RESULTS OF BMP APPLYING TO SHIMP CULTURE IN NORTH CENTRAL VIETNAM

Nguyen Xuan Suc
Research Institute for Aquaculture 1

I. INTRODUCTION

Household shrimp production is the predominant form of coastal aquaculture in Vietnam. In 2006, approximately 459,000 tonnes of shrimp was produced comprising 12% of total fisheries production in Vietnam (USDAFAS 2007). Approximately 34% of shrimp production (158,000 tonnes) was exported at a value of USD 1.46 billion. Shrimp production is increasing, with an average of 13% growth experienced each year from 2000 to 2006 (USDAFAS 2007).

In recent years, residues and contaminants have been detected in exported shrimp, with devastating results in markets. In 2003, five consignments from Thua Thien-Hue province to the European Union were destroyed or returned because of the presence of residues and a far larger quantity from all north central provinces were similarly treated in 2004. The loss of production, negative environmental and socio-economic impacts, and food safety concerns has provided impetus for the development and extension BMP for shrimp farms. BMPs have been used in many countries to implement the more general principles of responsible shrimp farming (FAO 2005). BMPs are voluntary and are becoming widely used as an important strategy to enhance the marketability of aquaculture product.

A number of projects have contributed to the development of practical BMPs for shrimp farming in Vietnam (e.g. a DANIDA-funded and a NAFIQAVED). These projects have proposed specific BMPs and have conducted some small-scale testing of these BMPs. Their findings have not yet been widely disseminated among producers and BMP implementation is still limited. The benefits of applying BMP to household farms remain to be fully investigated. However, experience in Thailand, India and Bangladesh has shown that small-scale farmers who applied BMPs made gains in efficiency, productivity and quality (SUMA, 2004).

This report presents the key results of project that “Technical and economic feasibility of applying the Better Management Practices (BMP) to household aquaculture in Vietnam". Project focused on BMP applying to shrimp culture of small-scale households in North Central (include Nghe An, Ha Tinh and Thua Thien Hue provinces). Two main issues which are presented in this report includes impact of BMP applying to environmental and economic indicators of shrimp households

II. OBJECTIVES

The overall objective of this project is to investigate the effectiveness of BMP application to small-scale household farms through reducing negative environmental impacts, increasing yields, lowering risks and improving product quality - thereby contributing significantly to long-term poverty alleviation and income generation for households directly involved in aquaculture production chains.

The short term objectives of the project are: a) to carry out an analysis of current status of household aquaculture and identify incentives and constraints to BMP application; b) to develop appropriate BMP guidelines and manuals for household aquaculture in the North Central region of Vietnam; and c) to build capacity for BMP application among stakeholders involved in aquaculture product market chains, especially smallholder producers.

III. METHODOLOGY

Baseline study for assessment of BMP status: Standardised surveys and participatory assessment methods were developed and used for assessing current aquaculture status, incentives and constraints of farmers to BMP application and draft BMP action plans for demonstration at household farm level. In each province 30 household farms were sampled. Data were processed and analysed to serve as the basis for demonstration farm selection and kept as baseline indicators for comparison with demonstration and control farms during and after the project implementation.

On farm trials for BMP development: Two types of common farming systems practiced by household farmers: semi-intensive and improved extensive. In the semi-intensive systems, a group of 20-30 farms in each province was selected and be encouraged to form an aqua-club or association for BMP demonstration. BMP practices will be promoted and shared among group members throughout the project implementation period. Each semi-intensive group, one household farm was selected to demonstrate BMP application through experiment treatment. To be considered for selection, household farms need to already conform to some initial criteria for BMP such as appropriate infrastructure and irrigation systems. In the improved extensive systems, two groups of 20-30 farms per province were selected and encouraged to form aqua-clubs or associations and the applying procedure is similar to the semi-intensive.

BMP protocol for demonstration in the project sites has been developed. These tentatively include: practices of pond preparation, seed selection and stocking, feed and feeding management, water quality management, disease management, post-harvest handling and product control. Post-larvae that are free of white spot disease (WSD) and Monodon Baculovirus (MBV) are used in trials. Some data (observations of shrimp health, feed tray clearance, water quality data) were collected daily by farmers using field test kits and equipment. Farmers were given a farm record book to write all practices, data recordings, seed, and feed and water inputs he/she applies to the farm. Environmental data (salinity, pH, DO, BOD, NH3, NO2) were collected and analysed monthly by project staff. Shrimp product samples were checked for chemicals and antibiotic residues one month before harvest (with specific analysis for contaminants banned by EU).

Building capacity for BMP implementation: During the project implementation, capacity of stakeholders for BMP implementation were built through participating in project meetings, training courses, workshops, cross visits and study tours.

