International Journal of Agriculture Innovations and Research
Volume 2, Issue 5, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 08/03/2014 | Accepted on : 27/03/2014 | Published : 05/04/2014

Sustainability of Polyculture Model for Small Aquaculture Farmers in Phu Vang District, Thua Thien Hue Province, Vietnam

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Abstract **– The study was conducted to assess the sustainability of polyculture aquaculture model in five communes in Phu Vang district, Thua Thien Hue province Vietnam. The water quality parameters included in the study are: pH, temperature, salinity, DO, BOD, COD, TDS, NH3, NO3, turbidity, phosphates and heavy metals. The socio-economic situation and natural conditions in Phu Vang district, Thua Thien Hue province was also done. The results of the study has developed a polyculture model which includes selected three species: Tiger black shrimp *(Penaeus monodon),* Rabbitfish *(Siganus guttatus)* and Kinh (*Siganus canaliculatus*) for high economic efficiency, almost 200 million VND/hectare (10,00usd/hectare) for small aquaculture farmers, as well as contribute to the development of sustainable aquaculture in Phu Vang district.**

Keywords **– Mac Nhu Binh-Polyculture.**

I. INTRODUCTION

In recent years, aquaculture sector has been considered as one of the key economic sectors of Vietnam. The country is endowed with 3,260km coastline; 12 lagoons, straits and bays; 112 estuaries and canals; and thousands of small and big islands scattered along the coast (Nguyen Anh Tuan, 2003). In the inland area, an interlacing network of rivers, canals, irrigation and hydro electric reservoirs has created a great potential of water surface with an area of about 1,700,000 hectares. In addition, Vietnam has various species of which many are of high value and suitable for culture, of aquaculture development (Nguyen Anh Tuan 2003).

As a coastal province in the Central of Vietnam, Thua Thien Hue has 128 km of coastline, 22,000 hectares of lagoons (Tam Giang - Cau Hai lagoons) and over 200,000 hectares of forest (Lam Thi Thu Suu et al., 2006). According to Nguyen Quang Linh et al., (2010), Tam Giang - Cau Hai lagoon systems cover over 22,000 hectares, along the coastal region from North to South of Thua Thien Hue with 70 km and more than 380,000 inhabitants living around the lagoon. There are many livelihood activities such as fishing, aquaculture and farming, which are active on the lagoon systems and buffer zones. Aquaculture systems are diversified: pond, net-closure in high and low tide systems. Therefore, aquaculture is a strength of Thua Thien Hue and one of the priority sectors in the strategic development of socio-economics of the province.

Phu Vang district is plain and coastal lagoons of Thua Thien Hue province. In Phu Vang, the communities generally depend on three main income generating activities such as open fisheries, aquaculture, agriculture and livestock. Other complementary occupations include trade, seasonal work, construction and service. However, the people are doing aquaculture and open fishing as their primary source of income. According to Lam Thi Thu Suu (2010), since aquaculture being the mainstay of the local economy, Phu Vang district faces serious challenges due to environmental pollution and disease outbreaks.

According to Ton That Chat et al., (2008), the intensive farming of tiger shrimp has developed so fast beyond the ability of management and supervisory authorities. Some of the problems faced by the tiger shrimp farming were water pollution, and mass mortality of shrimp culture. Most shrimp cultures in Phu Vang were wiped off in 2007 due to infection by the white spot syndrome virus (WSSV).This phenomenon caused a huge economic loss to shrimp farmers (Phu Vang District Report, 2007). Facing this reality, many farmers are now converting their farming methods from tiger shrimp monoculture farming into a polyculture farming with multi species. Polyculture farming is initially good for economic efficiency.

However, several challenges are encountered in the polyculture model such as selecting the appropriate aquaculture species and the suitable farming models representative of each eco-regions in order to improve economic efficiency for farmers. This is the main reason why the proposed study was conducted. The study aimed to evaluate the sustainability of polyculture model for small farmers in Phu Vang district, Thua Thien Hue province, Vietnam.

