes	40.00
	b) No	60.00
7.	**Crop intensity**	
	a) Two crops/year	90.00
	b) Three crops/year	10.00
8.	**Perceived farming success rate**	
	a) >75 percent	40.00
	b) 50-75 percent	54.50
	c) <75 percent	5.40
9.	**Information seeking behaviour* Multiple response**	
	a) DoF/MPEDA-NaCSA/Res.Instt./ Institutional	10.00
	b) Private companies/Aqua consultant	98.00
	c) Print & Social media/Internet	68.00
10.	**Avg. Farm productivity /ha**	
	a) Upto 4 t/ha	1.56
	b) 5 to 8 t/ha	84.44
	c) >8 t /ha	14.00

Table 2: Risk perception and assessment by shrimp farmers and extension professionals

Sl. No	Risk category	Mean risk score of farmer respondents and risk ranking (n=240)	Mean risk score of extension professionals and risk ranking (n=60)
1	Market and price risks	24.67±0.96 (I)	20.85±3.53 (III)
2	Poor seed quality	24.48±1.63 (II)	24.58±1.39 (I)
3	Disease risk	24.30±1.24 (III)	20.59±2.03 (V)
4	Poor pond preparation	20.15±3.07 (IV)	20.78±3.82 (IV)
5	Poor biosecurity and farm infrastructure	19.82±3.08 (V)	21.03±4.10 (II)
6	Social risks	17.63±3.36 (VI)	16.53±4.54 (VI)
7	Climate and water quality risks	16.33±1.58 (VII)	15.61±2.73 (VIII)
8	Institutional risks	16.26±3.89(VIII)	14.67±3.36 (IX)
9	Poor feed management	15.87±2.28 (IX)	15.90±4.05 (VII)
Mann Whitney U test statistics indicate a significant difference in the risk perception of the two groups (P value < 0.05)			

Matrix 1: Risk Matrix of shrimp farming as perceived by the shrimp farmers (n=240)

Impact Likelihood	Disastrous (5)	Extremely Negative (4)	Moderately Negative (3)	Minor Negative (2)	Slightly negative (1)
Very high (5)	1. Market price (High input costs Low sale price; Inadequate bargaining power; Oligopsony market structure, lack of domestic consumption) 2. Disease (EHP, WFS and WSSV)	3. Poor seed quality; 4. Poor biosecurity & farm infrastructure; 5. Poor pond preparation.			
High (4)		6. Poor feed management; 7. Social risks; 8. Institutional risks	9. Climate & water quality risks		
Likely (3)					
Low (2)					
Very Low (1)					

Table 3: Influence of farmer profile characteristics with their risk perception

S. No	Profile characteristics	Mean risk perception score	Non-parametric statistic	Significance level
1	**Farming experience**		Kruskal Wallis test score 2.79 ($p > 0.05$)	Non-significant
	a) <10	16.90±1.11		
	b) 11 to 20	16.74±1.11		
	c) > 20	16.70±0.86		
2	**Educational status**		Kruskal Wallis score 24.3 ($p<0.05$)	Significant
	a) Up to Middle school level	17.20±1.09		
	b) Matriculation	17.09±1.37		
	c) Higher Secondary	16.65±0.98		
	d) Graduation	16.59±0.91		
	e) Diploma	17.03±1.25		
	f) Post-Graduation	16.01±0.00		
3	**Member of farmers association**		Mann Whitney U test score 4708.5 ($p<0.05$)	Significant
	a) Yes	17.13±1.12		
	b) No	16.64±1.05		
4	Production system		Mann Whitney U score: 5241.0 ($p<0.05$)	Non-significant
	a) Low saline	16.77±1.08		
	b) Brackish water	17.01±1.14		
5	**Farm size**		Kruskal Wallis score: 13.02 ($p<0.05$)	Significant
	a) ≤2 ha	15.87±0.87		
	b) 3 to 5 ha	16.96±1.07		
	c) > 5 ha	16.83±1.10		
6	**Training in shrimp farming**		Mann Whitney U score: 4255.00 ($p<0.05$)	Significant
	a) Yes	17.10±1.12		
	b) No	16.39±0.92		
7	**Crop intensity**		Mann Whitney U score: 2718.00 ($p>0.05$)	Non-significant
	a) 2 crops/year	16.78±1.08		
	b) 3 crops/year	17.16±1.25		
8	Productivity		Kruskal Wallis Score 4.85 ($p<0.05$)	Not significant
	a) Upto 4 ton/ha	17.37±0.55		
	b) 5 to 8 ton/ha	16.75±1.09		
	c) >8 ton /ha	17.07±1.17		

