INTEGRATED AQUACULTURE ADAPTATION TO CLIMATE CHANGE: CASE OF SHRIMP – RICE ROTATION FARMING SYSTEM IN KIEN GIANG PROVINCE

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SUMMARY

The paper aims to improve sustainability of the integrated aquaculture adaptation to climate change by analysing the case of shrimp – rice rotation farming system in An Bien district, Kien Giang province. The survey was conducted with 100 households and group discussions with different stakeholders in the district. The results show that shrimp farming in the model bring more benefit than the rice monoculture system. However, the financial efficiency of shrimp farming is affected by the way of farming that the households applied (using of nursing pond and fingerling testing). In the context of climate change, the system intermediates between rice cultivation and shrimp farming which helps farmers gradually adapt in order to stabilize and improve their income. The model also brings social contributions such as creating seasonal job, stimulating the development of logistic activities. In terms of environmental sustainability, controlling use of chemicals and antibiotics, and ability to expand the system to other districts are the main benefits. For sustainable development of the model, a number of suggestions have been made for improving land use planning and investment; strengthening quality management and inspection of shrimp farming; and improving production organization & management and extension services.

Keywords: Adaptation to climate change, integrated aquaculture, Mekong Delta, shrimp - rice rotation farming system.

1. INTRODUCTION

The Mekong Delta is one of the key agricultural economic zones in Viet Nam, with an area of 40,816.4 km^2 and population of 17,804,700, representing about 18% of the country's population (GSO, 2018). In the region, paddy rice and aquaculture are the main economic activities. In 2016, the region contributes 58% and 71% of nationwide in terms of volume, valued at US$ 1.6 billion and $US 3.8 billion for rice and aquaculture respectively, in which shrimp farming contributes about US$ 2 billion (MARD and VASEP, 2016). Although the shrimp export brought billions of US$ and created jobs for millions of farmers, the master plan for the shrimp industry is still in existence. From 2000 to 2007 the area of shrimp farming in the Mekong Delta increased more than twice from 252,000 to 573,000 ha and continued to increase slightly. By 2011, the area of shrimp farming in the Mekong Delta reached 580,000 ha and about 630,000 ha in 2017. The fast growing of the shrimp industry is not only the increasing area but also the problem of intensification.

The Mekong Delta is most vulnerable to the impact of climate change due to sea level rising and some implied impacts are more flood and droughts (with less water in dry season), possible permanent inundation for some areas, increased salinity intrusion, both in terms of area and duration (Vu, D.T, et al., 2018; Hanoi Forum Towards Sustainable Development, 2018; Smajgl, A. et al., 2015) and increased risks of infectious diseases. In addition, the shortage of fresh water in flood season is now seriously increasing, which is one of the reasons for the decrease in rice cultivation area. Farmers face difficulties to maintain 2 to 3 crops of rice cultivation as before due to invasive and prolonged salt with high salinity. These changes, together with the limited availability of salt tolerance varieties, are challenging the sustainability of rice cultivation in some areas of salt-and-salty interstitial zones. This affects conventional farming systems and is a threat to the

livelihoods of many coastal communes in the region. Moreover, shrimp farming in particular and agricultural production in general face many other challenges such as water quality, environmental conditions, seed quality, feed and other input services. Therefore, integrated aquaculture adaptation to climate change have shown as an economic efficiency and environmental sustainability farming system (Pham Anh Tuan et al., 2015). However, with the rapid changes, without effective solutions it can easily break land use and production planning and rampant development will cause negative effects (Directorate of Fisheries, 2015; Ngoc Trinh and Minh Khanh, 2016). The paper aims to improve sustainability of integrated aquaculture by deeply analysing the case of shrimp – rice rotation farming system in An Bien district, Kien Giang province, the Mekong Delta, Vietnam.

2. RESEARCH METHODOLOGY

Kien Giang province is strategically located in the Gulf of Thailand, close to Southeast Asian countries such as Cambodia, Thailand, Malaysia and Singapore. The province has favorable conditions for economic activities with other countries and at the same time acting as a bridge connecting the provinces of the western region with the outside. With an area of 6,348.8 km² and a population of 1,810,500 people (GSO, 2018), the province has strengths in agricultural development, tourism and aquaculture. From 2000 to now, the economy has been growing steadily, helping Kien Giang to develop and raise incomes for people.

