ENVIRONMENTAL ISSUES IN THE DEVELOMENT OF THE AQUACULTURE FARMING ECONOMY IN VIETNAM

Le Van Thang

Center for Resource, Environment and Biotechnology of Hue University

1. Introduction

In its Resolution No 03/2000 NQ-CP, dated February 2nd, 2000, the Vietnam Government confirmed that "*the Government encourages and supports the development of farming economy, especially the effective investment, exploitation and usage of bare lands in the midlands, highlands, island and border areas, and strengthen the State's management of the farming economy to ensure the efficient and sound development of farming economy*".

Over the past several years, the farming economy in general and aquaculture farming economy in particular has been rapidly developed in Vietnam. Especially, the development of aquaculture farming economy in the Central Vietnam and Mekong River Delta has brought about significant economic benefits and made a great contribution to local endeavors of "hunger eradication and poverty alleviation". However, aquaculture farming economy has also caused serious environmental pollutions as well as natural resources degradations.

The State's key project with its code of KC.08.30 has outlined a panorama on the environmental issues in the development process of aquaculture farming economy in Vietnam. Within the scope of this paper, a major part of such environmental issues - the current status and changes of water environment - is taken into account.

2. The current status and changes of water environment in the aquaculture farming areas.

2.1. The current status of water environment

2.1.1. In Central Vietnam Coastal

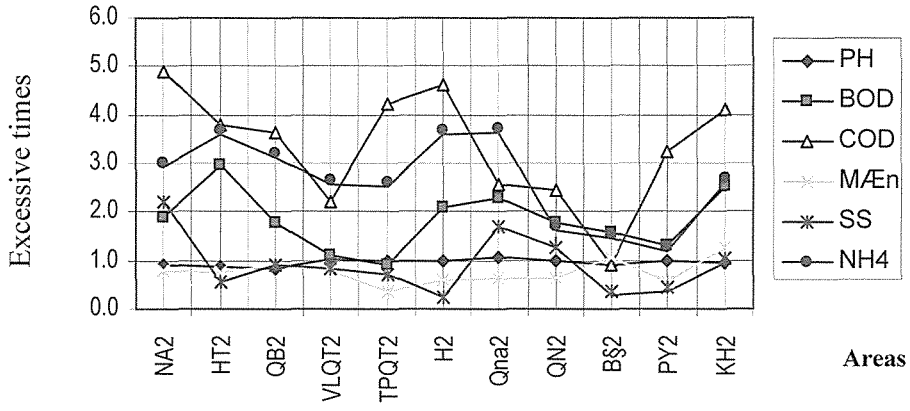

Figure 1: Levels of surface water pollution in Central Vietnam Coastal

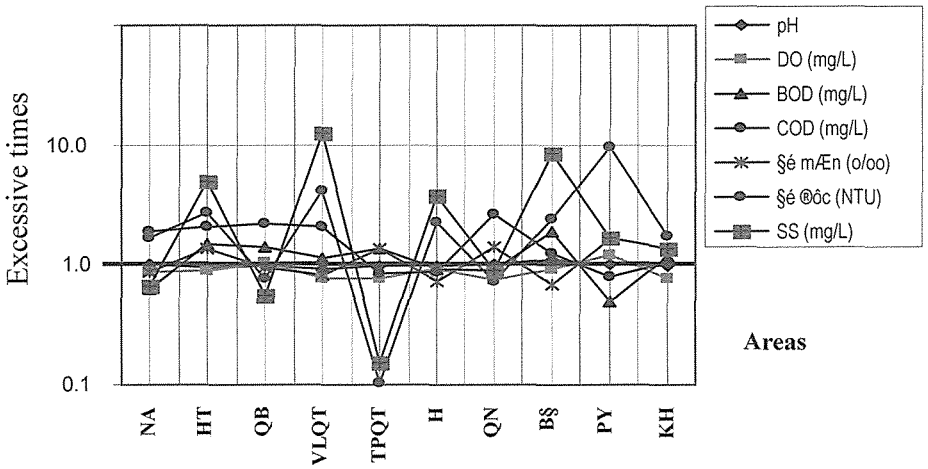

Figure 2a: Comparison between the supply water and wastewater qualities of aquaculture ponds in central Vietnam coastal

