Impact of irrigation works systems on livelihoods of fishing community in Ca Mau Peninsula, Viet Nam

Mai Viet Van*, Huynh Van Hien* Dang Thi Phuong*, Nguyen Thi Kim Quyen*, Dao Thi Viet Nga and Le Anh Tuan*****

* College of Aquaculture and Fisheries, Can Tho University, Can Tho City, Viet Nam
** Centre of Water Resources Conservation and Development, Hanoi, Viet Nam
*** Research Institute for Climate Change, Can Tho University, Can Tho City, Viet Nam

Abstract- Ca Mau Peninsula (CMP) locates in Mekong Delta, Vietnam is a conflict area in the use of freshwater and brackish water due to existing of both types of ecosystems. The irrigation works systems (IWS) in CMP were planned and constructed to serve local communities' economic development. The aims of this study are to investigate the impact of irrigation works on livelihoods of fishing community in Ca Mau Peninsula, Viet Nam. The study was conducted in six communes in five districts in the two provinces, Can Tho City (freshwater ecosystem) and Bac Lieu province (brackish water ecosystem). Six Rapid Rural Appraisal (PRA) meetings were held, four meetings located in the affected area of IWS (120 households) and two adjacent areas, which were not affected by IWS (120 households). Data on fish species compositions were collected three times a year. This paper argues that the highly construction inside IWS area caused lower fish species composition and lower fish production inside IWS area compared to outside IWS area in both freshwater and brackish water ecosystems. Limited households inside IWS area (9.3%) and outside IWS area (17.8%) involved in local associations fishing community in both ecosystems and they mostly had a very low annual accumulate income. Net, trap, mud chain, trawl and fishing rods were five main types of fishing gears of the professional fishing households. Survey result also shows that the majority of fishermen understood rules relating to activities of aquatic resources protection and management of the provinces though 25-30% of households still did not know anything about these regulations. Overall results revealed an impact of IWS on livelihoods of fishing community such as human resources, natural resources and physical capital. Therefore, there are urgent needs on training on the fishery regulations for fishermen in the regions focused on appropriate fishing gear, mesh size net, fishing ground and fishing seasons. In particular, investment in education and career training to improve opportunities to access employment for the community become necessary.

Index Terms- impact, irrigation works systems, livelihoods community, Ca Mau Peninsula

I. INTRODUCTION

Ca Mau Peninsula (CMP) is located in the South-West of the Mekong River Delta (MRD), Vietnam with a natural area of 1.6 mil ha, accounting for 43% MRD land area. It is classified into 7 eco-regions and 51 irrigation destinations including 6 provinces: Bac Lieu, Soc Trang and Ca Mau, Hau Giang, Can Tho and a part of Kien Giang province. CMP was the wide area in the MRD where fisheries activities take place in both freshwater and brackish water ecosystems. Over the past decade, the rice production with limited fresh water sources presented low economical efficiency, resulted in switching gradually to integration production models of agriculture, forestry and fisheries. The pattern of production has changed on the demand for water resources as well as integrated water resource management (Thang, 2011).

The irrigation works systems (IWS) in CMP were planned and constructed quite well. However, similar to other areas formerly, these irrigation systems were mainly used for agricultural production. This region was a key area for aquaculture development of the MRD, but no any specialized irrigation system to serve this purpose (Son, 2010). The problems arose, so far remain unresolved, especially issue of initiative water supply to the sub-regions on the needs of each object produced. Diversified agriculture production in combination with inadequate irrigation system has limited social-economic development in the region (Thang, 2011). IWS in medium flooded areas in the Mekong River Delta negatively influenced on aquatic resources (Sinh et al., 2007). Serious depletion of aquatic resources has a strong and negative impact on productivity of the inland fisheries as well as aquaculture activities relied on natural seed sources, and subsequently caused huge socio-economic impact on the community (Sinh, 2006). However, study on the impact of IWS on livelihoods of fishing community in CMP has not been in-depth investigated. This research aims to provide scientific data on rationalization the inlands fisheries and aquatic resources protection as well as the livelihoods of people in the area. The study will focus on impact of IWS in CMP on natural resources, human resources, social, financial and physical capitals in the sustainable livelihoods framework of freshwater and brackish water ecosystems.