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II. Research Methodology

Description of the study area

Phu Vang is a rural district of Thua Thien Hue province in the North Central Coast region of Vietnam. As of 2011 the district had a population of 178,968, covering an area of 280 km². It contains 20 communes (Fig. 1) and Phu Vang district is located on the depressed estuary plain of the Huong River Basin. Part of the lagoon area houses of Thuan An's villages, while another seven are near Tam Giang-Cau Hai lagoon and five are close to the sea (Le Nguyen Tuong et al, 2008).

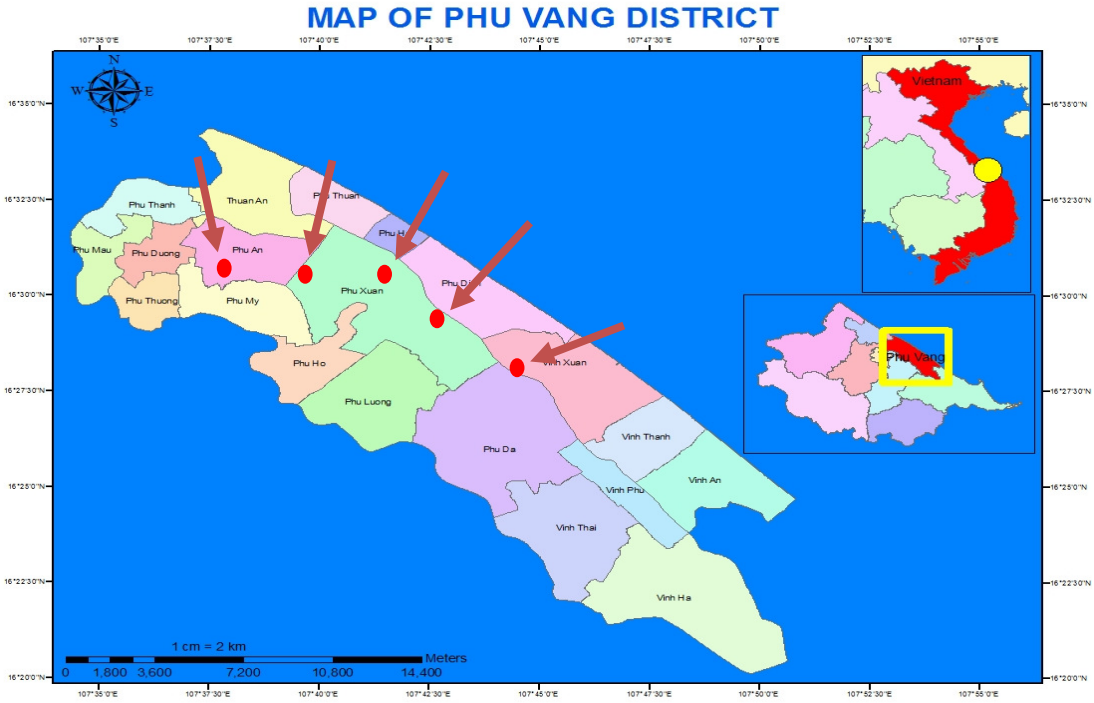

Fig.1. Map of Phu Vang district and study sites

The study was focused in five coastal communes that have developed aquacultural production to include: 1) Thuan An; 2) Phu Thuan; 3) Phu Hai; 4) Phu Duyen, and; 5) Phu Thanh (Fig.1, research area with red points). In addition, general information on weather and climate condition and current situation of water quality and aquaculture in Phu Vang district were collected and studied.

Research Instrument and data collection procedure

To evaluate the situation of polyculture in brackish water aquaculture in the Phu Vang district, investigation, collecting data from multiple sources including secondary and primary data were used. Secondary information was collected from government organizations such as Department of Fisheries, Department of Environmental and Resources, the district agricultural office, among others. The data since 2002 to present were analyzed and assessed.

Water quality assessment

Assessing the quality of water through the water by environmental factors by comparing with the National Technical Regulation on coastal water quality (NTR 08: 2008/BTNMT) for aquaculture purposes; Circular 44 / 2010/TT- MARD dated 22/7/2010 - regulations require water quality for aquaculture; National technical Regulation on surface water quality to protect aquatic life (NTR 38/2011/BTNMT).