IV. RESULTS AND DISCUSSIONS.

4.1 Environmental Quality of Shrimp Aquaculture Systems

Transparency: It is recommended that transparency remain between 25 and 40 cm for maximum production (Boyd 1990). If transparency is less than 25 cm and the pond is too turbid with phytoplankton, this may create problems with dissolved oxygen. If the reading is greater than 40 cm then the phytoplankton is too scarce. Transparency readings were found to be above the maximum level at the start of the production period in ponds of all three provinces, decreasing to within recommended levels half way through the season in Ha Tinh and Nghe An. While transparency readings were higher than recommended in the inlets and outlets of all provinces, transparency is considered to be an indication of pond condition and phytoplankton density, and is therefore less important in the inlet and outlet channels. Transparency levels in the inlet and outlet are unlikely to have an impact on the

environment, or affect food safety, as it is purely an optimal range for the best growth of the shrimp. Plankton blooms favour greater shrimp production by stimulating the growth of shrimp food organisms and it also limits the visibility of the shrimp from predatory birds, thus reducing stress to the target species allowing them to roam and feed, and develop more quickly.

Salinity: There is very little difference in salinity levels between water sources in any provinces. It is recommended that for maximum production, salinity levels remain between 15 and 25 % (Boyd 1990). Salinity levels remained between this range in Nghe An, but increased to 27 % by the end of the cultivation period in Ha Tinh, and dropped below this range mid-season in Thua Thien-Hue due to heavy rainfall which is common for that time of year. Salinity levels in the inlet and outlet during and at the end of the trial are unlikely to have an impact on the environment or food safety. Ha and Suc (2007) indicates a range of 13-24 ‰ for the three areas prior to stocking.

pH: It is recommended that for maximum shrimp production, pH remain between 7.5 and 8.5 (Boyd 1990). The pH of the culture pond was consistently within this range throughout the season in all provinces. pH levels were lower than recommended in inlets and outlets in Nghe An and in the inlets in Ha Tinh, although this does not have an impact on shrimp production if pH levels are correct within the ponds themselves. pH levels in inlet and outlet canals during and at the end of the trial is unlikely to have an impact on the environment or food safety. The baseline data report (Ha and Suc 2007) indicates a range of 6-8.30 for the three areas prior to stocking.

Dissolved oxygen (DO): Generally, dissolved oxygen levels are highest in the inlets, and lowest in the outlets. Dissolved oxygen of the culture pond at Ha Tinh and Thua Thien-Hue sat above 5.5 mg/l (above 5 mg/l being optimal) even though the outlet pond readings did drop below 4.5 mg/l. At Nghe An, dissolved oxygen dropped below 5 mg/l for most of the season and ended at around 3.75 mg/l. Despite the dissolved oxygen of the outlet pond in Ha Tinh dropping to around 2.75 mg/l at the end of the season, the culture pond stayed at a stable 5.5 mg/l. As shrimp spend most of their time on the pond bottom, the mud/water interface and its oxygen content is very important. Almost all muds are devoid of oxygen below a depth of a few centimetres because of poor water circulation and microbial activity within the mud. Maintenance of oxygenated conditions at the mud surface is particularly important in shrimp ponds as oxygen is needed for shrimp and food organism respiration, it promotes microbial degradation of organic matter, and prevents the release of toxic, reduced substances such as hydrogen sulphide and nitrite (Boyd 1990). If the readings where taken at the same position each time in the culture ponds it may be that there were other stagnant areas of the pond, which were not aerated and circulated properly, hence causing an overall reduction of oxygen in the system. DO at these levels are unlikely to affect food safety, however DO levels in outlets that fall lower than 5mg/l may have an impact on the environment, and plants and animals in the surrounding aquatic ecosystem. Under normal stream conditions 3.0mg/l or less, of DO is regarded as hazardous for a significant variety of fish fauna (Ellis 1937).

Water temperature: There was little difference in the water temperature between water sources in any of the provinces. For shrimp production, it is recommended that the temperature remains between 25 and 33^{o}C for maximum production. Temperature remained within this range in all provinces. Temperature increased over the season in all provinces, and experienced significant increases mid-season in TT-Hue and Nghe An corresponding to the drop in salinity and pH of the water.

Ammonia (NH_3): Ammonia levels were consistently low in all water sources and provinces throughout the season. Levels were below 0.1 mg/l in all sources, which is the maximum recommended level for Vietnam (internationally, Chin & Chen (1987) consider 0.13 mg/l of ammonia to be a safe level for shrimp pond conditions). Generally, ammonia levels were found to be higher in the outlets than in the ponds and inlets. Levels of ammonia in the outlet channels were not significantly high and would be unlikely to impact the environment or food safety standards. Ammonia is more toxic when dissolved oxygen concentration is low, however with increasing carbon dioxide (which occurs when DO is low) the toxicity of ammonia decreases (Boyd 1990).

