As. J. Energy Env. **2010**, 11(02), 77-89

Asian Journal on Energy and Environment

ISSN 1513-4121

Available online at www.asian-energy-journal.info

Research Article

Changes in surface water quality and community-based resources management of the Tam Giang Lagoon, Central Vietnam

Nguyen Huu Ngu*

Faculty of Land Resource and Agricultural Environment, Hue University of Agriculture and Forestry, No.102 - Phung Hung Street, Hue City, Vietnam.

*Author to whom correspondence should be addressed, email: nguqld@yahoo.com

Abstract

This paper attempts to examine the changes to surface water environment and community based resources management activities in the Tam Giang Lagoon, Central Vietnam. The results show that the lagoon's surface water is being polluted. BOD, COD and nutrient concentration have increased in the lagoon's surface water environment. It is shown that there is a presence of organic substances. Due to the effects of globalization on trade in seafood products and changes in lagoon's water quality by aquaculture development; the local government has issued many regulations to manage the lagoon's resources. Among those policies, the establishment of a fisheries association and/or self-management team is considered as an appropriate solution to develop aquaculture and capture aquatic resources in the lagoon. However, the benefit and power of the resource users have not been stipulated for both fisheries association and self-management team. Instead of this, it is only the individual member's responsibility and duty in using the lagoon's water surface areas. As a result, most of the resource users in the surveyed area have not participated in these organizations as their members. The resource user must undertake all activities in relation to aquaculture by themselves, without support from these organizations.

Keywords: community based resource management, biochemical oxygen demand, chemical oxygen demand, surface water environment, self-management team, Tam Giang Lagoon.

Introduction

The effects of globalization on demand for sea food products and climate change are the great challenges to manage and use natural resources in developing countries. Several theories and arguments have emerged as a result of experience in fisheries resource management around the world, particularly those relating to community based management in coastal regions. Community based resource management, as explained by Korten [1], includes several elements such as a group of people with common interests, mechanisms for effective and equitable management of conflict,

and broadly distributed participation in the control of resources within the community. Sajise [2] has argued that community based resource management is a process by which the people themselves have the opportunity and/or responsibility to manage their own resources, define their own needs, and make decisions that affect their socioeconomic welfare. According to Ferrer and Nozawa [3], community based resource management is people-centric, community-oriented and resource-based. The idea has grown from the basic premise that people have the innate capacity to understand and act in order to solve their own problems. Building on their current experience people can, together as a group, further their knowledge and create a group consciousness. Meanwhile, Rivera [4] has argued that community based resource management is a process of governance and political decision-making, geared toward the formation of partnerships and power sharing. It is consensus-driven and geared toward achieving a balance of interests. The emphasis is on communities and at its core, the community organization. With the debates as mentioned above, it can be said that there is no definitive model of community based resource management which can be referred to in order to manage natural resources, because the relevant terms and concepts originate from geographical contexts, historical circumstances and the specific culture of each country. In the case of coastal and lagoon resources, McCay [5] stated that "current top-down and bureaucratic fisheries management approaches, based on centralized government interventions, are unable to address most of the contemporary problems, such as rehabilitation of stocks, resolving user group conflicts and sustaining livelihoods of fishing communities". This is because people have not been granted the rights to manage and fish on common fishing grounds. Due to these reasons, Pomeroy [6] suggested that fisheries often cannot be managed effectively without the cooperation of fishing communities. Instead, fishermen should be organized into formal associations and should be granted the right to manage and exploit the fisheries resources by themselves. If the fishermen conceive that the resources being exploited are their own property, this will give a greater incentive to the fishermen's community to create their own management system.

In the coastal region of Central Vietnam, the rural communities still rely heavily on natural resources for their livelihood. Accordingly, their access to common property such as coastal/lagoon resources and its water surface area are substantially important. However, the management of use rights and access to resources in practice seems to create conflicts among the users either in groups, organizations or individuals because of changes in policies, regulations and customary use. It may lead to greater vulnerability for the poor who are strongly dependent on the lagoon resources and new conflicts among members inside and outside communities. It also the cause behind environmental degradation due to the discharge of untreated sewage, pesticides and fertilizers from aquacultural and agricultural activities. The changes in opportunities for using resources and rapid aquaculture development are becoming a part of potential society conflicts for communities around the lagoon. Some researchers such as Ton That Phap [7], Truong Van Tuyen [8] and Le Van Mien [9] have tried to describe issues of co-management in planning of waterway systems, dynamics of property rights, lagoon activities and social organization of the fishermen in the Tam Giang Lagoon. However, this work only skimmed the surface and does not go into detail on the changes to the water environment as well as rural resident's livelihood. Moreover, this research did not mention the changes in natural resource management policies under the impact of aquaculture development, land allocation policy as well the increasing export demand for seafood products. In order to compensate for the deficiencies described above, field work was conducted in Phu An commune, located in the Tam Giang Lagoon, Central Vietnam in September, 2009. Thus this paper attempts to examine the changes to the surface water environment and community based resources management activities in the Tam Giang Lagoon.