Polyculture models

With the goal of developing good aquaculture practices, transfer advanced technologies and diversify income sources for small famers in locality, the research set-up an experimental poly-culture models in five communes: Thuan An, Phu Thuan, Phu Hai, Phu Thanh and Phu Dien. The model combined different products such as fish and shrimp. Technical assistance such as feeding management, technique in aquaculture etc. was provided to 5 households in the village. Financial assistance was also provided. In return, the households also contributed to ensure the success of the endeavor such as 100% of the costs of upgrading their respective ponds as well as the equivalent labor requirement. This was provided to encourage the households to take responsibility for taking care of the research as well as having the sense of ownership. The result of the model was evaluated and later recommend to local authorities and local people.

The evaluation of water quality in the research area includes water in fish ponds, lagoon (source of water supply for aquaculture) in the research areas. The water samples were collected at surface using 5L plastic bathometer at 5 communes in Phu Vang district. The samples were treated and maintained for analyzing operations at the methods described by APHA 1995. Some water quality parameters were immediately measured on the survey time on ponds was stored to analyze at the laboratory.

Analytical Procedure/Statistical Methods

Number of samples and statistical analysis for PRA method

A total of 203 households (directly or indirectly involve in aquaculture activities) in five communes were interviewed through questionnaires. In addition, representatives from the local authority, unions, organizations and production groups in 5 communes during the process of investigation and impacts analysis were interviewed. All data including secondary data were synthesized using SPSS software to compare, and evaluate information base.

Other Statistical analysis

All data were analyzed by fitting regression equations using the SPSS (version 17.0) software. One-way analysis of variance (ANOVA) was used in this study for water environment parameters analysis. By the way, we was used:

Mean: Calculate the average value and variation of the data.

Kruskal Wallis H: Testing nonparametric more than 2 independent factors.

Significance in all statistical tests were tested at a P=0.05 level. All the results will be represented as tables or graphs.

III. Results

The situation of polyculture in brackish water aquaculture in Phu Vang district

According to the Report of the Department of Agriculture, PhuVang district, (2012), conversion process from intensive prawn farming to poly-culture mainly takes place from 2006 after raising prawn monoculture became inefficient mainly because shrimp were infected with white spot syndrome virus (WSSV). After losing a lot from prawn monoculture, farmers decided to venture into polyculture farming with multi species, which markedly brought them economic efficiency.

In 2012, the total area of brackish water aquaculture reached 2045 hectares, of which 1695 ha (83%) was devoted to poly-culture and 350ha (17%) was devoted to monoculture prawn farming (Department of Agriculture, 2012). The poly-culture areas in Phu Vang district is shown in Table 1.

Table 1: Total area of brackish water poly-culture in each commune, Phu Vang district(Report of the Department of Agriculture, PhuVang district, 2012)

S.No.	Communes	Poly-culture			
		Total (ha)	High Tide (ha)	Low Tide (ha)	Pen Culture (ha)
1	Tan An	300.0	38.0	144.0	118.0
2	Phu Thuan	55.2		55.2	
3	Phu Hai	10.9	5.4	5.5	
4	Phu Dien	33.0		33.0	
5	Vinh Xuan	84.0	45.0	39.0	
6	Vinh Thanh	25.1	23.4	1.7	
7	Vinh An	19.2	16.6	2.7	
8	Vinh Phu	25.0	15.0	10.0	
9	Vinh Ha	171.9		171.9	
10	Phu Da	66.0	28.6	37.4	
11	Phu Xuan	433.2	271.8	61.4	100.0
12	Phu My	213.7	15.1	11.7	187.0
13	Phu An	249.9	5.6	94.1	150.2
14	Phu Thanh	8.0		8.0	
	Total (ha)	**1,695**	**464.3**	**675.5**	**555.2**

Currently, brackish water poly-culture is done in two seasons per year. The main breeding season starts in February until July (lunar calendar), while the second season startsin the middle of July until December. Species being cultured includes tiger black shrimps, blue crab, spotted scat, rabbitfish, Kinh, mullet, snapper, seabass, grouper, etc and seaweed. During the second season, stocking density is usually low because of the abundant rain, and low temperature and salinity. Hence, the number of species being cultured is also limited; black tiger shrimp, mullet, crap and tilapia are the main species cultured for this season.