II. METHODS

A. Sample design and data collection

The study was conducted from January to December, 2015 in CMP with two representative ecosystems including Can Tho City (fresh water ecosystem affected by the O Mon-Xa No irrigation system) and Bac Lieu province (brackish water ecosystem affected by the Quan Lo-Phung Hiep irrigation system) (Figure 1). Respondents were households who participated in fishing natural aquatic resources, aquaculture households using fingerlings from natural resources, the poor households (agricultural production landless and minority households who have participated in fishing natural aquatic resources), managers and representatives of local organizations. Interviewed households were randomly selected from a list of respondents provided by Can Tho and Bac Lieu Provincial Agriculture Department.

Secondary data were collected from relevant documents, previous studies have been published domestically and internationally, some final reports of the specialized agencies of the province in the study area. Primary data was collected following the method of Participatory Rural Appraisal (PRA) (Lammerink and Wolffers, 1996) and household face-to-face interview by a structure prepared questionnaires. Accordingly, the study was conducted in six communes in five districts in the two provinces, corresponding to six PRA meetings, four meeting located in the affected area of IWS with 120 households and another 120 households in two adjacent areas which were not affected by IWS (Figure 1; Table 1).

Data on fish species compositions distributed in the study area were collected throughout the year with three sampling phases in dry season (Phase 1: 3/2015, Phase 2: 05/2015 and Phase 5: 11/2015) and two sampling phases in rainy season (Phase 3: 07/2015, Phase 4: 09/2015). The fish sampling was done inside and outside water bodies of the IWS areas in both freshwater and brackish water ecosystems. Fish identification and classification was done following Eschmeyer (1998) using grade class, order, family, and species. Also, specific species identification was based on documents described by Khoa and Huong (1993), Khang (1958), Rainboth (1996) and Dinh et al. (2013). To update the fish scientific names, document of Fröese and Pauly (2015) was used.

B. Data analysis

The collected data from the local reports, data of PRA meeting and household survey were cross-checking input, encrypted and analysed. Descriptive statistics method (SPSS 13.0) was used to present indicators of incidence (percentage, mean, standard deviation) to describe the current status. Analysis the impact of the IWS on livelihoods of natural fisheries community based on methods of Neefjes (2000) and DFID's Sustainable Livelihood Framework (2001). In the following section this paper will focus on analyzing impacts of IWS on five different capitals in the sustainable livelihoods framework (DFID, 2001)

III. RESULTS AND DISCUSSION

Impact of IWS on the natural resources capital

The highly construction inside the IWS area caused lower fish species composition. The systems of canals, dikes and flood control canals in both freshwater and brackish water ecosystems were important factors affecting livelihoods of fishing communities (Table 2). In the freshwater ecosystem, the number of canals level 2 and level 3 inside the IWS area was nearly three times higher than that of outside area, and the total length of the canals level 2 and level 3 inside the IWS area was nearly two times longer than that of outside area (77.6 and 40.84 km, respectively). Similarly, in brackish water ecosystem, the number and total length of canals level 2 and level 3 inside IWS area was nearly three times higher than that of outside area. Moreover, inside IWS area of brackish water ecosystem, there was three canals level 1 with the total length of 183 km (Table 2). Results from fish species composition distribution showed that number of fish species outside IWS area was much richer than that of inside area in both two ecosystems. In freshwater ecosystem, there were 52 species distributed inside IWS area and 79 species distributed outside. Similarly, in brackish water ecosystem, 79 species were found inside IWS area and 83 species outside. This showed that IWS negatively affected aquatic species population though water surface area inside the IWS was significantly higher than that of outside area. In addition, farmer (78.7%) reported that the systems of dykes, embankments and flood control drains themselves caused water pollution. The water quality inside the IWS area was heavily affected through agricultural activities. Chemical pollution from agriculture (reported by 65.2% farmers, n=120) is the main reason causing lower fish species composition inside IWS area.