Study Site

Phu An Commune is one of 21 communes and towns of Phu Vang District, Thua Thien Hue Province, Central Vietnam (Figure 1). It is located on the shore of the Tam Giang Lagoon, one of the biggest lagoons in Asia whose area is about 22,000 hectares with a length of 70 km along the coast. About 6,140 households are directly participating in exploitation and aquaculture activities in the lagoon. Among them, about 900 households live on the lagoon's water surface [10].

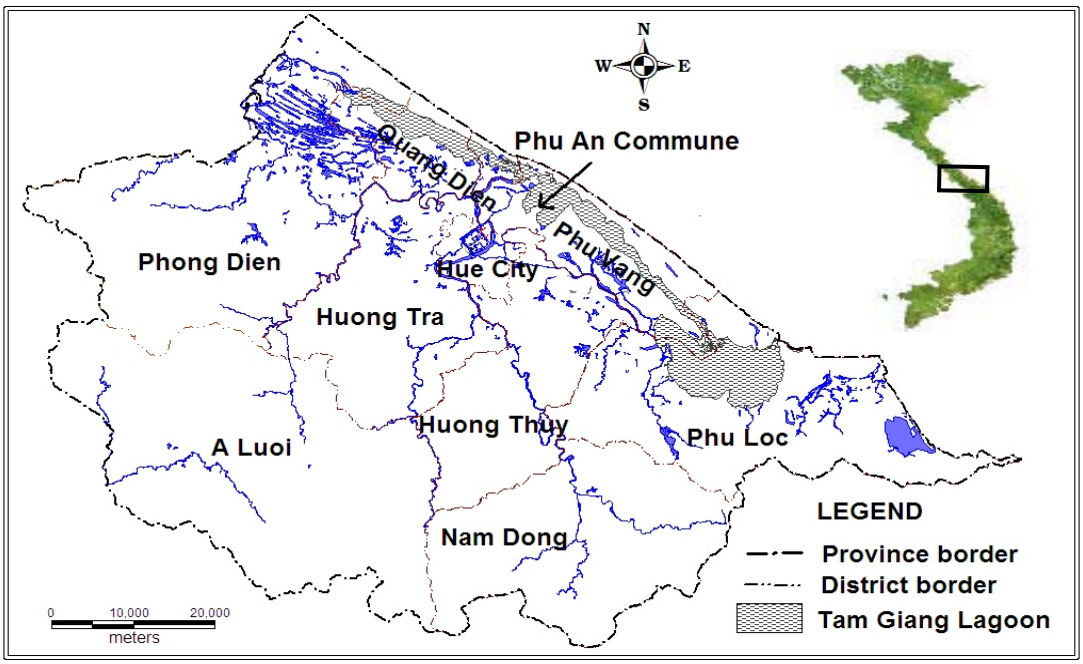

Figure 1. Location map of the study area; arrow indicates Phu An Commune.

Source: Faculty of Land Resources and Agricultural Environment, Hue University of Agriculture and Forestry, Vietnam, 2009 (modified by the authors).

The total area of Phu An Commune is 1,128 hectares and over 500 hectares are occupied by Tam Giang Lagoon, which is utilized for fishing and traffic (Figure 2). Community settlements exploit the lagoon's resources such as fish, shrimp, shellfish, edible seaweed and also farm on the sandy land at its edge. The area used for food production is 269 hectares, of which 220 hectares are planted to spring paddy crop (from December to April) and 49 hectares for summer paddy crop (from May to September).