IV. The Results of Polyculture Models

Based on the situation and assessment of the impacts of aquaculture activities in Phu Vang district, Thua Thien Hue province, we have developed a polyculture models in five communes: Phu Tan, Thuan An, Phu Thuan, Phu Hai and Phu Dien. These are the communes which have developed aquaculture activities in PhuVang district.

Actual survey has shown that monoculture of *P. monodon* in PhuVang was not effective in recent years, so we have to implement a "polyculture model" for small aquaculture famers.

The basis to develop the models of polyculture and techniques

Aquaculture production model should be based on the actual conditions of the locality, such as infrastructure for aquaculture, pond conditions, water resources and water quality for aquaculture, species, the breeding animal, climatic conditions, the investment capacity of the people, and compliance with the provisions of the law for aquaculture in the area.

Ponds

Ponds should have a suitable area for farming to be effective. Pond area suitable for polyculture models is from 3000 to 10,000 m^2.We chose the pond area of 5000m^2 to implement these models. This area has been designed and built mostly in the locality.Ideally ponds should have separate intake and outtake sluice gates, the water level height must at least be 1 meter. Aquaculture model is implemented by the method of semi-intensive so that ponds needed water system fan (or aeration).

Species have sufficient convergence with the following criteria: high economic value, abundant breeding source, easy to buy, fast growth rate, shorter culture period and particularly the ability to adapt well to the conditions of the local climate. Thus, two traditional species were Golden rabbitfish (*Siganus guttatus)* (Figure 2a) and black tiger shrimp *(P. monodon)* (Figure 2b) and, selected specie of native fish, White spotted spinefoot or Kinh (*Siganus canaliculatus)* (Figure 2c). Both siganids are generally called rabbitfishes.

Fig.2a. Black tiger shrimp: *Penaeus monodon*

Fig.2b. Kinh: *Siganus canaliculatus*

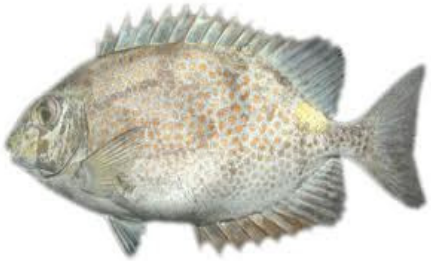

Fig.2c. Golden rabbitfish: *Siganus guttatus*

These species were distributed more in the Tam Giang – Cau Hai lagoon. They can live and grow well at salinities from 5-37ppt, temperature 24-33^{0}C, pH 7-8.5. Kinh and G. rabbitfish are two herbivorous fishes, the favorite foods are seaweed. However, these species can eat commercial feed. Because these species do prey on each other, they were selected to be in the same polyculture pond. Fish has the ability to grow fast and after four months can be harvested. Sources of the Golden rabbitfish, Kinh and Black Tiger shrimp are abundant and easy to buy in PhuVang district and as well as the neighboring districts.

Density, breeding size for stocking and feed use

Species	Density (pieces/m^2)	Size (cm)	Feed use
Tiger shrimp	7	1 – 2	Commercial feeds
G. rabbitfish	1	4 – 5	Commercial feeds and seaweed
Kinh	4	2 – 3	Commercial feeds and seaweed

Pond management

The water quality parameters such as temperature, pH, salinity, DO were measured twice/day: 7:00 in the morning and 2:00 in the afternoon. Other parameters such as BOD_5, COD, ammonia, NO_3, TDS, turbidity etc. were measured twice a month. Fish were fed twice a day (7 - 8 pm and 17 - 18h). Fish are fed mostly with commercial feed (daily feed intake of 10% of body weight), supplemented with seaweeds once a week. Water pond is replaced twice a month and every time we changed a maximum of 30% of the water in the pond.

The results of the poly-culture models

The results of the water quality parameters of the pond

The evolution of the water quality parameters of the pond is summarized in Table 2. As shown, water quality parameters such as water temperature, pH, salinity, DO were all within the appropriate range for the species. The water quality parameters in the pond have almost no significant changes during the culture period. Although there were differences when comparing the water quality parameters inside and outside the pond but the water quality parameters such as BOD_5, COD, ammonia, NO_3, Cb, Cu, Zn and Cd were within the limit allowed for aquaculture when compared to Circular 44, Standards of Brackish Water Quality for Shrimp Culture in Ponds.