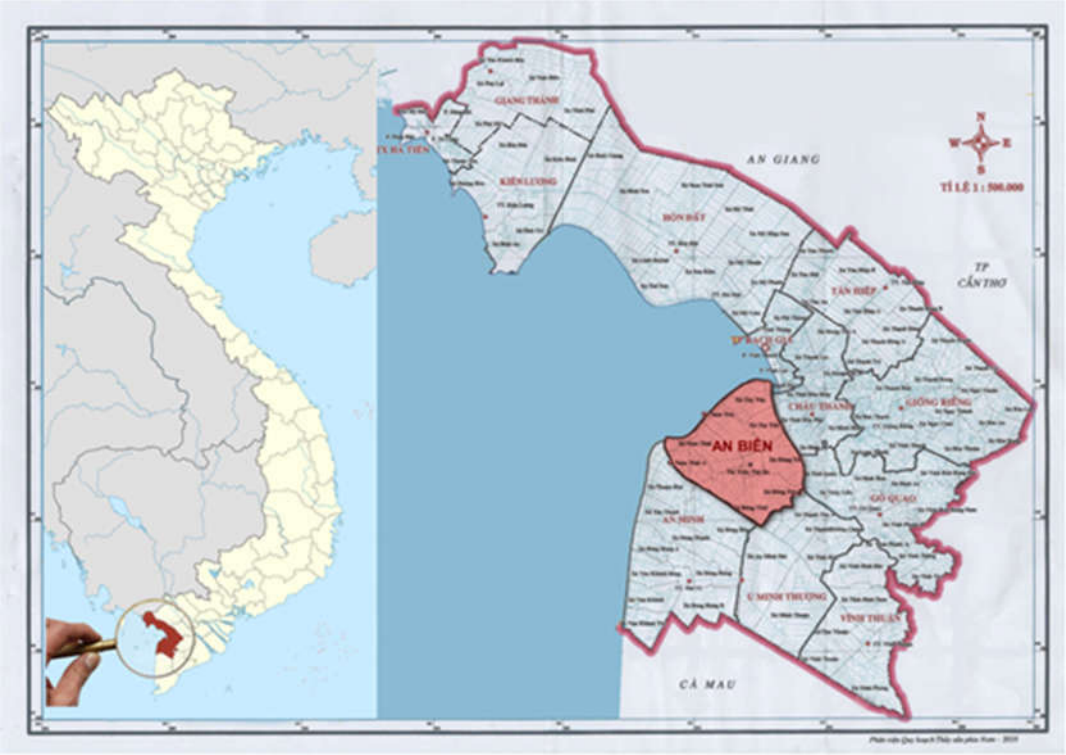

Figure 1. Map of Kien Giang province and An Bien district

An Bien district has a great diversity of agricultural production systems, which has resulted in many applied integrated models of agricultural - forestry - aquaculture. The rice production in "larged field" harvesting average 4.5 tons/ha and many models of intensive fish farming is invested with high efficiency and stability. In particular, the model of shrimp and blood cockle is strongly developed in the district. Recently, the tendency of shifting from salinity-sensitive rice cultivated areas in the dry season to producing one rice crop - one shrimp farming has brought economic efficiency and adaptation to environmental

change conditions.

To explore deeply about the system and its economic efficiency, the survey was conducted in 4 communes of An Bien district by questionnaires with 100 households practiced shrimp – rice rotation farming. In addition, a number of group discussions with different stakeholders in the district have been carried out to analyse strengths, weakness, opportunities and threats of the model.

Table 1 provides information about household samples and technical characteristics of shrimp farming practiced by these households in the study site. The results show that there are differences in term of the household and technical characteristics related to shrimp farming in the shrimp - rice rotation farming systems such as experiences in cultivating, time of shirmp culture, shrimp productivity and shrimp size.

Table 1. Household and technical characteristics sample description (n = 100)

Indicators	Min	Max	Mean ± Standard Deviation
Age of HH 's head (years)	23	68	42.5
Number of HH labors	2	6	4.43
Education of HH's head (%):			
- Primary school			24
- Secondary school			42
- High school			19
- Vocational training			15
Percentages of labors for shrimp – rice rotation model (%)			65.4
Experience of cultivating shrimp – rice rotation farming (years)	6	28	15.43
Shrimp pond area (ha)	0.69	1.65	1.10 ± 0.24
Shrimp nursing pond area (m^2)	0,00	300	86.80 ± 86.06
Shrimp density (fingerlings/m^2)	5	8	6.43 ± 1.23
Shrimp culture time (days)	68	140	111.61 ± 15.55
Shrimp survival rate (%)	52	72	63.42 ± 5.48
Shrimp productivity (kg/ha/crop)	50	500	269.75± 129.10
Shrimp size (number of shrimp/kg)	30	50	37.07 ± 6.14