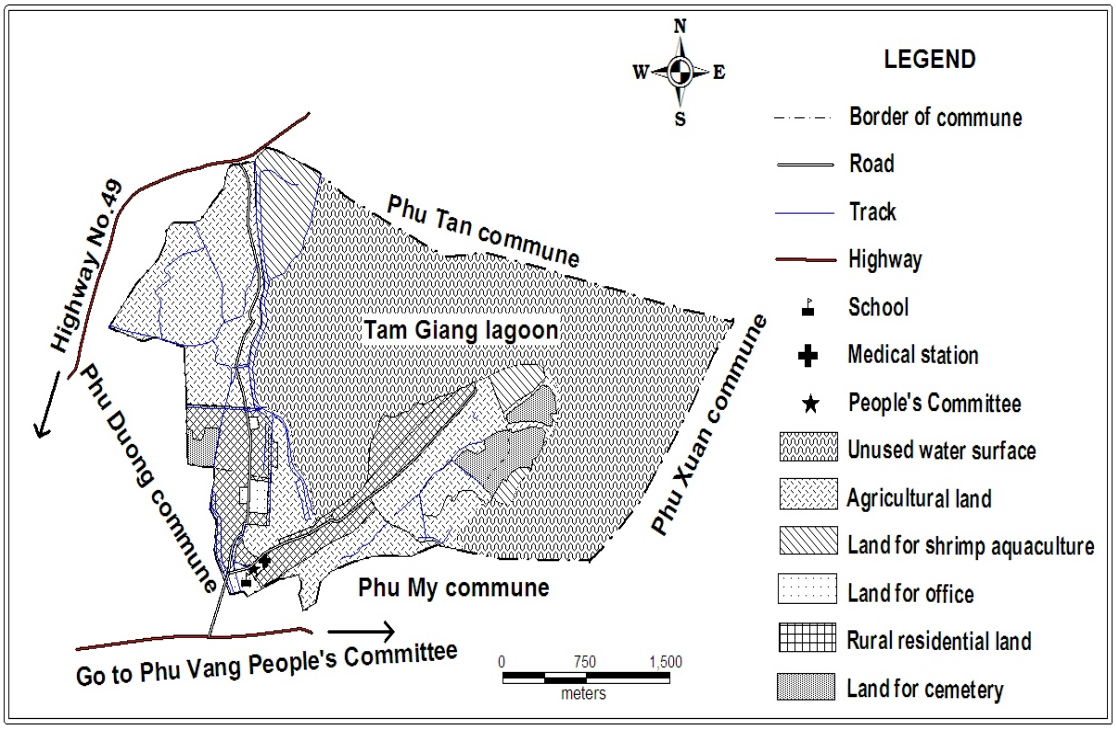

Figure 2. Land use map of Phu An Commune.

Source: Faculty of Land Resources and Agricultural Environment, Hue University of Agriculture and Forestry, Vietnam, 2009 (modified by the authors).

Administratively, Phu An Commune is divided into four villages. The population is 8,749 persons with 1,583 households as of 2006. About 82% of households are involved in agriculture and/or aquaculture, 13% in only fishing including net-enclosures and 5% in services such as distilling rice liquor, woodworkers, barbers and retailers. The proportion of households who use electricity is about 95%, while the proportion of households who use tap water for daily use is 85%. The rest use water from ponds, wells and/or the lagoon. The average income per capita per year is about 327 US$ [11].

Methodology

In order to conduct this research, diverse sources of data were used including (i) a secondary researched review of published literature and legal and policy documentation in relation to changes in the lagoon's resource management policy, aquaculture development activities under land policy and demand for seafood products, as well as changes in surface water environment by elements of BOD_5, DO, COD and other nutrients concentration, and (ii) information collected via key informants such as the local authorities, the local resident groups in the Phu An Commune and the managers of Thua Thien Hue Fisheries Resources Protection Agency and Thua Thien Hue Department of Fisheries. Among the interviewees, seven key informants provided directly useful information for this research. The characteristics of these seven are farmers, fishermen and officials. The information provided was accepted with confidence because most of them were over 60 years old and thus have first-hand experience in relation to historical changes in the lagoon's utilization and management.

Results

Changes in lagoon's surface water environment from aquaculture development

The "Doi Moi" policy initiated by the Vietnamese Government in 1986 and the consequent widening of the export market for marine and farm products between Vietnam and countries around the world, have been fueling rapid changes in the rural society of Vietnam, especially in the field of natural resources use and management. This has motivated households to participate strongly in production activities as independent economic units for improving their lives. Following the increase in demand for seafood, due to the effects of globalization, shrimp aquaculture in the Tam Giang Lagoon was introduced by the local government in 1999 as an alternative to fishing in order to improve the income of the fixed gear fisher and the mobile gear fisher, as well as to reduce exploitation on the lagoon's resources [12]. However, the implementation of the master plan for management and reduction of exploitation of the resources was delayed until 2003. Prior to this period, there were no fisheries management plans. Provincial governments did not implement many laws and regulations fearing that they would cause severe disruption and hardship to small-scale fishers [13]. This has led to more encroachment of the fishing ground by fishermen and farmers to earn additional income, as well as an increasing number of participators, intensification of exploitation, higher risk of environmental degradation and rapid exhaustion of the lagoon's resources [14, 15, 16, 17]. Negative environmental impacts are increasing in recent years. The chemical and organic fertilizers along with the manufactured feed are added to increase production. Results in Table 1 show some changes in the lagoon's surface water environment in the period of 1998-2007.