Results on growth, survival, productivity and, yields of the aquaculture models

Results of the model showed that shrimp and fish rapidly grew after more than four months of culture (from March 14, 2013 to August 2, 2013) the average weight of shrimp in ponds was 17.26g/pc, Golden rabbitfish was 208g/pc and, Kinh was 53.3g/pc (Table 3).The highest average weight of shrimp in the pond at Phu Hai (17.8 ± 2.1g/pc), and lowest in Phu Dien (16.6 ± 2.5g).Results of statistical analysis showed no statistical differences between the ponds in PhuThanh, Phu Hai, Phu Thuan and Thuan An. However, there was a statistical difference

between the average weight of shrimp of those ponds compared to the pond in Phu Dien (p> 0.05) (Table 3). The average survival rate of shrimp in ponds was 74.6%, yields with an average of 0.9 tons/ha, This yield is quite high for polyculture ponds.

Table 2: The average value of the water quality parameters in the ponds

Ponds	t^o (^{0}C)	pH	Sal (ppt)	DO mg/l	BOD_5 mg/l	COD mg/l	TDS mg/l	Tur NTU	NH_3 mg/l	NO_3 mg/l	PO_4 mg/l	Cu µg/l	Pb µg/l	Zn µg/l	Cd µg/l
PTa	31.5	7.7	12.1	5.2	2.6	6.7	21.4	6,8	0.03	0.12	0.27	19.5	0.62	8.10	0.51
TA	31.0	7.7	11.7	5.1	3.1	6.7	20.6	6,3	0.01	0.12	0.22	24.3	0.73	10.6	0.66
PT	30,5	7.6	12.0	5.4	3.4	7.0	18.0	5,8	0.02	0.15	0.20	21.6	0.75	7.45	0.53
PH	31.0	7.8	12,5	4.9	3.6	6.8	18.3	6,1	0.02	0.11	0.26	20.4	0.91	7,37	0.57
PD	32.0	7.9	13.0	5.6	2.9	6.6	17.4	5,5	0,04	0.09	0.27	20.6	0.63	7.30	0.50

Table 3: Average weight, survival rate, yield and productivity of aquaculture models

Ponds/ species	Tiger shrimp *P. monodon*				G. Rabbitfish *S. guttatus*				Kinh S.*canaliculatus*			
	AW (g/pc)	SR (%)	Y (Tons)	P Tons/ha	AW (g/pc)	SR (%)	Y (Tons)	P Tons/ha	AW (g/pc)	SR (%)	Y (Tons)	P Tons/ha
Phu Tan	17.5^a±2.6	78	0.477	0.95	169^a±3.7	89	0.75	1.50	47.8^a±1.9	81	0.77	1.54
Thuan An	17.3^a±3.1	75	0.454	0.90	162^a±2.8	86	0.70	1.40	46.6^a±3.2	83	0.77	1.54
PhuThuan	17.1^a±2.4	74	0.443	0.87	146^b±3.1	92	0.67	1.34	44.2^a±2.8	78	0.69	1.38
PhuHai	17.8^a±2.1	77	0.479	0.99	164^a±2.6	84	0.69	1.38	47.4^a±3.0	79	0.75	1.50
PhuDien	16.6^b±2.5	69	0.401	0.82	160^a±3.4	82	0.65	1.30	45.3^a±2.4	76	0.69	1.38
Average	**17.26**	**74.6**	**0.451**	**0.90**	**208**	**88.6**	**0.69**	**1.38**	**46.26**	**79.4**	**0.73**	**1.46**

a,b: The letters in the same column different it will be different in terms of statistics (p<0.05)
AW: average weight; SR: Survival rates; Y: Yields and; P: productivity

Fish ponds also achieved high growth rates. The average weight of the Rabbitfish was 208g/pc. However, G. rabbitfish in Phu Thuan has showed slow growth compared with other ponds. The statistical analysis showed that there was significant difference across the different ponds (p> 0.05) (Table 3). The average survival rate of the G. rabbitfish in the ponds was 93%, an average yield was 1.9 tons/ha. The average weight of Kinh was 56.26g/ piece, the survival rate was 79.4% and the average yield was 1.78 tons/ha.