(Sources: Household survey, 2017)

3. Shrimp – rice rotation farming system in Kien Giang province

3.1. The change of conventional farming to shrimp – rice rotation system

Kien Giang has the largest area of shrimp-rice farming in the Mekong Delta, and the province has started to develop shrimp farming in the rice field since 2002, in the interstitial areas between fresh and brackish water under the tidal regime and saline intrusion season. In the period of 2010-2015, the area of shrimp - rice farming in Kien Giang grows by 7.1% per year. In 2010, average shrimp productivity was 300 kg/ha, in 2014 reached 373 kg/ha, increased 6.1%. In 2015, the area of shrimp – rice farming exceeded 9.1% and the shrimp production was 26,699 tons (Kien Giang DARD, 2015). Shrimp farming combined with rice cultivation has become one of the suitable farming models in the fresh and brackish intercropping areas of the province. Therefore, the shrimp-rice development planning is mainly in the districts of An Bien, An Minh, U Minh Thuong district, Vinh Thuan, Go Quao, Hon Dat and Kien Luong. According to the strategy of Kien Giang province, it is expected that by 2020, the model of shrimp - rice rotation will reach 80,000 hectares with the

average productivity of shrimp will be 380 - 500 kg/ha/year; and in 2030 the area of shrimp - rice will reach 90,000 ha. Four districts including An Bien, U Minh Thuong, Hon Dat and Kien Luong are planning to extent the shrimp-rice rotation areas (Kien Giang DARD, 2017).

An Bien district has 21,019 ha of shrimp farming, of which 1,450 ha is mono - shrimp farming and 19,569 ha of integrated shrimp – rice system, accounting for 93% (People's Committee of An Bien district, 2017). Presently, saline intrusion into the inland, causing loss of agricultural land (mainly paddy rice), at the same time, the supply of fresh water is mainly based on natural rainfal, the production of 2 - rice crops is more difficult and inefficient. Instead, the option of replacing one crop in the dry season by shrimp farming is an effective solution to improve production efficiency.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pond preparation		Shrimp farming					Saline washing		Rice cultivation		

Figure 2. Cultivation calenda for shrimp – rice rotation farming system

Farmers spend two months for pond preparation, abour five months for shrimp farming from March to July, two months for saline washing before the new rice cultivation period of three months.

3.2. Sustainability of shrimp farming in the shrimp – rice rotation system

3.2.1. Financial efficiency and factors influencing financial efficiency

Table 2 provides financial efficiency of shrimp farming in the shrimp - rice rotation system. The results show that the price of shrimp is different among households and range from VND 150,000 to 190,000 and with this price of shrimp can make an avarage profit of more than 12 million VND per ha per crop, which is much higher than rice cultivation in compared time.

Table 2. Financial characteristics of shrimp farming

Indicators	Mean ± Standard Deviation	Interval [Min – Max]
Price of shrimp (VND/kg)	175,830 ± 9,010	150,000 - 190,000
Total Variable Cost (Mil.VND/ha/crop)	31.66 ± 8.71	18.75 - 56.74
Total Fix Cost (Mil.VND/ha/crop)	3.40 ± 0.76	1.97 - 5.20
Total Cost (Mil.VND/ha/crop)	35.06 ± 9.27	21.28 - 61.73
Revenue (Mil.VND/ha/crop)	47.40 ± 22.96	8.00 - 92.89
Profit (Mil.VND/ha/crop)	12.34 ± 17.95	(- 24.48) - 51.04
Profit Cost Ratio (times)	0.33 ± 0.53	(- 0.71) - 1.25

(Sources: Household survey, 2017)

Table 3 and 4 show the differences on technical and financial efficiency of households with and without nursing ponds and fingerling testing. It also shows some of the main factors influencing productivity and profit of shrimp farming in the model.

The results show that, the farming households who has nursing pond and doing fingerling testing significantly got higher shrimp productivity than the other ones. It leads to the big difference on profit earned by two groups. This means that financial efficiency of shrimp farming in the model is strongly affected by the way of farming that the households applied. Moreover, percentages of profit lost households are much different between these two groups. For households has nursing pond there is no profit lost households but the one without nursing pond, the percentage of profit loss is 62.5%. Similarly, there are 10.3% of households with fingerling testing lost their profit, but more than 57% of households lost their profit if they did not test fingerlings (see table 4 and 5).