Table 1. Changes in the lagoon's surface water environment in the period of 1998 - 2007

Element	Unit	Year					
		1998[1)]	2004[1)] (June)	2006[2)]			2007[2)] (May)
				April	May	Nov	
BOD_5	mg/l	0.15	1.21	0.90	2.00	0.40	1.70
DO	mg/l	7.60	5.60-6.5	7.10	6.00	5.50	-
COD	mg/l	1.50	4.12	9.00	4.00	7.00	9.80

Source: [1)]Nguyen Huu Cu and Mauro Frignani [18]

[2)] Nguyen Van Hop, *et.al* [19]

Results in Table 1 indicate that BOD_5 (biochemical oxygen demand) increased during the dry season in the period of 1998-2004, from 0.15mg/l to 1.21mg/l. Especially, BOD_5 accelerated to 1.70mg/l in 2007. As a result, DO (dissolved oxygen) also decreased. Results in Table 1 also show that COD (chemical oxygen demand) in the water of the Tam Giang Lagoon increased in the period of 1998 – 2004, from 1.50mg/l to 4.12mg/l, and especially COD accelerated to 9.80mg/l in 2007. In the research of Nguyen Van Hop, *et.al* [19], the authors concluded that "the anxious problems of the lagoon water quality were organic pollution (high COD concentration), bacteria pollution (high total coliform and fecal coliform concentration) and level of nutrients (nitrogen and phosphorus) potential to eutrophication". Although, nitrate (NO3) concentration was not very high (<0.26 mg/l) compared with the Vietnam Standard TCVN 5942-1995 (≤ 15 mg/l) for surface water used for multi-purposes, the total nitrogen (TN) level in several areas of the lagoon is higher than international standards [19]. According to American standards, total nitrogen (TN) applied to coastal water is (TN < 0.9 mg/l), the Chinese standard for fish culture (TN < 0.5 – 1.0 mg/l) and the Japanese standard for coastal water (TN < 0.03 – 0.05 mg/l), shows that TN levels in some areas of the lagoon exceeded the requirements (1.72 mg/l in May, 2006 and 1.28 mg/l in May, 2007 respectively [19]) applied for coastal ecosystem conservation and aquaculture. In addition,

this research stated that phosphorus was the limiting factor in the lagoon and phosphate (PO_4) concentration was 0.01 mg/l-0.03 mg/l [19]. As a result, it can be said that the lagoon has been in eutrophic condition for some time [20]. Do Cong Thung [21] also stated that microorganism pollution in the Tam Giang Lagoon water was higher than allowable standards from 3 to 30 times. Average concentration of total coliform in the lagoon water (ranging from 2,900 to 69,000 MPN (Most Probable Number)/100 ml) exceeded the permitted level of Vietnam standard TCVN 5943-1995 (<1000 MPN/100 ml) of water quality used for multi-purposes [19]. Thus, it can be affirmed that there was presence of organic substances in the water environment of the Tam Giang Lagoon and the lagoon's water has clear indications of being polluted.

According to the survey conducted as part of this research, other reasons which also directly caused changes to BOD_5 and DO contributions described above are: (i) the households who are involved in aquaculture activities did not strictly treat wastewater and redundant food in the process of shrimp pond sanitation, and (ii) chemical fertilizer of agricultural activities, waste industry of brewery and oil storage around the Tam Giang Lagoon. Due to these environmental changes, there was an increased failure rate in shrimp aquaculture activities, as shown in Table 2.

Table 2. Changes in household's shrimp aquaculture activities in the Tam Giang Lagoon.

Catalogue	Year			
	1998[1)]		2007[2)]	
	Household	%	Household	%
Profit	1,445	80	2,294	37
Loss	89	5	1,096	17.85
Breakeven	268	15	2,750	44.79
Total	1,802	100	6,140	100

Source: [1)]Thua Thien Hue Department of Fishery [22]
[2)]Thua Thien Hue Department of Fishery [23]

Results in the Table 2 shows that households participating in aquaculture activities accelerated in the period 1998-2007, from 1,802 households to 6,140 households. The participation of crowded resource users without any clear institutional or resource management, such as a master plan for management and exploitation of the lagoon's resources, was the main reason for the proliferation earth ponds, uncontrolled encroachment of water surfaces and growers working to different phases of production. As a result of this unprofessional production, the rate of failed households by shrimp/fish disease increased 17.85% in 2007 (this was only 5% in 1998).