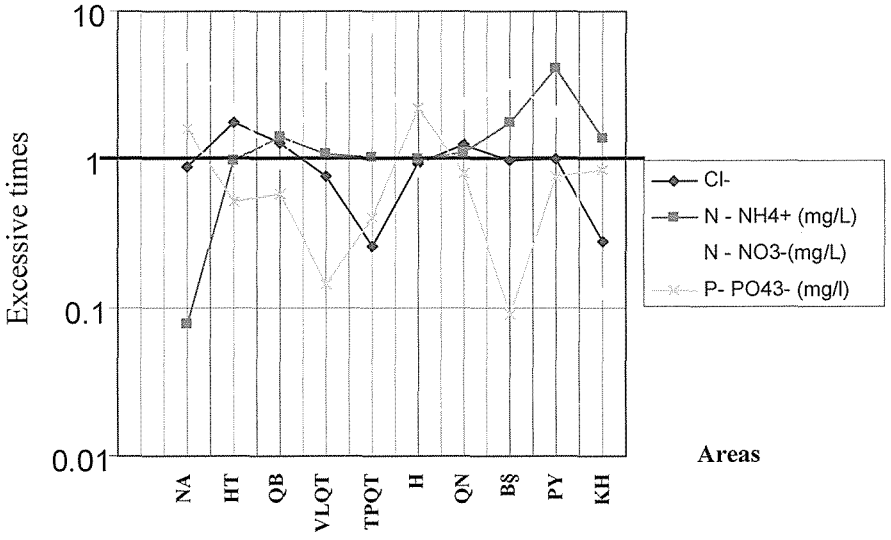

Figure 2b: Comparison between the supply water and wastewater qualities of aquaculture ponds in central Vietnam coastal

2.1.2. In Mekong River Delta

On average, NO_2^- concentration measured in intensive culture is respectively 5.7 and 41.5 times higher than that in semi-intensive and extensive cultures. NO_3^- concentration of intensive culture is respectively 3.5 and 2.3 times higher than that of semi-intensive and extensive cultures. PO_4^{3-} of intensive culture is equal to that of semi-intensive culture and a bit higher than it is in extensive culture. H_2S concentration of intensive culture is 1.5 times higher than that of semi-intensive culture and 2.7 times higher than extensive culture. NH_3 concentration of intensive culture is nearly double as much as that of semi-intensive one and 19.6 times higher than that of intensive one. The NH_3 concentration in both intensive and semi-intensive cultures exceeds the Vietnam's standard 5943-1995. SiO_2 of extensive culture is tenfold highjer than that of semi-intensive culture

and 12.5 times higher than that of intensive one.

The overuse of chlorine in intensive culture ponds and chlorinated herbicides used in the mixed culture of rice and shrimp poses a serious threat to soil and water environment. Our collected data indicate that the amount of chlorine used in intensive culture ponds may climb up to 100kg/ha per year, in semi-intensive ponds: 200-300 ml/ha or even up to 600ml/ha per year.

2.2. The potential environmental changes

2.2.1. Scientific bases for forecasting environmental changes

1. The environmental change forecasting method

The environmental change forecast is based on the general environmental management framework with triangle type: pressure - state – response (figure 3)