Alkalinity: Alkalinity averaged approximately 85 mg/l in all water sources, although it increased significantly to approximately 100 mg/l in Ha Tinh during the end of the data collection period. This increase corresponds to a drop in temperature, salinity and pH. Alkalinity in all water sources generally remained within the safe range of 80-120 mg/l. Alkalinity is defined as the sum of exchangeable bases reacting to neutralise acid when an acid is added to water. Alkalinity plays two important roles in water. Bicarbonates, and carbonates to a lesser degree, are a storehouse of carbon needed in photosynthesis for phytoplankton growth. They also constitute the major buffering system to reduce fluctuations in pH. Alkalinity levels in outlets and inlets at all times during the trial was unlikely to have any impact at all on the environment or affect food safety.

Nitrite: There are significant differences in nitrite levels across provinces and water sources. It is recommended that nitrite levels remain below 0.30mg/l to maximise shrimp production. Whilst sub-lethal concentrations of nitrite increases the susceptibility of fish to bacterial diseases (Hanson & Grizzle 1985), nitrite levels were significantly lower than this level for all water sources in Thua Thien-Hue, and generally for inlets and ponds in Ha Tinh and Nghe An. As there are many factors which affect the nitrite toxicity in fish and shrimp ponds (e.g. chloride concentration, pH, animal size, previous exposure, nutritional status, infection and dissolved oxygen concentration (Schwedler et al. 1985)), it is difficult to pinpoint one variable. However, attention to dissolved oxygen is again highlighted as important.

Sulphides: It is recommended that sulphides remain below 0.2mg/l for maximum production. Sulphide levels in Thua Thien-Hue were consistently and significantly below this level for all water sources in Thua Thien-Hue, and for inlets and ponds in Ha Tinh and Nghe An. Sulphide levels were higher than recommended in the outlets in Nghe An, and in Ha Tinh at the beginning of the season. Toxic amounts of hydrogen sulphide block the electron transport system and stops oxidative respiration. Blood lactate concentrations also increase and anaerobic glycolysis is favoured over aerobic respiration, suggesting that the toxic effect is hypoxia. Therefore, increased levels of dissolved oxygen are desirable (Boyd, 1990). Hydrogen sulphide toxicity is also more common in acidic environments as pH decreases. As hydrogen sulphide is toxic at low concentrations and egg survival and fry development of fish can be limited by 0.006mg/l H_2S, impact on the environment should be monitored. If the pond water can be aerated prior to discharge this would minimise the environmental impact of H_2S. At the levels reflected in these data food safety is not a concern.

4.2 Shrimp product quality analysis results

Shrimp product quality samples in crops of 2007 and 2008 were analysed and collected by officials from Vietnam's National Fisheries Quality Assurance and Veterinary Directorate (NAFIQAVED) – the agency which controls food safety and veterinary services for seafood products. The data includes chemical and microbiological analysis (Table 1). Results

indicate non-existent amounts of almost all compounds, except a negligible positive result for Furazolidone (AOZ) in ponds 8 and 9 in 2007 (Ha Tinh province) and Salmonella in ponds 2 and 3 (Thua Thien-Hue province in 2007) and pond 1 in Ha Tinh in 2008. While the Salmonella detected is of most concern, there is little likelihood that it would impact on the health of the shrimp, nor is it likely to affect food safety or off-side environmental conditions.

Table 1: Chemical and microbial analysis of shrimp products.

Pond	Year	Chemical analysis					Microbial analysis			
		CAP (µg/kg)	AOZ (µg/kg)	AMOZ (µg/kg)	AHD (ppb)	SEM (ppb)	TPC	E. coli	Salmon-ella	V. ch
TTH1	2007	ND	ND	ND	ND	ND	5.5*100,000	Neg	Neg	Neg
	2008	ND	ND	ND	ND	ND	4.7*100,000	Neg	Neg	Neg
TTH2	2007	ND	ND	ND	ND	ND	6.5*10,000	Neg	Pos	Neg
	2008	ND	ND	ND	ND	ND	7.1*10,000	Neg	Neg	Neg
TTH3	2007	ND	ND	ND	ND	ND	6.5*10,000	Neg	Pos	Neg
	2008	ND	ND	ND	ND	ND	6.2*10,000	Neg	Neg	Neg
NA1	2007	ND	ND	ND	ND	ND	2.7*10,000	<10	Neg	Neg
	2008	ND	ND	ND	ND	ND	2.3*10,000	<10	Neg	Neg
NA2	2007	ND	ND	ND	ND	ND	1.2*100,000	<10	Neg	Neg
	2008	ND	ND	ND	ND	ND	1.4*100,000	<10	Neg	Neg
NA3	2007	ND	ND	ND	ND	ND	2.9*100,000	<10	Neg	Neg
	2008	ND	ND	ND	ND	ND	1.8*100,000	<10	Neg	Neg
HT1	2007	ND	ND	ND	ND	ND	4.1*10,000	<10	Neg	Neg
	2008	ND	ND	ND	ND	ND	5.3*10,000	<10	Pos	Neg
HT2	2007	ND	Pos	ND	ND	ND	3.7*10,000	<10	Neg	Neg
	2008	ND	ND	ND	ND	ND	4.0*10,000	<10	Neg	Neg
HT3	2007	ND	Pos	ND	ND	ND	4.3*10,000	<10	Neg	Neg
	2008	ND	ND	ND	ND	ND	3.9*10,000	<10	Neg	Neg