According to statistics of the Thua Thien Hue Department of Fisheries [24], the acreage of shrimp/fish aquaculture decreased in the years 2003, 2004, 2005 and 2007 and was 167 ha, 1,368.5 ha, 635.2 ha and 1,053 ha, respectively. Besides, the rate of profitable households decreased to 37% in 2007 (this rate was 80% in 1998). Rate of breakeven households increased to 44.79% in 2007 (this rate was only 15% in 1998). Due to the failure of shrimp/fish aquaculture, some of these households were no longer able to invest in the additional resources required to continue shrimp aquaculture. The decrease in their revenues due to serious disease during these periods resulted in them being unable to cover the costs for feeding and prevention of disease. Moreover, the high pressure from loan interest for the initial investment pushed them to abandon shrimp aquaculture [25].

Changes in policies at provincial level in the 2000s

Under the pressure from this exploitation of the lagoon's resources, the provincial government and related agencies have promulgated many decrees and regulations in order to manage the lagoon's resources. These documents are indicated in the Table 3.

The contents of Table 3 show that the provincial government has started to pay attention to the lagoon's resource management by determining the core of issues as follows: (i) the households have to join in the Fisheries Association (hereafter called FA) as its members if they want to receive exploitation rights in the lagoon; (ii) to define the fishing rights in the lagoon for the resource users; (iii) shrimp aquaculture by earthen ponds to be reduced to a maximum the resource can withstand; and (iv) depending on ecological characteristics of each region, the provincial government would stipulate the usage time and grant the fishing rights for one year, five years or ten years.

Table 3. Decrees in relation to the lagoon's resource management.

Name of Decree	Main contents	Issuing Authority
Decree No.3667/2004/QD-UBND. Decision of the Provincial People's Committee approval of the overall planning for the management and exploitation of fishery resources on the lagoon system of Thua Thien Hue Province towards 2010.	- New subjects (labour, boats, fishing tools) are not allowed to freely participate in the exploitation of fishery resources on the lagoon - All exploitations in the lagoon have to need permission certificate. - Fish corral exploitation is banned for three months/year	Provincial People's Committee
Decree No.4260/2005/QD-UBND. Decision promulgating the regulations on the management of lagoon fisheries in Thua Thien Hue.	- Individuals and household's participating in lagoon fisheries have to organize themselves in fishing associations at the village's level, inter-village or commune levels. The State will only delegate the power of lagoon fisheries management to the fishing association at the grassroots level. - The fishing rights in the lagoon area include the rights and responsibilities to timely prevent acts of fishery law violation, responsibilities of protecting fishing grounds, developing aquatic resources, ensuring free access to water ways, preventing degradation of the water environment and ensuring submission of taxes to the State. - Only issue fishing certificate for one year (or hand over authority to Communal People's Committee to organize auction annually), five years and ten years depending on the lagoon's zone to the fishing associations	Provincial People's Committee
Decree 1068/2007/QD-UBND Decision of the Provincial People's Committee approval of the planning for fisheries production in the lagoon until 2010, towards 2020.	- Shrimps aquaculture by earth ponds will be reduced to a maximum. - No extension of land allocation, no legalization of net enclosure ponds - Grant the use right to Fisheries Association.	Provincial People's Committee

With these regulations, the resource users, instead of independent units in using the lagoon's resources as before, have to join the FA. When they become FA members, they will have legal authority to receive the water surface usage rights for fishing in the lagoon. However, according to the survey conducted as part of this research, there still exists a form of *de facto* ownership of water surface in the lagoon. The local people still have ownership of the area where they have encroached in the past. This right has not been mentioned in the Vietnamese Laws. Thus, it can be challenged legally in the process of community based natural resource management and policy changes of the authorities.

Endeavor of community based management of the lagoon's resources and its inadequacy at the community level

To implement the decree No.4260/2005/QD-UBND, the Phu An People's Committee established the FA in 2005. The number of members was 101 households out of 382 households who are directly participating in fishing and aquaculture activities in the lagoon. The FA is managed by the People's Committee and related agencies in terms of specialty as indicated in Figure 3. Functions of the FA can be summarized as follows: (i) to help its members raising awareness on protection and development of lagoon resource management policies such as dissemination of new decrees/regulations in relation to aquaculture; (ii) to discuss experiences on aquaculture, help each other when having disasters, diseases and financial difficulty, and (iii) resolving conflicts in fishing grounds and about resources among individuals and/or household members. However, the water surface of households was currently self-managed by themselves in reality. In other words, the households are keeping *de facto* ownership which has been handed down from their ancestors. As a result, the role of the FA has been diminished in terms of the lagoon's resource management. The process of suggestion for granting a fishing license has not been promoted because many households did not participate in the FA as its members. Fishing and aquaculture activities are continuing with or without the FA. The Communal People's Committee still manages the lagoon's activities such as collecting taxes, solving conflicts and coercing the reduction of encroachment of households to waterways for aquaculture.