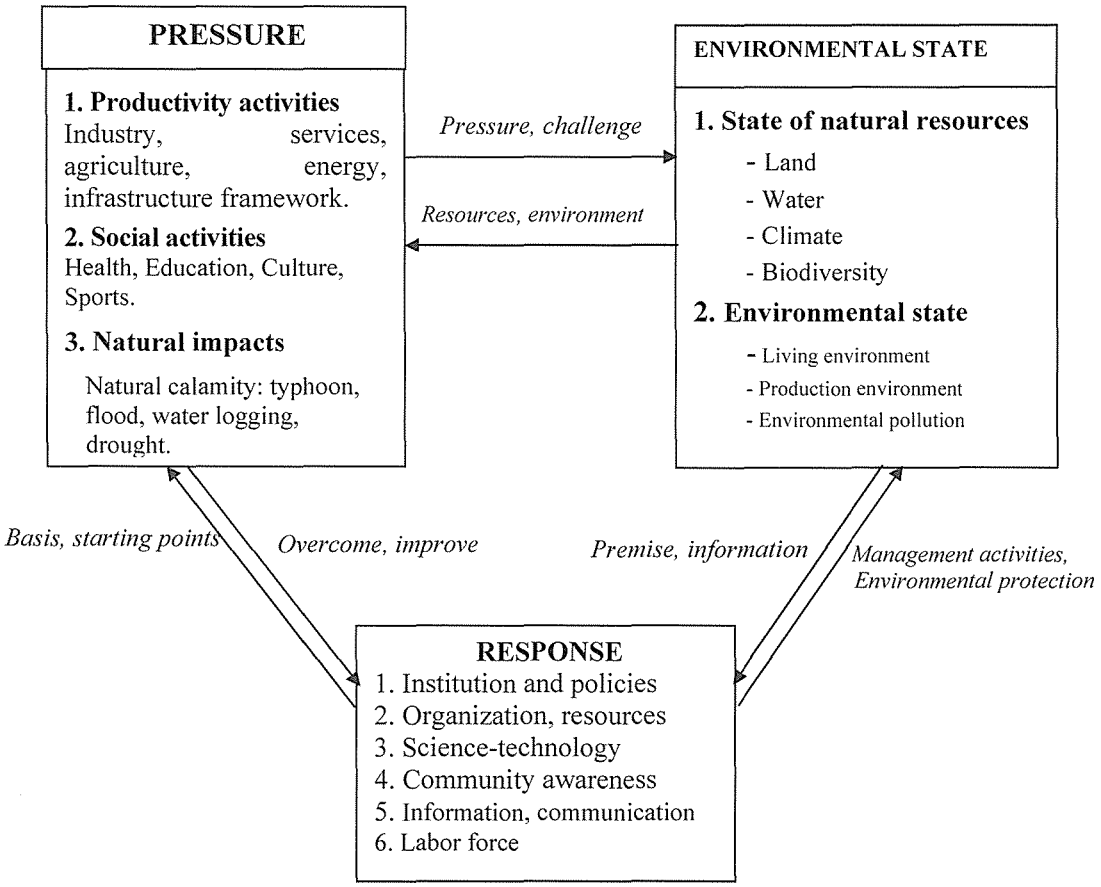

Fig 3: "Pressure - State - Response" model used for the evaluation and study of environmental changes in aquaculture farming

In the above noted model, several environmental change forecasting methods can be used as follows:

+ *"Researching over the past – forecasting the future"* method

+ GIS method

+ Forecasting method on the emission sources based on *"pollution coefficient"*. Project KC.08.30 has used the method of "*pollution coefficient*" for the environmental forecast of the aquaculture farming.

2. Bases for studying the environmental changes

Bases for studying the environmental changes are shown below:

- Natural conditions and resources,
- Current state of environment,
- Socio-economic planning and development,

- Development and number of aquaculture farms.

3. Potential environmental changes

Criteria framework on the development of environmental change matrix

A. Farm scale and infrastructure
   a. Farm development (number of farms/year): Under 10.000 farms : +; Between 10.000 - 20.000 farms: ++; Over 20.000 farms: +++
   b. Pond area: Under 0,4 ha: +; Between 0,4 - 1 ha: ++; Over 1 ha: +++
   c. Production type: Extensive culture +; Improved extensive culture: ++; Semi-intensive culture, intensive culture: +++
   d. Farm's infrastructure: Simple: +; Semi-modern: ++; Modern: +++

B. Levels of knowledge and technology on aquaculture
   a. Application of technology and sciences into production: Simple: +; Medium: ++; Advanced : +++
   b. The manager's competence: High: +; Middle: ++; Low: +++
   c. The worker's competence: High: +; Middle: ++; Low: +++

C. Environmental management and protection
   a. Environmental monitoring programme: Properly implemented: +; Improperly implemented: ++; Not implemented: +++.
   b. Organization and environmental protection measures: Regularly implemented: +; Irregularly implemented: ++; Not implemented: +++.
   c. Effects of pollution treatment: Good: +; Medium: ++; Not good: +++.
   d. Environmental protection policy and framework: Good and comprehensive: +; Incomprehensive :++; Insufficient: +++.
   e. e. Chemical and antibiotic control: Good control:+; Insufficient control: ++; No control: +++

Scenario description

Scenario 1: In the event that there will be no significant improvement of environmental protection activities, the environmental pollution is likely to increase in conjunction with the rapid growth of the number of farms, the development of industries, tourism, trade - services, etc.