Coding: CAP: Chloramphenical; AOZ: Furazolidone; AMOZ: Furaltadone; AHD: Nitrofurantoin; SEM: Nitrofurazone; TPC: Total plate count; E. coli: Escherichia coli; V. ch: Vibrio cholerae**;** ND: Not Detected; Neg: Negative; Pos: Positive; TTH: Thua Thien Hue; NA: Nghe An; HT: Ha Tinh

4.3 Household shrimp production

This sub-section presents the household production results of 3 provinces (Nghe An, Ha Tinh and Thua Thien Hue). It is also compared the economic analysis results of 3 household groups that are applied BMP (BMP), non-applied BMP (Non-BMP) and baseline survey (Baseline)

Shrimp harvesting size and productivity.

The analysis results of shrimp harvesting sizes and productivities are presented in Table 2. Comparison among provinces, shrimp harvesting size of Nghe An in BMP group was biggest (23.7 g/shrimp on average) and smallest at Ha Tinh in non-BMP farmers (16.2 g/shrimp). The difference of two these mean was significant (about 32%). Comparison among groups, the average of harvesting size of BMP group was bigger than two other

groups non-BMP and Baseline (20.4 compare to 18.2 and 17.1 g/shrimp). The differences of shrimp size among groups was not much, however this was a significant effected to total income because of shrimp prices. Normally, big shrimp size is higher price. For example, shrimp size at 30 g/individual in Nghe An has price of 100 thousand VND/kg. At the same time, shrimp size at 25 g/individual has price of 80 thousand VND/kg.

Table 2. Harvesting size and productivity.

Indicator	Province	BMP	Non-BMP	Baseline	Average
Harvesting size (g/shrimp)	Nghe An	23.7	17.5	17.3	19.5
	Ha Tinh	19.0	16.2	20.5	18.6
	TT-Hue	20.4	17.7	17.2	18.4
	Average	**19.7**	**17.1**	**18.2**	**18.3**
Productivity (kg/ha)	Nghe An	2,172	1,330	1,470	1,657
	Ha Tinh	1,078	904	480	821
	TT-Hue	1,483	1,264	1,280	1,342
	Average	**1,578**	**1,166**	**1,080**	**1,275**

In general, the productivities of shrimp culture in study areas fluctuate between 0.5 to 2.2 tonnes/ha. Nghe And has productivity highest in all 3 groups of BMP, non-BMP and Baseline which were 2,172; 1,330 and 1,470 kg/ha, respectively. In contrast, productivity in Ha Tinh province was lowest, fluctuation between 480 and 1,078 kg/ha. The difference of productivity between highest and lowest show that it was significant difference (about 78%). Comparison among groups of farmers, the average of productivity of BMP was highest (1,578 kg/ha), follow by non-BMP and Baseline groups (1,166 kg/ha and 1,080 kg/ha, respectively). There was a significant difference of productivities between BMP with non-BMP and Baseline households, the percentage of differences were 26% and 32%, respectively. Productivity of shrimp culture is based on many different factors, but two major factors that were investment rate and disease outbreak.

Pond preparation cost

Table 3 presents the hire labor cost, fertilizers and lime cost during pond preparation. The hire labor cost of BMP, non-BMP groups were lower than that of Baseline in both values and percentages, however, the differences were not significant. Comparison among provinces, the value of hire labors cost of Nghe An province was nearly double higher than that of Ha Tinh and Thua Thien Hue (4.6 mil. VND compare to 2.8 mil. VND/ha). However, if comparison of percentage, hire cost of Nghe An was lower than that of Ha Tinh (6% compare to 8%). It was note that the hire cost of Ha Tinh in Baseline data occupies 17%, but in Nghe An and TT-Hue were only 3% and 6%, respectively.

Table 3. Hire labor, fertilizers and lime costs.