According to key informants, the unsuccessfulness of the Phu An's FA is due to following reasons:

- lack of stable financial resources to put plans into action because the FA is a voluntary organization;
- lack of awareness among members/community on mandate, powers, responsibilities and benefits that are vested in the FA. There is not any detailed decentralization to the FA while there are many responsibilities they have to do as mentioned above; and
- lack of awareness and knowledge among members in relation to aquatic resources management for sustainable utilization. The resource users continue to exploit resources without considering fisheries size, some individuals even use electric tools for fishing.

In the process of finding sustainable and effective management, the Phu An People's Committee established six self-management teams (hereafter called SMT) in 2008 as another model of community based resource management. These teams exist parallel with the FA and it are controlled directly by the Phu An People's Committee. The function of SMTs has been stipulated as follows: "SMT has responsibilities of preservation, management, help each other in exploiting and aquaculture within its team". There are 75 households who participated in these teams. Some of these members are also the households that have been mentioned in the FA above. It means that they are members of both the FA and SMT.

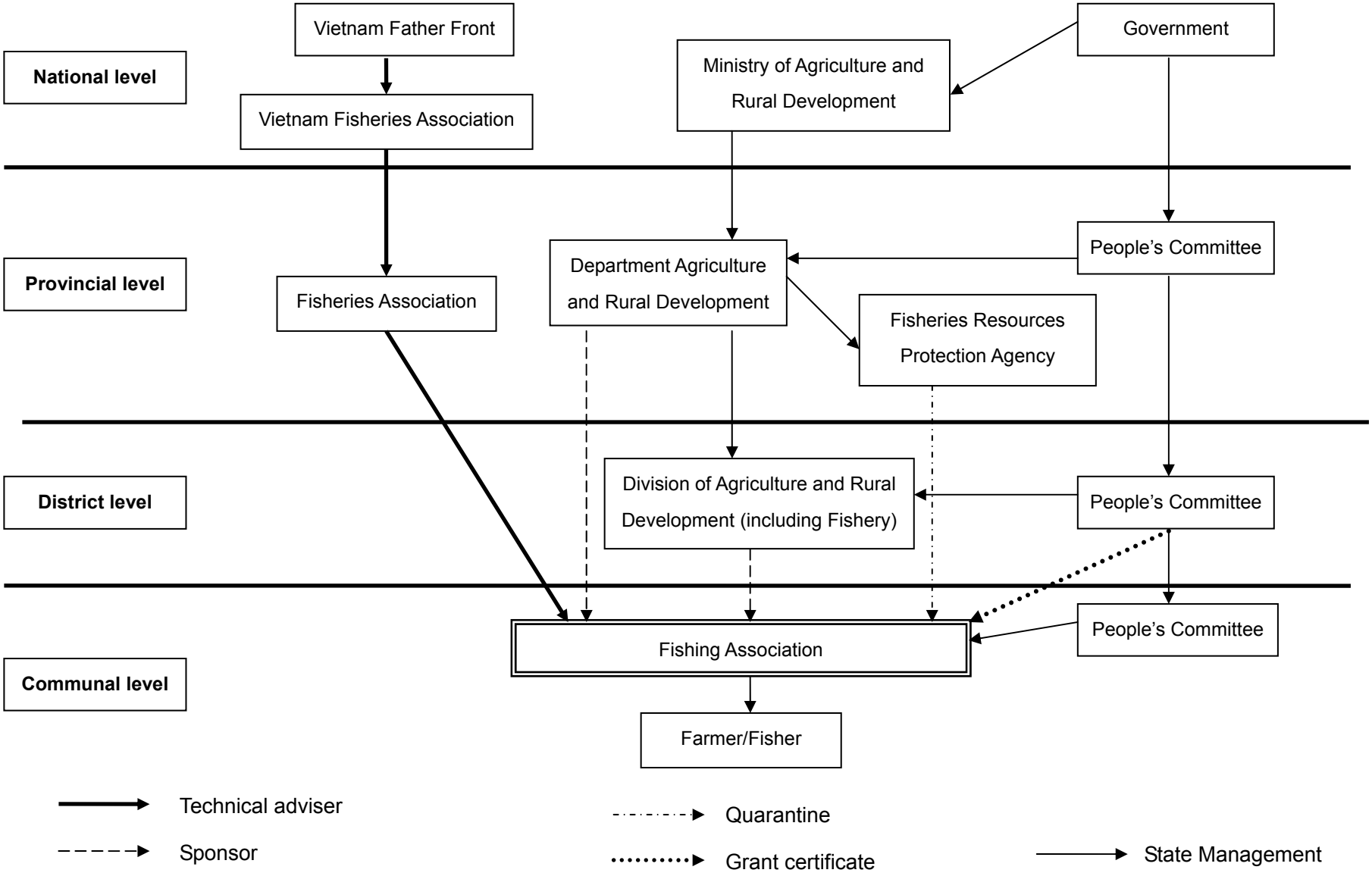

Figure 3. The structure of fisheries association

Source: Author survey, 2009

The results of the survey show that over two thirds of households from the total of 382 in the commune did not participate in these organizations because:

- they said that the FA as well as SMTs could not help them in aquaculture activities such as supplying shrimp/fish for grow out, consultancy on shrimp/fish disease treatment and finding markets for selling their aquatic products. In other words, they have not received any economic benefit or technology from the FA or SMT. They themselves must do all these activities without support from these organizations;
- they believed that the local government has still not established reasonable and sustainable policies to manage the lagoon's resources. The proof is that the granting of fishing licenses had not been implemented at the time of the survey, although the related decree was issued in 2005;
- they did not know how the policy will change because it has not the sure guarantee of the government like agricultural land in relation to the usage time and the water surface ownership where they are doing aquaculture activities; and
- being sampan people, this high risk group has not received any support and guaranteed policy related to the ownership in using the lagoon's resources. They continue to access to the open-access area for their livelihood.

It can be said that the establishment of SMT and the FA has revealed the confusion that exists in relation to the lagoon's resource management by the local government. This is due mainly to:

- according to decree No.4260/2005/QD-UBND of provincial government, the fishing license is only granted to the FA. Meanwhile, the Communal People's Committee established SMTs and suggests the district level grant the fishing license to these teams. This is surely impossible because of opposition to the provincial decree;
- the benefit and power of resource users has not been stipulated for both SMT and the FA. It is only member's responsibilities and duties in relation to the using lagoon areas; and
- as for households who have been granted certificates with usage time of five years or ten years, the local government gave a legal usage right on the allocated areas. However, if granting the fishing licenses to the FA, there will be an overlapping on the usage rights of allocated areas, for example: whether the local government will revoke the use right of the allocated households or not; and how to use their water surface areas after deadline for use right.

These are the challenges faced by the local government in attempting to set up the institutions and regulations on sustainable resource management for the lagoon and to guarantee the local people's livelihood.

Conclusions

This paper attempts to examine the changes to the surface water environment and the endeavors for community based resources management in the Tam Giang Lagoon. Results of the research showed that in the period of 1998-2007, BOD_5, COD and nutrient concentration have increased significantly in the lagoon's water environment. Total nitrogen levels applied to coastal water in some areas of the lagoon exceeded the requirements of international standards applied for coastal ecosystem conservation and aquaculture. Moreover, average concentration of total coliforms in the lagoon water exceeded the permitted level of Vietnamese standards for water quality used for multi-purposes. It was shown that there was a presence of organic substances and the water in the

lagoon shows clear signs of pollution.

This is one of main reasons which led to an increasing rate of failed shrimp aquaculture during the period of 1998-2007 in households, as well as the decreasing yield of fisheries exploitation in the period of 2001-2003.

Under pressure from increasingly exploited resources, the local government endeavored to build an institution for resource management based on the community. The core of this institution is to grant fishing rights to the community through the FA or SMT in the specified territory. However, the benefits and powers of the resource users have not been stipulated for both fishing association and self-management teams. Instead of this, members only have responsibilities and duties in relation to using the lagoon. As a result, most of the resource users in the surveyed area have not participated in these organizations as their members. The resource users must undertake all activities in relation to aquaculture by themselves, without support from these organizations. Whether these models bring benefits and sustainable resource management to local communities or not is the great challenge for both resource users and local government. The core issue that needs to be addressed in the process of the lagoon's resource use and management is to give clear authority and benefits to the resource user. In other words, it is necessary to decentralize to the resource users themselves. Only they have the motivation to manage sustainable resources when it is made clear the benefits that they will receive in the long term. When the law and/or decrees have still not granted the rights clearly, coupled with benefits to the resource user, the current resource management is continuing to be *de facto* ownership. As a result, this can be challenged by legislation. The success or failure of these models is currently the greatest challenge to the policy makers.

References

1. Korten, D.C. (1987). Community management: Asian experience and perspectives. Kumarian Press, Connecticut, United States.

2. Sajise, P. (1995). Community based resource management in the Philippines: perspective and experiences. The Fisheries co-management workshop at North Sea Center, Hirtshals, Denmark.

3. Ferrer, E. and Nozawa, C. (1997). Community based coastal resource management in the Philippines: key concepts, methods and lessons learned, *The International Development Research Centre Planning Workshop on Community based natural resource management*, Hue, Vietnam.

4. Rivera, R.A. (1997). Re-inventing power and politics in coastal communities: community based and coastal resource management in the Philippines. *Marine Affairs Program,* Dalhousie University, Canada.