Economic calculation of aquaculture models

Preliminary results of calculations of economic efficiency of aquaculture models (Table 4) showed that after 4.5 months of culture, all the models obtained high profit rates. The profit rates of pond culture in Phu Thanh was highest (VND 121.1 millions), this is a very high profit rate in times of difficulty for aquaculture today. Since then showed that poly-culture models capable of adapting to changing climate conditions present in Phu Vang district in particular and Thua Thien Hue province in general. Not only did the models bring economic improvement, those models also met the needs of diversified species and the form of aquaculture in the locality at present. In addition to the traditional species such as Golden rabbitfish and Tiger shrimp, Kinh are considered for high economic value, so it might be a promising species in the future when the shrimp are at risk due to environmental pollution and disease outbreaks.

However, as a kind of semi-intensive farming methods, these models still have the disadvantage of high initial capital investment. Therefore many farmers will don't have investment conditions, some households have bank loans with interest payments to monthly so their income will be reduced. So, depending on the investment capacity of farmers, they can reduce the density of the species and culture as with extensive farming methods.

Table 4: Economic accounting of the aquaculture model Units: VND

Contents	Ponds				
	P. Thanh	T. An	P. Thuan	P. Hai	P. Duyen
Total expenditure items:					
Ponds prepare			4,000,000.00		
Salary for labors			21,000,000.00		
Shrimps breeds			1,590,000.00		
Kinh breads			6,000,000.00		
Rabbitfish breads			3,000,000.00		
Feeds			75,820,000.00		
Limes, Vitamins.			5,000,000.00		
Electricity, diesel			18,000,000.00		
Depreciation and another expenses			15,000,000,00		
Total			**134,410,000.00**		
Total revenues					
Shrimp	58,110,000.00	59,020,000.00	57,590,000.00	62,270,000.00	52,130,000.00
G. Rabbitfish	105,000,000.00	98,000,000.00	93,800,000.00	96,600,000.00	91,000,000.00
Kinh	92,400,000.00	92,400,000.00	82,800,000.00	90,000,000.00	82,800,000.00
Total	**255,510,000.00**	**249,420,000.00**	**234,190,000.00**	**248,870,000.00**	**225,930,000.00**
Profitability/pond	**121,100,000.00^a**	**115,010,000.00^a**	**99,780,000.00^b**	**114,460,000.00^a**	**91,520,000.00^b**

a,b: The letters in the same column different it will be different in terms of statistics (p<0.05)

Indicators comparison between monoculture of tiger shrimp and polyculture in Phu Vang

Comparison of water quality between the prawn monoculture and polyculture ponds

In recent years, many studies have addressed water quality between monoculture prawn and polyculture ponds. Most studies have shown that the water quality parameters of theprawn monoculture farming ponds was always higher than the water quality parameters in polyculture ponds. A typical example is the study of Tran Tuan et al. (2009), the study was conducted in Thuan An commune, Phu Vang district, Thua Thien Hue province. The results of the study is showed in Table 5.

Table 5: Comparison of water quality between monoculture tiger shrimp and polyculture ponds (Tran Tuan et al., 2009)

Water quality parameters	**Monoculture ponds**	**Polyculture Ponds**
Temperature (^oC)	24 – 35[a]	24 – 34[a]
pH	7.2 – 9.0[a]	7.4 – 8.8[a]
Salinity (ppt)	13 – 14[a]	13 – 14[a]
DO (mg/l)	4.3 – 5.3[a]	5.2 – 5.7[b]
BOD (mg/l)	2.6 – 4.1[a]	2.2 – 3.7[b]
COD (mg/l)	14.8 – 19.4[a]	6.6 – 11.2[b]
NH_3(mg/l)	0.2 – 0.7[a]	0.1 – 0.3[b]
NO_3(mg/l)	0.15 – 0.80[a]	0.1 – 0.17[b]

a,b: The letters in the same column different it will be different in terms of statistics ($p<0.05$)

The Table 5 showed that almost of the water quality parameters such as DO, BOD_5, COD and NH_3in the prawn monoculture ponds were higher than polyculture ponds. This means that the water quality in the prawn monoculture ponds will decrease during the culture period andexcessive comparisons with water quality standards for aquaculture in Vietnam, while water quality in polyculture ponds were always stable and level allowed for aquaculture.