Table 3. Technical and financial efficiency of HHs with and without nursing pond

Indicators	Nursing pond (n=52) [Mean ± Standard Deviation]	Without nursing pond (n=48) [Mean ± Standard Deviation]
Survival rate (%)	66.67 ± 4.10	59.90 ± 4.55
Size of shrimp (number of shrimp/kg)	33.27 ± 2.40	41.19 ± 6.30
Productivity (kg/ha)	334.40 ± 80.97	199.71 ± 135.47
Total Cost (Mil.VND/ha/crop)	37.04 ± 9.85	32.92 ± 8.16
Revenue (Mil.VND/ha/crop)	58.21 ± 14.92	35.68 ± 24.48
Profit (Mil.VND/ha/crop)	21.18 ± 9.41	2.76 ± 20.07
Profit Cost Ratio (times)	0.60 ± 0.27	0.03 ± 0.58
Percentages of profit loss HHs (%)	0	62.5

(Sources: Household survey, 2017)

Table 4. Technical and financial efficiency of HHs with and without fingerling testing

Indicators	Fingerling testing (n=58) [Mean ± Standard Deviation]	Without fingerling testing (n=42) [Mean ± Standard Deviation]
Survival rate (%)	66.19 ± 4.13	59.60 ± 4.80
Size of shrimp (number of shrimp/kg)	34.76 ± 4.30	40.26 ± 6.87
Productivity (kg/ha)	315.52 ± 105.19	206.55 ± 133.41
Total Cost (Mil.VND/ha/crop)	37.28 ± 9.95	32.00 ± 7.29
Revenue (Mil.VND/ha/crop)	54.89 ± 18.61	37.06 ± 24.53
Profit (Mil.VND/ha/crop)	17.61 ± 13.79	5.06 ± 20.50
Profit Cost Ratio (times)	0.48 ± 0.39	0.11 ± 0.61
Percentages of profit loss HHs (%)	10.3	57.1

(Sources: Household survey, 2017)

Table 5 compares technical and financial characteristics of shrimp farming in the model between profit gain and loss households. There are big difference between two groups, especially in term of shrimp farming experience, productivity, size of shrimp, revenue, profit and profit cost ratio. Therefore, improving farming techniques is important to increase financial efficiency of the system.

Table 5. Technical and financial characteristics of profit gain and loss households

Indicators	Profit gain (n=70) [Mean ± Standard Deviation]	Profit loss (n=30) [Mean ± Standard Deviation]
Shrimp pond area (ha)	1.12 ± 0.25	1.03 ± 0.19
Shrimp farming experience (years)	17.31 ± 3.99b	8.83 ± 1.56
Shrimp density (fingerlings/m^2)	6.69 ± 1.17	5.83 ± 1.18
Shrimp culture time (days)	115.37 ± 14.15	102.83 ± 15.33
Survival rate (%)	65.59 ± 4.45	58.37 ± 4.20
Size of shrimp (number of shrimp/kg)	33.43 ± 2.34	45.57 ± 2.97
Productivity (kg/ha)	340.37 ± 81.00	104.97 ± 33.89
Total Cost (Mil.VND/ha/crop)	37.17 ± 9.42	30.15 ± 6.79
Revenue (Mil.VND/ha/crop)	59.75 ± 15.01	18.58 ± 5.95
Profit (Mil.VND/ha/crop)	22.58 ± 9.94	(-11.57) ± 4.51
Profit Cost Ratio (times)	0.63 ± 0.27	(- 0.39) ± 0.13

(Sources: Household survey, 2017)

3.2.2. Social contribution

The shrimp-rice rotation model plays an important role in economic development in the region. In addition to increasing farmers' income, shrimp farming has been a factor in stimulating the development of logistics such as fingerling supply, medicine and chemicals, feed, seasonal labor, and export activity of the region. Shrimp farming in the dry season (when rice cannot be cultivated) creates jobs for local people, reducing the pressure of urbanization or increasing population in big cities. Moreover, in the context of climate change and salinity intrusion, the shrimp-rice rotation system plays the role of intermediating production between rice cultivation and shrimp farming (fresh and brackish water systems), which helps farmers gradually adapt in order to stabilize and improve their income and economic development in the area.

Labor involved in shrimp- rice rotation production accounts for 65.4%. However, the experience of shrimp-rice rotation farmers is relatively high (15.43 years) (Table 1), as most middle-aged and older people still work in agriculture. The study does not directly compare the per capita income, but the results from discussion show that the average income from integrated shrimp - rice increases sharply compared to monoculture. Therefore, the households participating in the shrimp-rice model had higher income than the mono-rice farmers.