Indicator	Province	BMP	Non-BMP	Baseline	Average
Hire labor cost ('000 VND/ha)	Nghe An	6,510 (6)	4,424 (6)	2,890 (5)	4,608 (6)
	Ha Tinh	1,749 (4)	1,707 (4)	5,160 (17)	2,872 (8)
	TT-Hue	2,627 (3)	2,734 (5)	3,160 (5)	2,840 (4)
	Average	**3,629 (4)**	**2,955 (5)**	**3,740 (7)**	**3,441 (5)**
Fertilizers and lime cost ('000 VND/ha)	Nghe An	3,143 (3)	3,652 (6)	1,540 (2)	2,778 (4)
	Ha Tinh	1,366 (2)	1,280 (3)	1,340 (4)	1,329 (3)
	TT-Hue	2,973 (4)	1,920 (3)	1,140 (2)	2,011 (3)
	Average	**2,494 (3)**	**2,284 (4)**	**1,350 (2)**	**2,043 (3)**

Notice: Numbers in bracket ( ) show % compare to total cost

For fertilizer and lime costs, in general, the average of this cost was about 2 mil. VND/ha and occupies 3% compare to total cost. Comparison between BMP, non-BMP households with Baseline group, there was a noticeable difference of value this cost (2.5 and 2.3 compare to 1.3 mil. VND/ha). However, comparison of percentage of fertilizers and lime costs shows not much difference among groups of BMP, non-BMP and Baseline (3%, 4% and 2%, respectively). And there was also no significant difference among provinces in term of percentage of fertilizers and lime cost, fluctuation between 2 to 6%.

Shrimp seed and feed costs.

Shrimp seed and feed cost are presented in Table 4. Seed and feed cost, normally, occupy a biggest cost in shrimp aquaculture. Seed cost, in general, on average, occupies 13% of total cost and value at 7.8 mil. VND/ha. There was no significant differences of seed cost among 3 groups of BMP, non-BMP and Baseline (12%, 14% and 13%, respectively). The percentages of seed cost were also not much different between provinces of Nghe An, Ha Tinh and TT-Hue. Nghe An has the lowest of seed cost (9%), this cost occupies about 15% in two other provinces

Feed cost was the biggest compare to other costs in shrimp operation. On average, feed cost occupies 61% of total cost and value at 38 mil. VND/ha. Comparison among groups of BMP, non-BMP and Baseline, the lowest of percentage of feed cost was in BMP group (57%). In contrast, in value of seed cost, Nghe An was highest (approximate 44 mil. VND/ha) and lowest in baseline households (33.7 mil VND/ha). There was a remarkable difference in seed cost among provinces and fluctuation between 47 and 72% of total cost. The percentage of feed cost depended on 2 major factors that were feed quality (or price) and feeding management. In term of over feeding, it was not only over-expenditure but also results in water pollution.

Table 4. Shrimp seed and feed cost

Indicator	Province	BMP	Non-BMP	Baseline	Average
Seed cost ('000 VND/ha)	Nghe An	10,102 (9)	7,865 (11)	4,510 (7)	7,492 (9)
	Ha Tinh	8,362 (15)	7,066 (15)	4,580 (15)	6,669 (15)
	TT-Hue	8,089 (12)	8,958 (15)	9,630 (15)	8,892 (14)
	Average	**8,851 (12)**	**7,963 (14)**	**6,740 (13)**	**7,851 (13)**
Feed cost ('000 VND/ha)	Nghe An	59,492 (53)	42,345 (60)	44,500 (72)	35,429 (62)
	Ha Tinh	32,082 (59)	28,975 (61)	14,140 (47)	25,066 (58)
	TT-Hue	40,238 (58)	36,821 (63)	42,440 (66)	39,833 (62)
	Average	**43,937 (57)**	**36,047 (61)**	**33,690 (65)**	**37,891 (61)**

Notice: Numbers in bracket ( ) show % compare to total cost

Bio-product, chemical, energy and other costs.

Values and percentages of bio-products, chemicals, energies and other costs are showed in Table 5. On average, cost of bio-product and chemical occupies 7% of total cost and value at approximately 5 mil. VND/ha. Non-BMP group has highest of this cost (9%), follow by BMP farmers (7%) and baseline data (5%). There was a significant difference in this cost of different provinces in both values and percentages. The proportion of bio-products and chemicals costs of Nghe An, Ha Tinh and TT-Hue were 10%, 8% and 4% of total cost, respectively. In value, this cost in Nghe An was four times and double higher than that of Nghe An and TT-Hue, respectively.