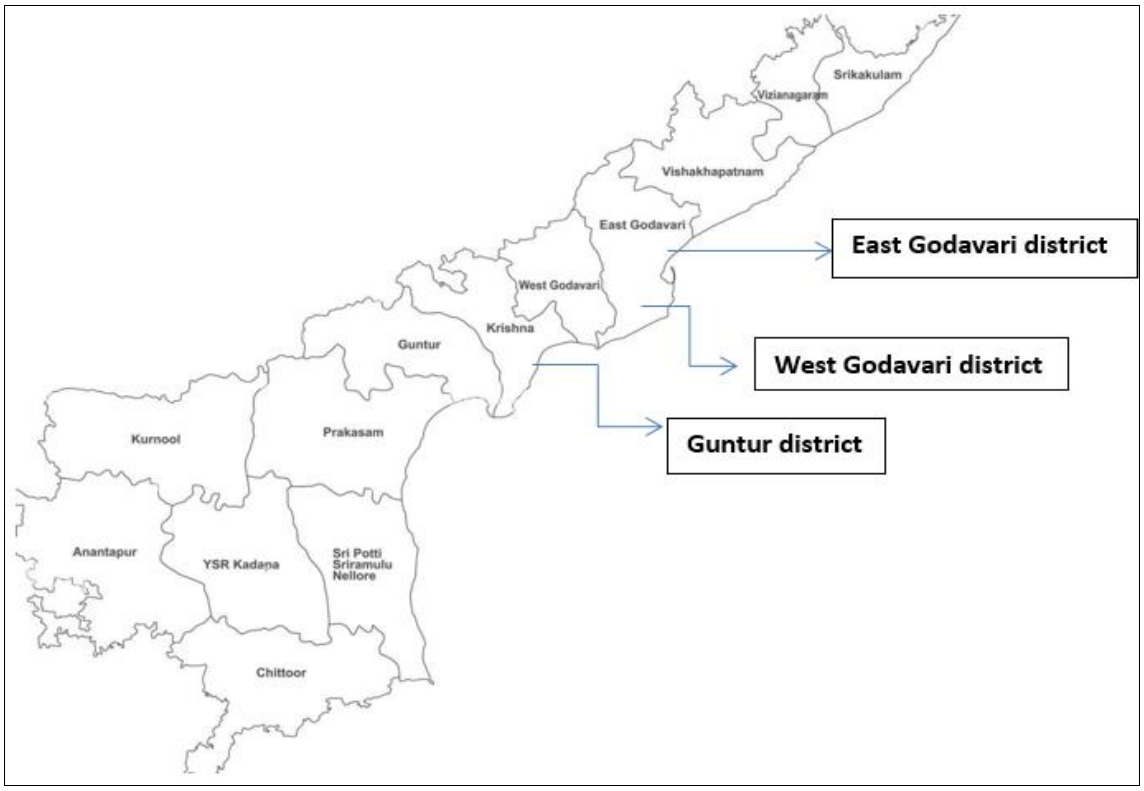

Fig 1: Study Area Andhra Pradesh State, India

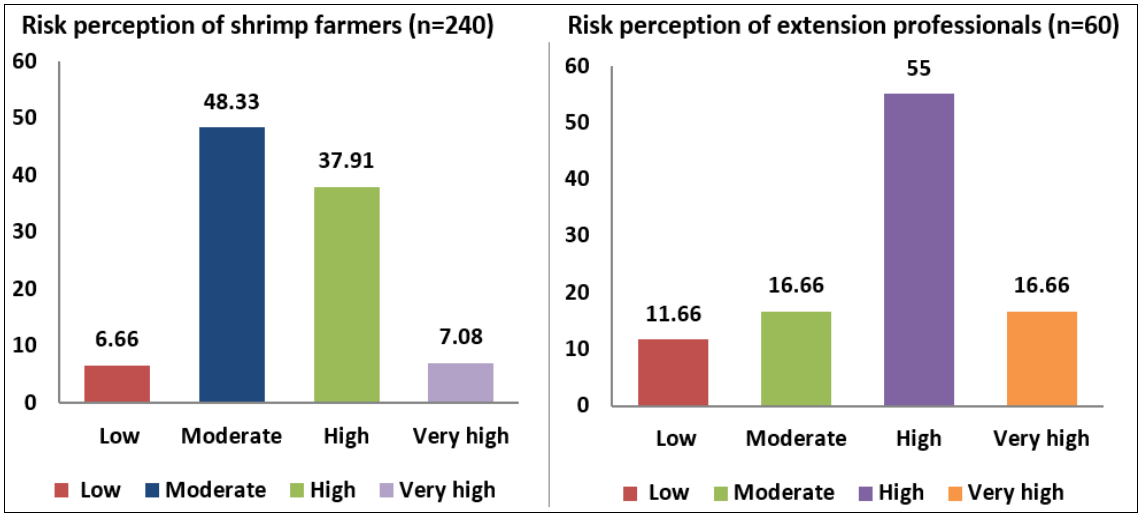

Fig 2: Risk perception of the respondents

Conclusion

Shrimp farming is an intensive production system and producing a high value produce, hence, subject to production and income risks. The respondents of the study assessed that market price and diseases were two major risks in shrimp farming at present. Therefore, market demand based farming, when to supply, what size and strengthening farmers' social capital to enhance their bargaining power vis-à-vis inputs suppliers and shrimp buyers are the strategy to minimize the market risk. Similarly, quality seed selection and stocking density as per the carrying capacity of ponds, adoption of farm biosecurity and better management practices by the farmers are essential to prevent and manage production risks. Implementing shrimp crop insurance inclusive of parametric, disease and price coverage, promoting domestic consumption and market intelligence are also important as institutional measures to minimize the risks and enhance the profitability of in shrimp farming.

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