Survey results show that in freshwater ecosystem, the fishing production outside IWS area was four times higher than that of inside area. For brackish water ecosystem, the fishing production outside IWS area was almost two times higher than that of inside area. The study results also in agreement with Sinh et al. (2007) stated that the O Mon-Xa No irrigation system (in freshwater ecosystem) caused a decrease in yields of fishing at a rate of 9-10% annually. According to research results of Phu (2013) in An Giang province, the system of flood prevention dykes of the province was one of the reasons of natural fishery resources decline (80-90% reduction) compared to area without embankment. The decline of aquatic resources inside the IWS itself has affected income of fishing households, as they had to move further to catch fish. Households stated that natural aquatic resources reduced 50-60% in comparison to five years ago. The decline of aquatic resources directly affected the livelihood of fishing households, especially poor households. According to Sinh et al. (2007) when the fishing production dropped, the fishermen (especially poor households mainly living by fishing activity) would prolong fishing period, or buy more different fishing gears, or use destructive fishing gears (electromagnetic pulse, chemical, smaller mesh size catching nets) in order to increase the fishing quantity. This has caused great pressure on natural aquatic resources.

Weather is also an important element toward natural aquatic resources which directly affects the livelihood of fishing households. Results show that 75.8% of fishing households in freshwater ecosystem and 86.7% of households in brackish water ecosystem believed that the weather in recent years was not favorable for fishing activities in the area. For example, farmers reported that more frequent storms, higher periods of saline intrusion, and unexpected drought and floods. Natural disasters caused negative effects on agricultural production and rural livelihoods (Birkmann et al., 2012; Dung et al., 2012; Tuan, 2014). Prediction on climate change were reported as sea level would rise by 1 meter in the next 50 years, while 43% MKD area would be submerged in seawater (Carew-Reid, 2007) and the MKD has been become one of the hardest affected areas due to the climate change (Wassmann et al., 2004; Dagupta et al., 2007). These changes and predictions of natural hazards potentially affected development policy on aquatic resource management.

Impact of IWS on human capital

In the freshwater ecosystem, the number of male employees participating in fishing inside IWS area was more than that of outside IWS area (1.3 versus 1.2 persons, respectively), while the number of female workers engaged in fishing was the same both inside and outside of the IWS area. For brackish water ecosystem, both the number of male workers and female workers participating in fishing activities were the same both inside and outside IWS area (Table 3). Average age of fishermen in both ecosystems was above 40. With this average age, most of them have to work to support their families. So the employment selection to stabilize livelihoods becomes important. Most of the fishermen in both ecosystems had education level of primary and secondary school, while few fishermen had high school and higher education level (college and bachelor degree). Illiteracy rate in brackish ecosystem (14.2%) was higher than that of the freshwater ecosystem (5.9%). In particular, the illiteracy rate in the surveyed households outside IWS area was higher than that of inside in both ecosystems. The main reason was that the majority of fishermen (above 40 years old) went through the war and did not have opportunity to go to school. When socio-economic conditions of the province began to improve (especially areas inside the IWS was invested well in terms of infrastructure, electricity, roads, and schools), many rural families have invested in education for their children. Education level of young workers has been raised. However, the majority of young workers preferred non-agricultural careers or worked in industrial zones in urban, peri-urban areas and big cities. This circumstance led to the present situation in rural areas that only permanent labor force beyond age of 40 and illiteracy rate outside IWS area was higher than that of the inside IWS area.

Survey result also shows that the majority of fishermen understood rules relating to activities of aquatic resources protection and management of the provinces. However, there were 25-30% of households still did not know anything about these regulations (Table 4). Therefore, there are urgent needs on training on the fishery regulations for fishermen in the regions focused on appropriate fishing gear, mesh size net, fishing ground and fishing seasons.

Currently, the many types of fishing gears are used for fishing in different water bodies that enhanced fishing production. Fishing gears were very diverse and plentiful; many fishing gears with smaller mesh sizes can catch most fish species. However, some of the water bodies such as canals and fields have been closed by dikes in both ecosystems, thus, fishermen need to move to another place for fishing. The survey shows that the production of natural aquatic resources in the study area has diminished substantially compared to previous years (described bove). In brackish water ecosystem, 64% of households said that depletion of aquatic resources caused by the use of destructive fishing gears; following by fishing of juveniles or broodstocks in spawning season (50%); the increase in number of fishermen (42%); and about 13-25% of households said that IWS prevented migratory routes of fish and shrimp, polluted water environment that affected life of aquatic species (Table 5). In freshwater ecosystem, 36.9% of households reported that fish production declined due to low floodwater level; followed by using destructive fishing gears (35.1%); fishing for aquaculture (snakehead); especially 28.8% of households said that the reason of aquatic resources decline was prevention of fish migration by IWS, and the increased fishing of juveniles and broodstocks in their breeding season (Table 5).