3.2.3. Environmental sustainability

Environmental sustainability is assessed based on some criteria such as adaptability to climate change, use of chemicals and antibiotics, and the ability to expand the system. Shrimps - rice is a particularly important model of the the coastal provinces, especially in the Ca Mau peninsula (consist of Ca Mau, Bac Lieu and Kien Giang provinces). Because this area does not have fresh water from the Hau river system for rice cultivation in the dry season, the application of the shrimp - rice rotation model not only brings high finanicial benefit but also suitable to the context of climate change and salt intrusion into the interior. This can be seen as a transition between brackish water ecosystems (near the sea) and freshwater eco-regions (in fields).

During the implementation of the rotation system, there has been considerable interest in reducing drug and chemical use in shrimp farming and rice cultivation. Changing of the environment from fresh to salty and vice versa as well as changes in farming practices have reduced the disease outbreaks of rice and shrimps over time of production. Most of the development of the shrimp-rice model has been going deeper into the interior, creating a buffer between the two areas of salty-and-fresh water cultivation. With the high economic efficiency and sustainability of the shrimp-rice system, this model will be further developed in the Ca Mau peninsula in the coming time to optimize the efficiency of land and water resource use in the context of increasing climate change and salinity intrusion.

3.3. Sustainability of the system: suggestions and policy recommendations

The results from group discussion with different stakeholders in the district, the SWOT-analysis the opportunities and challenges of the development of shrimp - rice rotation system is presented in table 6. The concerns pay attention mainly to social and especially environmental risks of shrimp farming in the model.

Table 6. SWOT- analysis of shrimp - rice rotation farming development Kien Giang

Strengths: Appropriate to natural and ecological conditions and adapted to climate change; Increased income and profit for farmers compare to rice monoculture; Increased efficiencies in term of finance, land and labour used compare to rice monoculture; Taking advantage of on-site and family labors, reducing the pressure of seasonal labor shortages; Outputs meet the diverse demand of the domestic and international markets; Limited risks due to price fluctuations and seasonality (reduction of rice price); Diversify income sources of households, creating more jobs for the rural population.
Weaknesses: Lack of master planning, backward infrastructure compared to development and shifting rate; Contamination of salt water and high risk to rice production; Need high investment capital, disadvantages for poor, less land and lack of capital households; Farmers have limited knowledge on new techniques and market information; Input and outputs prices fluctuating.
Opportunities: Diversification of agricultural products and raw materials for processing and export; Expand the export market for high value-added fishery products; Formation of new production organization and economic activity models.
Threats: The ability to recover traditional rice production systems is low and requires high costs; The risk of food insecurity at the farm and country levels; Negative environmental impact and sustainable development if break land use and production planning; Social impacts (due to bankruptcy and failure of the new model).

(Sources: Group discussions, 2017)

Base on the analysis of weakness and threats from SWOT of shrimp - rice rotation system, there are a number of suggestions for strengthening sustainability of the model:

Firstly, improving land use planning and investment to avoid unsustainable shifting shrimp - rice rotation farming by followings: (i) Local authorities should make clear land use and production planning in the district based on the central and provincial economic development plans and climate change scenario to enhance shrimp value, as the key coastal products; (ii) There is a need for increased investment to develop infrastructure for shrimp farming, especially the irrigation system for ensuring the water source for shrimp farming and rice cultivation; (iii) Investing equipment to test shrimp seed quality, testing and rapid disease outbreak in shrimp; (iv) To continue investing in research and breeding to create many rice varieties with good salinity tolerance, insect resistance, good yield and quality; (v) Putting more investment to produce high quality shrimp fingerlings for farmers.

Secondly, strengthening quality management and inspection of shrimp farming to reduce environmental risks of spreading out the model by: (i) Improving the management of the quality of aquatic seeds - rice varieties, related services such as breeds, chemicals, feed and materials for aquaculture as well as pesticides for rice; (ii) Strengthening the supervision and prevention of aquatic diseases, especially shrimp diseases; (iii) Strongly monitoring of discharge, slurry from shrimp ponds to the canal system causing pollution to the whole region.

Thirdly, improving production organization & management and extension services to reduce social impacts of shrimp farming and to upgrade shrimp value chain. The advantages of

group and cooperative in shrimp farming are reducing cost (for example, fingerling testing and input sharing cost) and increasing bargaining capacity of farmers to deal with price fluctuating. In term of environmental risk, farmer group and cooperative activities can efficiently manage disease to deal with the seriousness and safety of the outbreak. In addition, farmer group and cooperative can make use of support from the Government and extension services in applying VietGAP and other third party certification schemes, which ensure sustainability of shrimp farming in the cultivation model.