Energy in shrimp aquaculture in this study were used for two major purposes that were pump and paddle-wheel operation. Energy that was used to light ponds area was not much. On average, energy cost was nearly 5 mil. VND/ha and occupies about 7% of total cost. There was a considerable differences of energies cost in both percentages and values of BMP, non-BMP and Baseline groups, which were 11%, 3% and 7%; and 9 mil., 2 mil., and 3,7 mil. VND/ha, respectively. Comparison among provinces, energy cost also had significant differences in both value and percentages (fluctuation between 1 mil. to 13.7 mil. VND/ha and 2% to 13%)

Other costs, on average, occupy 6% of total cost and value at 2.5 mil VND/ha. The fluctuation of this cost was high in both value and percentages. In value, it was fluctuated between 0.1 to 5 mil. VND per ha, and highest in TT-Hue of BMP household at 5.4 mil. VND/ha, and lowest in Ha Tinh of Baseline data at 0.1 mil./ha. In percentages, on average, it was shared between 2% to 5%. Comparison of average values of other costs, there was a measurable differences among groups BMP, non-BMP and Baseline which were 4.2 mil., 2.2 mil., and 0.8 mil. VND/ha.

Table 5. Bio-product and chemical, energy and other costs

Indicator	Province	BMP	Non-BMP	Baseline	Average
Bio-product and chemical cost ('000 VND/ha)	Nghe An	15,603 (14)	6,671 (10)	3,380 (5)	8,551 (10)
	Ha Tinh	2,951 (5)	5,406 (11)	2,030 (7)	3,462 (8)
	TT-Hue	1,037 (2)	3,199 (6)	2,890 (4)	2,375 (4)
	Average	**6,530 (7)**	**5,092 (9)**	**2,780 (5)**	**4,801 (7)**
Energy cost ('000 VND/ha)	Nghe An	13,694 (12)	3,230 (5)	4,540 (7)	7,155 (8)
	Ha Tinh	4,482 (8)	1,043 (2)	2,820 (9)	2,782 (6)
	TT-Hue	8,780 (13)	1,803 (3)	3,670 (6)	4,751 (7)
	Average	**8,985 (11)**	**2,026 (3)**	**3,680 (7)**	**4,897 (7)**
Other costs ('000 VND/ha)	Nghe An	3,704 (3)	2,036 (3)	650 (1)	2,130 (2)
	Ha Tinh	3,662 (7)	1,944 (4)	110 (0)	1,905 (4)
	TT-Hue	5,393 (8)	2,734 (5)	148 (2)	2,758 (5)
	Average	**4,253 (6)**	**2,238 (4)**	**850 (2)**	**2,447 (4)**

Notice: Numbers in bracket ( ) show % compare to total cost

Total income, total cost and benefit

Table 6 presents the results of total cost, total income and benefit of BMP, non-BMP and Baseline groups in provinces of Nghe An, Ha Tinh and TT-Hue. In this study, on-farm labors and opportunities costs were not counted in total cost.

For benefit, general average benefit calculating for all groups at all provinces was about 20 mil. VND/ha. The fluctuation of benefit of different provinces in different group was very high and ranging between 0.6 to 53 mil/ VND/ha. Comparison among groups of BMP, non-BMP and Baseline, showed there were noticeable differences of benefit. Benefit of BMP households was around double that of non-BMP and baseline groups (30.8 compared to 13.8 and 16.4 mil. VND/ha). On average, benefits from shrimp culture in Nghe An, Ha Tinh and TT-Hue were 32.6, 7.9 and 19.5 mil. VND/ha, respectively. In each province, fluctuation of benefit among groups was also big (Nghe An between 17.5 and 52.8, Ha Tinh between 0.6 and 14.4, TT-Hue between 16.4 and 24.3 mil. VND/ha).

For total cost, the general average value of total cost for shrimp culture of study areas was 63 mil. VND/ha. The fluctuation of total cost value was between 30 and 112 mil. VND/ha. Comparison among groups of BMP, non-BMP and Baseline data shows that there was a

considerable significant difference of total cost and average costs were 78.7, 58.6 and 52.7 mil. VND/ha, respectively. Between provinces, the total cost was also much different. On average, total cost of Nghe An, Ha tinh and TT-Hue were 81.5, 44 and 64 mil. VND/ha, respectively. The highest value of total cost was occupied in Nghe An of BMP group which was 112 mil. VND/ha. The smallest total cost value was in Ha Tinh of Baseline data (30 mil. VND/ha).

For total income from shrimp aquaculture operation, the general average value of total income reached at 84 mil. VND/ha. There was a big fluctuation of income of provinces which was between 31 and 165 mil. VND/ha. Comparison among groups, BMP farmers has highest income from shrimp (109.5 mil. VND/ha), follow by non-BMP and Baseline groups (72.5 and 69 mil. VND/ha). Comparison among provinces, the total income in Nghe An was double and 1.5 times higher than that of Ha Tinh and TT-Hue provinces, respectively. Total income of BMP household in all of 3 provinces was highest compare to other groups. However, total income of Baseline farms in Nghe An and TT-Hue was higher than that of non-BMP, but it was contrasted in Ha Tinh province.