Under the impact of IWS on declined production of natural aquatic resources, to adapt to those situations, fishermen stated that changing job and effective rearrangement family labor would be a better choice for stabilizing their livelihood. However, results showed that the majority of fishing households only arranged family labors into specific tasks in fishing activities rather than participate into other livelihood activities. Most of fishermen were in charge of activities related to natural fishing (above 90%). All decisions in consumption of fishing products were agreed mainly by women.

Analytical results on adaptability of community under the depletion of aquatic resources showed that fishing households (31.7%) will choose to become paid workers as they don't have land for farming and currently live in poverty. Other households (22.0%) would like to change to aquaculture to increase income due to owning less land for production. In addition, fishermen would like to choose some other occupations such as small business (19.0%), livestock and poultry (12.2%), crop cultivation (paddy and vegetables) (12.2%), workers in the industrial zone (4.9%) (Table 6). Overall, the majority of fishing households have expected to earn more when changing current job. In short, human capital becomes an important factor in selection of household livelihoods. The impact of IWS on aquatic resources may directly affect the fishermen labor force, leads to changes in human capital to adapt to the new economic circumstances.

Impact of IWS on social capital

Survey results shows that fishing community in freshwater ecosystem was mainly Kinh people (92.5%). Khmer people shared low percentage (7.5%), living primarily outside IWS. In the brackish ecosystem, most of respondents (99.2%) were Kinh people living both inside and outside IWS and the remaining was Khmer who live inside IWS area. According to De and Be (2005) Khmer people in the Mekong Delta heavily relied on agriculture activities following their own experience and it was difficult for them to adapt to the new technique application. Regarding to religion, the fishing community living in freshwater ecosystems had no religious affiliation accounted for the highest proportion (69.7%). Others followed Buddhism (24.4%), Catholics (3.4%) and Hoa Hao (2.5%). In brackish water ecosystem, the rate of fishing community without following religion up to 95%, the remaining was Buddhists (5%). There were no major differences regarding to religion between the communities living inside and outside IWS in both ecosystems. This means that following religions did not effect on livelihoods of fishing communities in both ecosystems.

The results of PRA survey and interviews fishermen show that in freshwater ecosystem, only 9.3% of households inside IWS area and 17.8% households outside IWS area involved in local associations (association of Women, Farmer's organization, Veterans Association, Red Cross, etc.) whereas in brackish water ecosystem, the corresponding rates were 10.4% (inside) and 7.2% (outside). This suggested that fishing community was limited in accessing information through the mass local organizations to apply scientific and technological achievements into households' production.

Results of PRA analysis on the relationship between fishing community and organizations and local unions in freshwater ecosystem show that scientists, the ward's people committee and the farmers' organization and agricultural extension service are most common organizations closed to economic activities of households. Other organizations such as agricultural enterprise, Bank, Youth Union and Veterans have not involved and associated to livelihood communities. In brackish water ecosystem, the scientists, veterans, retired people living in the local area have became pioneers in implementation and dissemination activities and new regulations to the community. They acted as transmission of indigenous knowledge, encourage people abide the law and integrate into society. Currently, the fishermen in the research area lacked the information on commodity prices and markets. This led to obstacles in selling products with the appropriate price, normally lower price by private traders. Therefore, it is essential to establish fishing association in order to access easily the scientific and technical information, access to capital for production as well as recommend solutions in the operation and regulation of water through IWS in order to enhance production and to stablize livelihoods. Tuan and Dung (2015) reported that local associations played an important role in sharing knowledge between agriculture communities. The changes in the natural conditions and socio-economic characteristics such as dikes construction in flood-prone areas, freshening projects in coastal areas, depletion of natural resources, policies of agricultural and rural development, agricultural product price volatility have caused both positive and negative effects on farmers in developing and implementing livelihood strategies to achieve livelihood outcomes expected.