4. CONCLUSION

The Mekong Delta is one of the key agricultural economic zones in Vietnam, but the region is also the most vulnerable to the impact of climate change due to sea level rising and some implied impacts are more flood and droughts, increased salinity intrusion, and increased risks of infectious diseases. Farmers face difficulties to maintain 2 to 3 crops of rice cultivation as before due to invasive and prolonged salt with high salinity. This affects conventional farming systems and is a threat to the livelihoods of local people in the region and integrated aquaculture adaptation to climate change have shown as an economic efficiency and environmental sustainability farming system. However, with the rapid changes, without effective solutions it can easily break land use and production planning and rampant development will cause negative effects. The research was conducted in An Bien district, Kien Giang province to analyse the sustainability of the shrimp – rice rotation farming system.

The results show the farming system is an adaptation model to climate change in the Mekong Delta. In the finance aspect, shrimp farming in the model bring more benefit than the rice monoculture system but the financial efficiency of shrimp farming is affected by the way of farming that the households applied, for examples the using of nursing pond and fingerling testing. The model also brings social contributions such as creating seasonal job, stimulating the development of logistic activities. The system intermediates production between rice cultivation and shrimp farming which helps farmers gradually adapt in order to stabilize and improve their income and economic development in the area. In term of environmental sustainability, controlling use of chemicals and antibiotics, and ability to expand the system to other districts are the main outcomes. However, some of the weakness and threats of the model are mentioned such as lack of master planning, backward infrastructure compared to development and shifting rate; farmers have limited knowledge on new techniques and market information; the ability to recover traditional rice production systems is low and requires high costs; the risk of food insecurity at the farm and country levels; negative environmental impact and sustainable development if break land use and production planning; and other social impacts. For sustainable development of the model, a number of suggestions have been made for improving land use planning and investment; strengthening quality management and inspection of shrimp farming; and improving production organization & management and extension services.

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NUÔI TRỒNG THUỶ SẢN KẾT HỢP THÍCH ỨNG VỚI BIẾN ĐỔI KHÍ HẬU: HỆ THỐNG CANH TÁC TÔM - LÚA LUÂN CANH Ở TỈNH KIÊN GIANG

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TÓM TẮT

Nghiên cứu nhằm mục tiêu cải thiện tính bền vững nuôi trồng thuỷ sản thích ứng với biến đổi khí hậu thông qua việc đánh giá mô hình canh tác tôm - lúa luân canh ở huyện An Biên, tỉnh Kiên Giang. Nghiên cứu đã thực hiện khảo sát với 100 hộ gia đình áp dụng mô hình này và các thảo luận nhóm với các chủ thể khác nhau ở cấp huyện. Kết quả nghiên cứu cho thấy mô hình canh tác này mang lại lợi nhuận cao hơn mô hình thuần lúa. Tuy nhiên hiệu quả tài chính của mô hình phụ thuộc nhiều vào phương pháp và cách thức canh tác (như sử dụng ao ươm và kiểm nghiệm tôm giống). Trong bối cảnh biến đổi khí hậu, hệ thống trung gian sản xuất giữa trồng lúa và nuôi tôm này giúp nông dân dần dần thích nghi để ổn định và cải thiện thu nhập. Mô hình canh tác này cũng mang lại những lợi ích về mặt xã hội như tạo việc làm vào mùa vụ và thúc đẩy phát triển các hoạt động hậu cần nghề cá. Ở khía cạnh bền vững môi trường, kiểm soát sử dụng hoá chất và kháng sinh và khả năng mở rộng mô hình sang các địa phương khác được coi là những lợi ích chính. Tuy nhiên, để mô hình phát triển một cách bền vững, cần thực hiện các đề xuất sau: cải thiện công tác lập kế hoạch sử dụng đất và đẩy mạnh đầu tư; tăng cường công tác quản lý và kiểm soát chất lượng trong nuôi tôm; và cải thiện hoạt động của các tổ chức sản xuất và dịch vụ khuyến nông.

Từ khoá: Đồng bằng sông Cửu Long, hệ thống canh tác tôm - lúa luân canh, thích ứng với biến đổi khí hậu, thuỷ sản kết hợp.

Received : 10/9/2019
Revised : 14/10/2019
Accepted : 21/10/2019