Table 1. Potential environmental changes in aquaculture farming according to the scenario 1

Year / Criteria	Before 2000	2000-2005	2006-2020
1. Farm scale and infrastructure			
- Farming development rate	+	++	+++
- Pond area	++	++	+
- Production type	+	++	+++
- Infrastructure	+	++	++
2. Knowledge, technology and sciences			
- Technological application	+	++	+++
- The manager's competence	+++	++	++
- The worker's competence	+++	++	++
3. Environmental protection and management			
- Environmental monitoring programme	+++	+++	++
- Organization and environmental management measures	++	++	++
- Effects of pollution treatment	+++	++	++
- Environmental protection policy and framework	+++	++	++
- Chemical and antibiotic control	+	++	++
Total	**24 +**	**25 +**	**26 +**

Scenario 2: The environmental pollution in aquaculture farming is likely to lessen because of the decreased number of farms toward the end of the industrialization, the more environmentally friendly development of industries, tourism, trade - services, etc., and the significant contribution of environmental protection activities. In 2015, the farming development will be more stable. In 2020, the sustainable farming models will be developed synchronously and exploited more effectively.

Table 2. Potential environmental changes in aquaculture farming according to the scenario 2

Year / Criteria	Before 2000	2000-2005	2006-2020
1. Farm scale and infrastructure			
- Farming development rate	+	++	+
- Pond area	++	++	+
- Production type	+	++	++
- Infrastructure	+	++	++
2. Knowledge, technology and sciences			
- Technological application	+	++	+++
- The manager's competence	+++	++	+
- The worker's competence	+++	++	+
3. Environmental protection and management			
- Environmental monitoring programme	+++	+++	+
- Organization and environmental management measures	++	++	+
- Effects of pollution treatment	+++	++	++
- Environmental protection policy and framework	+++	++	+
- Chemical and antibiotic control	+	++	+
Total	**24 +**	**25 +**	**17 +**

Note: +: Bad impact

2.2.2. The environmental changes in Central Vietnam Coastal

1. Potential changes of surface water environment until 2020.

Scenario 1: In the event that there will be no significant improvement of environmental protection activities, the pollution of surface water environment is likely to increase in conjunction with the rapid growth of the number of farms, the development of industries, tourism, trade - services, etc.

For this scenario, when the number of farm increases without proper environmental protection, the water environment quality in farms as well as in nearby coastal zones will be increasingly worse. In 2010, most of aquaculture farms will suffer losses due to polluted input water leading to the spread of disease and mass death of cultured organisms. In 2020, the pollution of water environment will be too worse to keep the aquaculture farming going on. This will be an alarming signal to environmental manager as well as economic manager to take into their consideration the sustainable development of aquaculture farming.

Scenario 2: The surface water environment in aquaculture farming is expected to be less polluted due to the decreased number of aquaculture farms toward the end of the industrialization, the more environmentally friendly development of industries, trade - services, etc., and the significant contribution of environmental protection activities. In 2015, the farming development rate will be more stable. In 2020, the sustainable farming models will be developed synchronously and exploited more efficiently.

For this scenario, the farming development rate gets more stable. In addition, relevant authorities will issue timely policies on environmental management and protection. Therefore, aquaculture farming will be surely developed in a stable and non-polluted way.

2. Potential changes of aquaculture wastewater until 2010 and 2020

In Coastal Central Vietnam, the aquaculture area is 30,828 ha, of which the Northern Central Vietnam accounts for 15,240 ha (49.44%) and the Southern Central Vietnam accounts for 15,588 ha (50.56%).

From our surveys in some local areas, the initial water level of pond is approximately 0.8-1 m in height. The water level is then increased to ensure a desirable height of over 1.4-1.5 m. Given that the average water level is 1.4 m during the whole production time, the total volume of water used for 1 ha of pond is 14,000 cubic m. In reality, ponds are added more water (about 20% of the total volume of water in pond) once a week and also needed spare water (about 50% of the total volume of water in pond). As a result, the total volume of water needed for 1 ha of pond is 54,600 cubic m, of which the wastewater of an aquaculture crop represents 30% of the total volume (16,380 cubic m).

With an aquaculture area of 30,828 ha, the volume of wastewater per crop in Coastal Central Vietnam is about 0.5 billion cubic m (*16.380 m^3/ha x 30.828 ha = 504.962.640 m^3*). There are two crops per year, so the total volume of wastewater per year is 1 billion cubic m. According to Vietnam Aquaculture Planning Institute, the aquaculture area of Coastal Central Vietnam in 2010 will be 58,000 ha, nearly double as much as that of 2003. Therefore, the total volume of wastewater will be double as well (2 billion cubic m).