Table 6. Total cost, total income and benefit of shrimp aquaculture

Indicator	Province	BMP	Non-BMP	Baseline	Average
Total cost ('000 VND/ha)	Nghe An	112,249	70,224	62,010	81,494
	Ha Tinh	54,654	47,423	30,180	44,086
	TT-Hue	69,137	58,169	64,410	63,905
	Average	**78,680**	**58,605**	**52,730**	**63,338**
Total income ('000 VND/ha)	Nghe An	165,072	87,780	89,480	114,111
	Ha Tinh	70,070	55,144	30,740	51,985
	TT-Hue	93,429	74,576	82,120	83,375
	Average	**109,524**	**72,500**	**69,160**	**83,728**
Benefit ('000 VND/ha)	Nghe An	52,823	17,556	27,480	32,620
	Ha Tinh	15,416	7,721	570	7,902
	TT-Hue	24,292	16,407	17,720	19,473
	Average	**30,844**	**13,895**	**16,430**	**20,390**

Benefit cost ratio.

Benefit cost ratio (BCR) is a very important indicator to assess the effect of shrimp aquaculture of households. BCR is measured by ratio between total income and total cost. Table 7 shows the BCR of different households groups (BMP, non-BMP and Baseline) in different provinces (Nghe An, Ha Tinh and TT-Hue).

In general average of BCR of all provinces was 1.3, it means that shrimp farms invest 1 VND, income 1.3 VND or benefit 0.3 VND. Comparison among groups, the BMP farms have the highest BCR, which was 1.37 on average, follow by Baseline and non-BMP groups (1.29 and 1.23, respectively). There was a remarkable significant difference in BCR among provinces in different groups and fluctuated between 1.02 and 1.47. The highest BCR was appeared in Nghe An province (1.29 on average) and lowest in Ha Tinh (1.30 on average)

Table 7. Benefit cost ratio (BCR)

Province	BMP	Non-BMP	Baseline	Average
Nghe An	1.47	1.25	1.44	1.39
Ha Tinh	1.28	1.16	1.02	1.15
TT-Hue	1.35	1.28	1.27	1.30
Average	**1.37**	**1.23**	**1.29**	**1.30**

Comparison of price of seed, feed and shrimp product

The price of input materials and output product is the important factors influent to the shrimp operation and income of shrimp households. In this sub-section, price of some major input materials, which were occupied high proportion of total cost (seed, feed), and shrimp product price were compared among provinces and groups of farmers. Table 8 presents the results of average value of price of seed, feed and shrimp product.

Table 8. Prices of seed, feed and shrimp product.

Indicator	Province	BMP	Non-BMP	Baseline	Average
Shrimp price (VND/shrimp)	Nghe An	42.0	44.3	35.2	40.5
	Ha Tinh	45.2	47.4	53.7	48.8
	TT-Hue	135.4	148.3	171.9	151.9
	Average	**74.2**	**80.0**	**87.0**	**80.4**
Shrimp feed price ('000 VND/kg)	Nghe An	19.0	18.5	14.0	17.2
	Ha Tinh	18.5	18.0	12.0	16.2
	TT-Hue	18.0	18.0	13.0	16.3
	Average	**18.5**	**18.0**	**13.0**	**16.5**
Shrimp product price ('000 VND/kg)	Nghe An	76.1	65.7	61.0	67.6
	Ha Tinh	65.0	61.1	64.0	63.4
	TT-Hue	63.2	59.2	64.0	62.1
	Average	**68.1**	**62.0**	**63.0**	**64.4**

For price of shrimp seed, the general price of shrimp seed of study area was 80 VND/shrimp. There was a not considerable difference in seed price among groups of BMP and non-BMP and Baseline. The price of seed of Baseline was slightly higher than that of two other groups (87 compare to 72 and 80 VND/shrimp). It was reality that the price of shrimp seed in 2007 and 2008 was cheaper than previous years, but the decrease of seed was not much over time. Comparison among provinces, the shrimp seed price of TT-Hue province was highest, approximate 3 times higher than that of other provinces. This was due to the shrimp seed size in TT-Hue was bigger (P45) than that of Nghe An and Ha Tinh provinces (P15).

For shrimp feed price, the average price of shrimp feed for all provinces of all groups was 16.5 thousand VND/kg. Feed price of baseline data was significant higher than that of BMP and non-BMP groups, the difference in price was about 5 thousand VND/kg, equivalent to 28%. The feed price was not much different among provinces. Feed cost occupies about 61% of total, so the increase of feed price over last 2 years has a negative impact on shrimp operation and income of shrimp households.