Comparison of production efficiency between monoculture and polyculture

According to Nguyen Tai Phuc et al., (2009), based on the data from the survey carried out in 117 aquaculture households applying different models of aquaculture: prawn monoculture and polyculture (shrimp, fish and crap) model at the research site, the study results showed that polyculture models not only bring in high the effective production and higher economic efficiency but also a positive influence to eco-efficiency. The result is showed in Table 6.

Table 6: Production efficiency from monoculture and polyculture models (Nguyen Tai Phuc et al., 2009)

No.	**Indicators**	**Units**	**Monoculture**	**Polyculture**	**Compared Monoculture/ Polyculture (times)**
1	Total Production Value (TPV)	1,000 VND	73,263.3	81,620.8	1.1
2	Intermediate Costs (IC)	1,000 VND	43,556.0	41,115.5	0.94
3	Value Added (VA)	1,000 VND	29,709.3	40,505.3	1.36
4	VA/TPV	Times	0.41	0.50	
5	VA/IC	Times	0.68	0.99	

Compared with prawn monoculture farming, effectiveness of polyculture model has higher in both absolute and relative. If on 1 hectare of pond area, total production value of polyculture model was 81.6 million, up 11% compared to prawn monoculture farming. Furthermore, in the polyculture models, the small aquaculture farmers can save expenses(e.g, Intermediate Costs (IC)of this models lower than 6% compared to prawn monoculture models)so the difference in the value added of these two models are quite large (VA/ha of polyculture models was higher than prawn monoculture about 36%).

The relative efficiency norms (VA/PTV;VA/IC) were differ significantly between the two aquaculture models. The added value created 1VND for intermediate costs of polyculture model was 0.99VND, higher than 44% compared to spawn monoculture models (0.68VND).

According to Nguyen Tai Phuc et al., (2009), besides caused by differences in the cost of production factors, the market for polyculture model stable (not forced prices) and low risk were important reasons to create differences in the efficiency of production of the two models. Therefore, polyculture model will bring high economic efficiency and stability to the small aquaculture famers, thus contributing to the development of sustainable aquaculture in Phu Vang district, Thua Thien Hue province.

V. DISCUSSION

As a coastal district, Phu Vang has very favorable conditions for the development of aquaculture. Located in the system Tam Giang - Cau Hai (22,000 ha), Phu Vang has 6,800ha of water surface can serve for aquaculture development. Fisheries has become an important sector in the socio-economic development of the district in recent years.

Aquaculture currently in Phu Vang district is at risk, aquaculture areas decreased over time, water pollution and disease often occurred, productivity and yields decreased etc. were the factors that have been mentioned and were evident in the results of our research. The total of aquaculture area of the district, especially in area of brackish water aquaculture has increased significantly in the period from 2002 to 2004. Through investigation we found that in this period the movement of tiger prawns

thrived, people in the lagoon belong to Phu Vang district was rushing shrimp ponds, thus the area of brackish water aquaculture ponds increased in this period. However, aquaculture area in Phu Vang district has decreased since 2005, especially in 2007 were only 1957.2ha (Phu Vang District Report, 2012). The main reason is the area of brackish water aquaculture plummeted, shrimp disease outbreaks in shrimp farming (mainly due White Spot Syndrome Virus) made the farmers more losses, no longer able to continue shrimp culture. Since 2008, aquaculture area district has increased significantly due to the policy of Phu Vang district was converted the production methods from monoculture of tiger shrimp to polyculture with multi species has been effective. There have been many support policies such as: government gave farmers loans with no interest for a period of 5 years for aquaculture development; technical support or supporting animal breeds etc. In particular, all the farmers get loans from the government (under the 134 program, poverty alleviation of the Vietnamese government) for aquaculture development, the loan amount is at least equal to 70% probability an investment of shrimp. In addition, the government also supports breeding and extension workers to support the local technical guidelines for aquaculture farmers. Then, the total area of polyculture occupied 83% of the total area of brackish water aquaculture (Phu Vang District Report, 2012).. The study has similar results to the study of Tran Thi Tu et al. (2012), they have shown that the water environment pollution and disease outbreaks lead to heavy losses for the aquaculture industry in Phu Vang district, Thua Thien Hue province in recent years. The author pointed out that, in 2010, total shrimp production has decreased 50% compared to 2004 (Tran Thi Tu et al., 2012).