Impacts on financial capital

In the freshwater ecosystem, the investment costs for annual fishing was very low (1.4 million VND/year) with an average income of 13.3 million VND/year and profit of 11.8 million VND/year. Therefore, after deducting living expenses, the annual saving amount of fishermen was very low. In brackish water ecosystem, the investment costs for natural fishing activities was 1.4 million VND/year, with an average income of 17.7 million VND/year and profit of 16.3 million VND/year (Table 7). With this profit, fishing communities in both ecosystems had a very low annual accumulate income. This issue shows that the fishing community in both ecosystems in the studied areas faced many difficulties about capital for re-investment in fishing or for investment into other activities to diversify livelihoods or for investment to expand production scale toward efficiently productive activities. Therefore, the fishermen should be supported in capital access to maintain fishing operations and there is a need for training on how to use capital efficiently for fishing community. The survey results show that the majority of fishermen in the community had no demand for loans, although the poverty rate in the study area was relative high. Phu (2013) suggested increasing capital access to fishermen who like to convert their fishing activities into other business. In the context of the impact of IWS on community livelihoods, the ability of investment into activities aimed to diversify income sources served their livelihoods was essential. Therefore, the investment in production equipment of the community currently needed financial support from the Government and non governmental organizations.

Impact of IWS on physical capital

Physical capital in this study was divided into two groups consisting of household's assets and infrastructure in the community (outside of the household). Survey results show that the most important physical capital of fishermen was fishing gears to serve household livelihoods. Fishing gears were different between professional fishing households (with income from fishing occupied higher than 50% of total income per year of the household income) and the seasonal fishing households. Net, trap, mud chain, trawl and fishing rods (gill net, tube trap for eels, mud chain, trawl net, and hook and line) were five main types of fishing gears of the professional fishing households. Meanwhile, besides net, trap and mud chain, fishermen also used long fence trap net and trap net as two other kinds of fishing gears which were used by many seasonal fishing households. Some fishing gears (tree branches or lift net) tended to decrease in number due to ineffective fishing and regulations on aquatic resource protection and regulations in river transportation. Particularly, snail's trawl net should be recommended for use to reduce the damage of yellow snails and increase the amount of natural food for aquaculture.

For freshwater ecosystem, 69.2% of fishing households used only one fishing gear. Households used two fishing gears shared only 27.5% of total surveyed households and only 3.3% of households owned three gears. In the brackish ecosystem, there was 89.2% of fishing households used one type of fishing gear, 10.8% of households owning two fishing gears and no households owning three or more gears. Comparision between the inside and outside of IWS area, the percentages of households owning one fishing gears in outside area were higher than that of inside IWS area at both ecosystems (71.7% and 66.7 % in freshwater ecosystem and 90% and 88.3%, respectively in brackish water ecosystem). However, the proportions of households using two or three fishing gears in freshwater ecosystem were higher than that of in brackish water ecosystem. It means that fishing effort on freshwater ecosystem was higher than in brackish water ecosystem.

According to the People's Committee of Can Tho city (2013), land resources in freshwater ecosystem included two main groups: alluvial soil (84%) and alkaline soil (16%). Land composed rich humus and nitrogen, medium of phosphorus and potassium level, with little or no toxicity, was favorable for rice and fruit cultivation. However, some limitations are found in the study area: (i) area affected by annual flood in which 25% of land was deeply flooded, especially at the end of the flood season that directly impacts on agricultural production, infrastructure, residents and urban areas; (ii) the degree of separation by infield rivers and canals was rather large, poor geological characteristics of works, negative impact on building the infrastructure and roadways; (iii) biological resources were declined, surface water in rural areas and urban areas tended to be polluted. In brackish water ecosystem, most agricultural land inside the IWS was saline, especially in the dry season; saline water season was more predominant than freshwater season. The rainy season was flooded partly by rainwater so that it was suitable for farming model of rice-shrimp or rice-fish integration. However, during cultivation, there is a need to complete works of saline-fresh water zoning, activeness in preventing and providing saline water and freshwater to minimize damage caused by shortage of saline or freshwater in different farming time. Meanwhile, outside the IWS area, it was mostly salinization alluvial soil, unsuitable for growing rice and orchards. It was only suitable for aquaculture (Vietnamese Ministry of Agriculture and Rural Development, 2006). The biggest difficulty of the research area was the lack of freshwater for agriculture production. Main water source from the Bac Lieu-Ca Mau canal was severely polluted (Department of Agriculture and Rural Development of Bac Lieu province, 2012).