3. Potential changes of groundwater environment up to 2010 and 2020.

Scenario 1: If the current situation (the over-exploitation of ground water, the non-treatment of aquaculture wastewater and the improper discharge of wastewater) keeps going on, the ground water quality will be much worse in 2010: some parameters such as BOD_5, COD, NH_4^+, Coliform, etc. will be significantly increased. At the same time, the salinization of ground water will increasingly occur affecting adversely the clean water supplied to people in Coastal Central Vietnam. In 2020, the ground water quality will be seriously declined, and even the exhausion of ground water and surface depression will take place. These are due to the over-exploitation of freshwater for the usage of aquaculture farms, especially the on-sand shrimp culture farms.

Scenario 2: In case most of farms will carry out the proper treatment of wastewaters before discharging them into receiving sources and comply with policies and measures on environmental management, some relevant parameters such as BOD_5, COD, NH_4^+, Coliform, etc. will be reduced as compared to those of 2005. With respect to the salinization of ground water, there needs to have a detailed study for the assessment of ground water reserve in each province, so that the planning of some specific areas appropriate for on-sand shrimp culture will be elaborately devised. Additionally, the development of irrigation works providing freshwater to aquaculture should be implemented to prevent the overexploitation of ground water.

2.2.3. The environmental changes in Mekong River Delta

1. Potential changes of surface water environment until 2020.

Scenario 1: The surface water pollution in farms caused by microorganism, organic substances, nutrients, chemicals, fertilizers and pesticides is increasing. At the same time, the rapid growth of the number of farms, the development of industries, trade-services and export processing zones is to make the matter worse. Moreover, the annual impacts of Me Kong River's flooding on Me Kong River Delta and the poorly improved of "rural clean water and sanitation" are ones of the main causes reducing the surface water quality.

Scenario 2: The surface water pollution in farms caused by microorganism, organic substances, nutrients, chemicals, fertilizers and pesticides will be lessened due to the decreased number of aquaculture farms, the more sustainable development of industries and trade-services, the considerable improvement of "clean water and rural sanitation" programme and the good implementation of environmental protection in aquaculture farming.

Apart from the property and human loss, the storm and flooding in Mekong River Delta also have adverse impacts on the surface water quality that pose a serious threat to a large-scale pollution in the study area and the spread of epidemics such as bacteria contamination, dermatological diseases, digestive diseases, gynaecological diseases, etc. Especially, the long-lasting waterlogging in the area presents serious impacts to water quality, the salinization and alum contamination of water and soil environments with a significant concern in Dong Thap and Long Xuyen Tetragon Region. These impacts also cause some problems such as

the control of the water quality due to high turbidity and much suspended solids in water, the supply of clean water, the rural sanitation security, the erosion, deposition and landslide in some river catchments.

As pointed out above, in case there will be no proper planning, management and sustainable development of aquaculture farming in the future, the potential serious degradation of surface water environment is definitely to occur. The pollution level may increase five and even tenfold as a result of the industrialization and modernization. Another problem is the control of pollution level and scale in upstream areas that have extensive impacts on downstream surface water in Me Kong River Delta.

2. Potential changes of groundwater environment up to 2020

Scenario 1: The pollution of groundwater in aquaculture farming caused by alum contamination, salinization, or by increased bacteria contamination, nutrients, organic substances, chemicals, pesticides and fertilizers will increase because of the rapid development of farms, industries, trade-services and increasing drought and salinity intrusion.

Scenario 2: The decreased number of aquaculture farm, the application of advanced aquaculture technology and planning, the usage of micro-organisms for treatment of pond bottom, and the cycled water usage will surely limit the usage of groundwater. Accordingly, the level of alum contamination as well as salinization will be lessened or remain unchanged.

In order to solve the problem of pollution and degradation of water environment in aquaculture farms, there needs to pay much attention to the "rural clean water and sanitation" programme, the environmental protection activities, the application of advanced technology, especially the application of high efficient aquaculture farming models, the good control of chemical residuals, fertilizers, pesticides, the accurate assessment of quality and reserve of groundwater for its proper use.

3. Solutions for environmental protection and sustainable development in aquaculture farming

3.1. Land

There needs to have encouraging, supporting and preferential solutions for farm owners in terms of tax rate and land allocation and land management.

3.2. Capital mobilization for investment in aquaculture farming

* To encourage and strengthen the capital mobilization available on market,

* To create legal capital in forms of property, valuable objects for investment as stipulated by Law,

* To create capital through the capital of foreign investment, joint venture and co-ordination with other farms, co-operatives, enterprises, companies, etc.