5. McCay, B.J. and Jentoft, S. (1996). From the bottom up: participatory issues in fisheries management. **Journal of Society and Natural Resources,** No. 9, pp.237-250.

6. Pomeroy.R.S. (1995). Community based and co-management institutions for sustainable coastal fisheries management in Southeast Asia. **Ocean & Coastal Management,** Vol 27, No 3, pp.143-162.

7. Ton That Phap (2002). "Co-management in the planning of a waterway system for aquaculture", *In Lessons in Resource Management from the Tam Giang Lagoon,* The Gioi Publisher, pp. 85-97.

8. Truong Van Tuyen (2002). "Dynamics of property rights in the Tam Giang Lagoon", *In Lessons in Resource Management from the Tam Giang Lagoon,* The Gioi Publisher, pp. 39-52.

9. Le Van Mien (2006). "Activities in Thua Thien Hue Lagoon", *In Report of Imola Project,* Thua Thien Hue Provincial People's Committee, pp.1-47.

10. Thua Thien Hue Fisheries Resources Protection Agency (2007). "Result of survey on the fisheries and aquaculture activities", *Thua Thien Hue Department of Fisheries,* Vietnam, unpublished. (in Vietnamese).

11. Phu An People's Committee (2005). Project for re-arrangement of land in Phu An Commune, Phu Vang District, Thua Thien Hue Province. (in Vietnamese).

12. Department of Fisheries and Thua Thien Hue People's Committee (2003). "Report on master plan of exploiting fisheries management in Thua Thien Hue lagoon", unpublished, pp. 1-217. (in Vietnamese).

13. Robert Pomeroy, Kim Anh Thi Nguyen and Ha Xuan Thong (2009). Small-scale fisheries policy in Vietnam. **Marine Policy,** 33, pp 419-428.

14. Nguyen Huu Ngu and Kim Doo Chul (2007). "Aquacultural development with the change of resources management in Tam Giang Lagoon, Thua Thien Hue Province, Central Vietnam", *Proceedings of the General Meeting of the Association of Japanese Geographers 72*、Kumamoto University, Japan, p.124.

15. Nguyen Van Hop, Hoang Thai Long, Nguyen Hai Phong and Thuy Chau To (2005). "Water quality of Tam Giang-Cau Hai Lagoon: status, concerns and control solutions", *Proceedings of National Conference on Thua Thien Hue Lagoon,* Ministry of Science and Technology and Thua Thien Hue People's Committee, pp.231-245.

16. Truong Van Tuyen (2005). "Extension of participatory planning in Tam Giang Lagoon system", *Proceedings of National Conference on Thua Thien Hue Lagoon,* Ministry of Science and Technology and Thua Thien Hue People's Committee, pp.153-168.

17. Tran Xuan Binh (2005). "Aquaculture development and poverty reduction in Thua Thien Hue Lagoon", *Proceedings of National Conference on Thua Thien Hue Lagoon,* Ministry of Science and Technology and Thua Thien Hue People's Committee, pp.169-185.

18. Nguyen Huu Cu and Mauro Frignani (2005). "Initial results of research on environmental lagoon shore, Central Vietnam between Italia and Vietnam", *In the Proceeding of "National Conference on Thua Thien Hue Lagoon"*, Ministry of Science and Technology and Thua Thien Hue People's Committee, pp 283-294.

19. Nguyen Van Hop, *et.al*, (2008). "Assessment of water and sediment quality of Tam Giang – Cau Hai Lagoon 2006 – 2007", *In the report of project "integrated management of lagoon activities in Thua Thien Hue Province"*, IMOLA project, pp 66-75.

20. World Health Organization and European Commission (2002). "Eutrophication and health", *Office for Official Publications of the European Communities*, Luxembourg, p.5.

21. Do Cong Thung (2007). "Environment and resources in the Tam Giang-Cau Hai Lagoon", *In the final report of project "integrated management of lagoon activities in Thua Thien Hue Province"*, IMOLA project, p.23.

22. Thua Thien Hue Department of Fishery (1998). "Report of summation on aquacultural activities in 1998 and orientation of 1999", pp.1-17, unpublished.

23. Thua Thien Hue Department of Fishery（2007). "Report of summation on aquacultural activities in 2006 and orientation of 2007", pp.1-32, unpublished.

24. Thua Thien Hue Department of Fishery (2007). "Report of summation on aquacultural activities and orientation of 2003, 2004, 2005 and 2007", unpublished.

25. Nguyen Huu Ngu and Kim Doo-Chul (2009). Rural Poverty and Livelihood Changes under the Aquacultural Development around Tam Giang Lagoon, Central Vietnam. **Geographical Review of Japan, Series B,** Vol. 81, pp. 79-94.