In addition, the results of the investigation concluded that disease has reduced productivity and aquaculture production in Phu Vang compared in the year 2003 and 2004 (Table 11). Le Duc Ngoan and Nguyen Duy Quynh Tram (2010) also concluded that outbreak occurred simultaneously in many places in Phu Vang district in 2007, with tiger shrimp mass die-offs causing low production efficiency, thus greatly affecting the income of the farmers. So many farmers have changed species and farming methods to suit the current conditions. Some moved away to other jobs, therefore aquaculture productivity has been significantly reduced in the whole district (Le Duc Ngoan and Nguyen Duy Quynh Tram, 2010).

In order to minimize the risks from prawn monoculture farming, in recent years there have been many small farmers in Phu Vang district was automatically converted into poly-culture model, and this polyculture model initially brought economic benefits, some families have removed their bank loans due prawn monoculture farming losses from previous years as well as improved their income (Department of Agriculture, Phu Vang District, 2012).

The results of the investigation showed that since 2006, some scientists initially evaluate the effectiveness of the polyculture model in brackish water aquaculture in Thua Thien Hue province in general and Phu Vang district in particular. There have been some studies done in this time such as: Ton That Chat et al. (2008) have conducted polyculture models with three species Rabbitfish, Tiger shrimp and Tilapia by improved extensive farming methods in Huong Phong commune, Huong Tra district, Thua Thien Hue province resulted in profits of 67 million VND/pond area of 0.5ha; Chau Thuc Phi (2011) conducted polyculture models between Rabbitfish, Mullet and black tiger shrimp in Huong Phong communes also with profits of 140 million VND/1ha. All these studies were conducted in the dry season from February to June (Lunar calendar). In second crops (in rainy season from July to November), the Center of Fisheries Extension of Thua Thien Hue province has done a polyculture model with three species including: black tiger shrimp, tilapia and blue crab in Thuan An commune, Phu Vang district. This model is implemented by extensive farming methods with low density (Shrimp: 5 pieces/m2, Tilapia: 0.5 pieces/m2 and; crab: 2 pieces/m2), resulted in profits of 63 million VND/ 0.5ha.

In this study, it is proposed polyculture model with three species including Rabbitfish, Kinh and black tiger shrimp by semi-intensive farming methods. Although the initial capital outlay was relatively high, profit margins were also significantly increased to more than 200 million VND/ha.

VI. CONCLUSIONS

As a coastal district, Phu Vang has many advantages for the development of aquaculture. Phu Vang natural conditions are relatively favorable, up to 6,800ha area of brackish water used for aquaculture.

Status of aquaculture in Phu Vang had many changes in recent years, aquaculture area decreased over time, the structure animals breeding and aquaculture methods has also changed, yields and productivity reduced, disease outbreaks etc. has made people's lives difficult, many households have converted aquaculture methods from intensive culture to extensive culture, some households left of ponds and moved on to other jobs, thus there were many significant changes in income and their lives.

Currently 83% of households in Phu Vang district have converted from monoculture of Tiger black shrimp to polyculture with multi species and has brought markedly economic efficiency. Polyculture models that have been experimented included three species: Golden rabbitfish, Kinh and tiger black shrimp has brought high economic efficiency, so this model can be replicated for the small farmers in Phu Vang district, Thua Thien Hue province.

ACKNOWLEDGEMENTS

The authors would like to thank Seameo Regional Center for Graduate Study and Research in Agriculture (SEARCA), College, Laguna, Philippines for funding this study.

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