* To create investment capital from State banks or foreign loans,

* To create capital from loan, collaterals at banks and credits,

* To create capital from funds of development, assistance, and insurance, ODA, international assistance and aids,

* To create capital from pushing up the flows of international investment capitals.

3.3. Funding policies for supporting the development of aquaculture farming

* To mobilize idle capital available on the market through solutions of mobilizing financial capital, banks and capital investment from overseas Vietnammeses,

* To reserve development suportting capital sources from State budget as stipulated by the government,

* To mobilize development suportting capital sources from stock market in accordance to government's financial and banking policies,

* To reserve development suportting capital sources from donative funds, sponsor funds as stipulated by government,

* To reserve development suportting capital sources from foreign and international loans as stipulated by goverment.

3.4. Tax policy

To introduce two main streams of incentive policy that create a system of adequate incentive policy at both central and local State levels. This will form a closed system starting from Law → Implementation → Management → Post-check during the course of implementing policies on State's taxes, capitals and credits.

3.5. Technology and science transfer

1. Defining policy model for technology, science and technique transfer

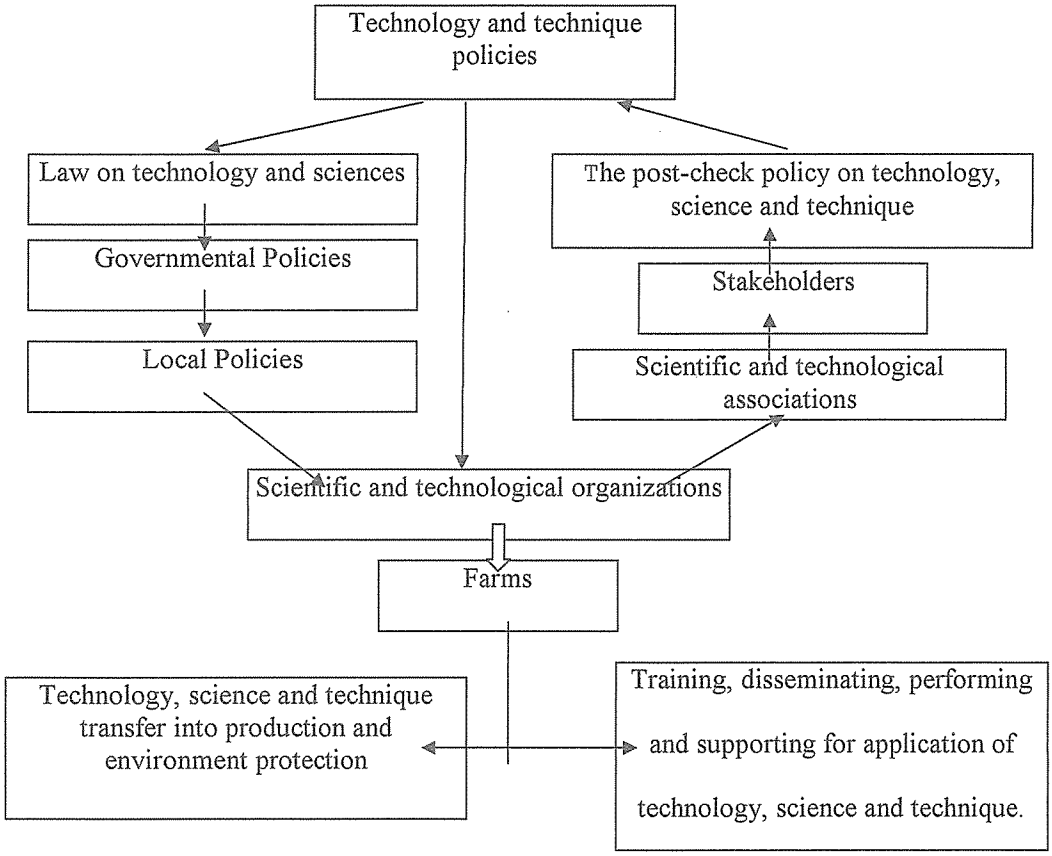

Figure 4: The technology, science and technique transfer policy

The policy model for technology, science and technique transfer to production types of aquaculture farming includes both basic framework of State's and Government's policies and encouraging and supporting policies to the development of aquaculture farming. The model has a connection and co-operation with multi-staholders in the development of aquaculture farming. The policy model for technology, science and technique transfer in aquaculture farming are shown in picture 4 as follows:

The core of the above noted model is aquiculture farms – the main objects for the application of the technology, science and technique transfer policy, the implementation of technology and science, the training and education, the development and promotion of technology and science market.