For shrimp harvesting product price, the general average of shrimp product price was 64 thousand VND/kg, one thousand higher compare to Baseline data. The BMP group had the highest shrimp product price which was 68 thousand VND/kg, and lowest price was at non-BMP group (62 thousand VND/kg). Normally, the bigger shrimp was sold with higher price, this was right in this case because the harvesting size of shrimp of BMP was bigger than that of other groups. The price of shrimp product in different provinces was not measurable differences, except shrimp product price of BMP farmers in Nghe An was much higher than that of other provinces. In general, the increase of shrimp product price was not much compare to baseline data (about 1.5%), however, the feed (main cost) quickly increased (increase 28%). Therefore, this was a constraint of shrimp operation in Vietnam, in general and in projects' areas, in particular.

V. CONCLUSIONS

Environmental indicators

- Environmental data reflected ongoing problems with transparency with readings being over the acceptable maximum level of 40 cm, some also fell below the minimum of 25 cm. If transparency is less than 25 cm and pond is too turbid with phytoplankton this may create problems with dissolved oxygen. If the reading is greater than 40 cm then the phytoplankton is too scarce.
- Results correlated with all ponds beginning in the optimal range, ponds in Nghe An and Ha Tinh rising steadily towards the end of the season and finishing over the optimal range at 27%. TT-Hue reflected an aberration with a sharp drop mid season to below the optimal range then rising gradually. Fluctuations in salinity are especially critical when shrimp moult.
- Low dissolved oxygen was problematic in the early mornings for most ponds. Some ponds suffered low dissolved oxygen both in morning and afternoon, with corresponding poor health, growth rates and increased shrimp mortality. Low dissolved oxygen levels are easily alleviated with aeration; hence it is highly recommended that effective aeration be put in place for future seasons and used at the applicable times of the day.
- All areas had temperature fluctuations throughout the season, although it stayed predominantly within the optimum range for this species. There was a rapid drop in temperature data in mid April for TT-Hue and early May for Nghe An.
- Alkalinity was generally within the optimal range for all ponds. Whilst the baseline survey at the TT-Hue site was the only area to have excessive alkalinity readings, the post cultivation period showed that the TT-Hue farmers had alkalinity under control; hence the conditions were better than when they started. Ammonia, nitrate and sulphide levels stayed within optimal levels.

Economic indicators

- The average value of total income from shrimp culture of all farms in study area was approximately 84 mil. VND/ha. There was a significant difference of income from shrimp culture of BMP, Non-BMP and Baseline groups. The income from shrimp culture of BMP group was highest, which was nearly double higher than that of Baseline and 1.5 times higher than that of Non-BMP group. Among provinces, there was a remarkable difference in income from shrimp culture, Nghe An received a highest income, which was double higher than that in Ha Tinh and 1.5 times higher than that of TT-Hue province.
- The average value of benefit from shrimp aquaculture of all farmers in study area was 20 mil. VND/ha. There was a very difference of benefit from shrimp culture among farms groups. The benefit value of BMP group was around double higher than that of Non-BMP and Baseline groups. Among provinces, there was a significant difference in benefit from aquaculture, benefit value from shrimp culture of Nghe An was 1.7 times higher than that of TT-Hue and four times higher than that of Ha Tinh province.
- The average value of total production cost of shrimp culture was 63 mil. VND/ha. There was a noticeable difference of total cost value among groups and provinces. Total cost of BMP, Non-BMP and Baseline were 79, 59 and 53 mil. VND/ha, respectively. Farmers in Nghe An spent highest cost value (81 mil. VND/ha, on average), this values in Ha Tinh and TT-Hue were 44 mil. VND/ha and 64 mil. VND/ha, respectively.
- The feed cost was a highest cost of shrimp production, which occupied 61% 0f total

cost. There was not a different in percentage of feed cost among farmer groups of BMP, Non-BMP and Baseline and among provinces. However, there was a significant difference of feed cost in value among groups and provinces because of different of investment levels of farm households.

- Other costs such as seed, fertilizers, hired labors, bio-product, energies etc occupied a low percentage of total cost, lower than 15%. The difference in percentage of these costs among farmer groups and provinces was not significant. However, like feed cost, there was a noticeable difference in value of these costs among farmers groups of BMP, Non-BMP and Baseline and among provinces of Nghe An, Ha Tinh and TT-Hue.
- The average value of Benefit Cost Ratio (BCR) of all studied farmers was 1.3. The BMP farmers group had a highest BCR (1.37) and smallest in Baseline group (1.23). Nghe An had the highest BCR (1.39) and lowest in Ha Tinh (1.15).
- Comparison of two input indicators of seed and feed prices and output of shrimp product price show that the price of feed was quickly increase from 2006 to 2008 (increase 28%). This was a constraint of shrimp aquaculture due to feed cost occupying 61% of production cost in shrimp aquaculture. The price of seed was slightly reduced, but the rate was very low (about 7%). The price of shrimp product was a slightly increase, but the increase was very low too (only increase 2%).

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