The scientific organizations play a key role in technological and scientific activities and the transfer of technology, science and technique to aquaculture farms as stipulated by Law and policies.

The scientific and technological associations play a key role in the satisfying and implementing the policies of science and technology based on State's technological and scientific Law and policies on post-checking of the technological and scientific activities of associations, co-ordinating, combining organizations of technology and science, stakeholders, and aquaculture farms in transferring technology, science and technique and post-checking technology and science activities in accordance to working regulations of associations.

The stakeholders is made up of organizations on encouraging agriculture and forestry expansion, businesses, individuals, organizations on training, education, communication, etc. that have inter-connected influences on the technological and scientific activities and the transferring of technology, science and technique between farms.

So, the above noted model comprises two main and secondary streams of technology and science based on the basic and extensive frameworks. It forms a policy system on technology and science that satisfies sufficiently and simultaneously the role of central and local governments and the role of organisations and individuals related to technology and science policies. Hence, it will set up a closed general system starting from Law → Implementation → Management → Post-check during the course of implementing technology and science policies.

2. Technology and science transfer solutions

To put aside a considerable budget and great efforts for Planning and Strategy on reserach and development of technology and science and transfering activities of technology and science to aquaculture farming according to annual planning on socio-economic development.

To push up the diversification of resources for researching activities and transfering technology and science on the basis of incorporating the policies on voluntary support and marketing.

To apply policies on development and construction of technology and science for aquaculture farming on the basis of technology and science policies, demands on economic development and environmental protection of aquaculture farms.

To enhance the dissemination, communication of knowledge and experience, performance of effective model, support of training and education, support of promotion and development of technology and science market.

To strengthen the co-operation, joint venture and collaboration between aquaculture farms in the transfering of technology, science and technique; to popularize typical models according to the demand on the development of economic co-operation and business model, farming companies; to carry out solutions on close co-operation between aquaculture farms and technological & scientific organisations and other stakeholders.

To increase and encourage the international co-operation in transfering technology, science and technique and developing the technological and scientific market for farms.

3. Solutions on postchecking the technology and science tranfer includes reporting framework, inspection and monitoring according to State management rules or working regulations of relevant organisations and associations.

3.6. Agriculture and forestry encouragement

To improve a system of organisations on the encouragement of agriculture, forestry and fishery; To develop and incorporate strategies and action plans of the encouragement on agriculture, forestry and fishery according to the general planning of socio-economic development; To identify solutions for promoting the encouragement on agriculture, forestry and fishery; To issue policies permiting and encouraging organisations and services on the promotion of agriculture, forestry and fishery; To set up businesses and companies

working in accordance to Vietnam Law; To develop and encourage the close connection, co-operation and services on agriculture, forestry and fishery encouragement with high responsibities and obligations.

The post-check of policies for agriculture, forestry and fishery encouragement should include framework of reporting, checking, inspecting, and monitoring according to State management principles or working principles of relevant associations and organisations.

3.7. Mitigation, prevention and treatment of pollution

General solutions on planning and environmental management in aquaculture farming: To incoporate environmental protection planning into regional socio-economic development planning; To develop integrated regional environmental management policies; To emphasize environmental education and raise people's awareness on the significance of environmental protection; To set forwards solutions on protection and development of protective forest; To assess and forcast carrying capacity of environment.
Technical solutions on mitigation and prevention of water pollution

3.8. Quadripartite policy

* Production of goods,
* Consumption of goods,
* Training and supporting to technology, science and technique transfer,
* For the authority

4. Conclusion

- Most parameters of surface water in Central Vietnam Coastal and Me Kong River Delta exceeds the Vietnam's Standards 5945-1995 and most parameters of aquaculture wastewater exceeds the Vietnam's Standards 5943-1995.
- In regards to environmental changes, the paper brings forwards two scenarios of surface water, aquaculture wastewater and ground water in Central Vietnam Coastal and Me Kong River Delta.
- Based on the current state of envieonment at aquaculture farms in both study areas, 8 solutions are outlined to make a contribution to the sustainable environmental protection in aquaculture farms.

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