Livelihood strategies for fishing community

Based on the results of the analysis on the livelihood capitals of fishermen above, livelihood strategies of fishing households in freshwater ecosystem and brackish water ecosystem were presented in Table 8 and Table 9. To adapt to the depletion of natural aquatic resources caused by IWS, fishing households have to use livelihood assets themselves to build or adjust adapted livelihood strategies. Fishermen would implement that process in the context of impacts of vulnerable context in accompany to affect by formal regulations and informal social ties (Chambers and Conway, 1992).

Adaptation strategies of farmers in developing countries with extremist phenomena of climate and fluctuations of socio-economic included intensive and diversified livelihoods or immigrant the labors (Paavola, 2008). Diversification of agricultural livelihoods is a process that the households increase activities which generate the income and capabilities to support the society in order to maintain their lives (Carswell, 2007). Livelihood strategies of households in each ecological sub-area were not only affected by ability to access to livelihood capitals of households but also due to factors related to pedology, access to water resources, markets, production experience. During implementing livelihood strategies, farmers would face with different influential factors; the livelihood results of each household would have certain differences. Therefore, the identification of factors affecting to fishermen' livelihoods was essential because it would be intervention points in terms of technique and policies to increase appropriate livelihood strategies and to minimize the failure in developing household livelihoods.

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

The highly construction inside the IWS area caused lower fish species composition and fishing production in both ecosystems. Within five types of capitals in livelihood framework of the community, the human resources, natural resources and physical capital played very important roles in fishing community. Human capital was the most important factor in livelihood strategies of fishing community in the study area. In particular, investment in education and career training to improve opportunities to access employment for the community become necessary. The situation of uneven distribution among livelihood capitals in the framework was factor affecting to economic development and social justice of the community in the research area

IWS has brought positive effects on the development of socio-economic and improvement of rural landscape of the study area. However, there are some limitations due to many objective and subjective reasons. For examples, operational process of IWS to regulate water for production has been unsuitable, has caused partly flooding in the rainy season in some areas. In addition, lack of water for agriculture in the dry season, increase the cost for pumping water for production are mainly caused by IWS. IWS for salinization prevention in some areas have not yet been completed, causing saltwater leaking into the freshening areas, while saline preventing schedule and freshwater keeping has not really suitable for actual demand of rice production, fruits and aquaculture in each period and different locations throughout the year.

Recommendations

To address the problem of water supply for production, there should have a common plan of water regulation for the province or the entire region in each specific month (*Establishing water regulation committee of the province/inter-province*) to comprehensive coordinate in taking water and drainage. Synchronous arrangement should be made on schedule of cultivation and water regulation in each area and ample notice to the public through the mass media and government at all levels (*15 day cycle with a water regulation schedule*).

Policy on water resource use should be based on specific purpose of use such as agriculture or aquaculture in the region which is regulated in the proper way under IWS.

Construction of IWS serve for aquaculture and fisheries should be taken into account with detailed appropriated research plan for brackish water ecosystem in CMP.

Also, there is a need on improving all livelihood capitals of household and community, building up modeling on water resource and fisheries management following ecopath approach and sustainability development. It is encouraging for artificial seed production used for restocking and recovering the aquatic resource, contributed to the better livelihood of fishing communities in the region.

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AUTHORS

First Author – Mai Viet Van, College of Aquaculture and Fisheries, Can Tho University, Can Tho City, Viet Nam. Email: mvvan@ctu.edu.vn
Second Author – Huynh Van Hien, College of Aquaculture and Fisheries, Can Tho University, Can Tho City, Viet Nam.
Third Author – Dang Thi Phuong, College of Aquaculture and Fisheries, Can Tho University, Can Tho City, Viet Nam.
Fourth Author-Nguyen Thi Kim Quyen, College of Aquaculture and Fisheries, Can Tho University, Can Tho City, Viet Nam.
Fifth Author- Dao Thi Viet Nga, Centre of Water Resources Conservation and Development, Hanoi, Viet Nam
Sixth Author- Le Anh Tuan, Resaerch Institute for Climate Change, Can Tho University, Can Tho City, Viet Nam.
Correspondence Author – Mai Viet Van, College of Aquaculture and Fisheries, Can Tho University, Can Tho City, Viet Nam. Email: mvvan@ctu.edu.vn, Tel: 0084 986767568, Fax: 0084 7103830323

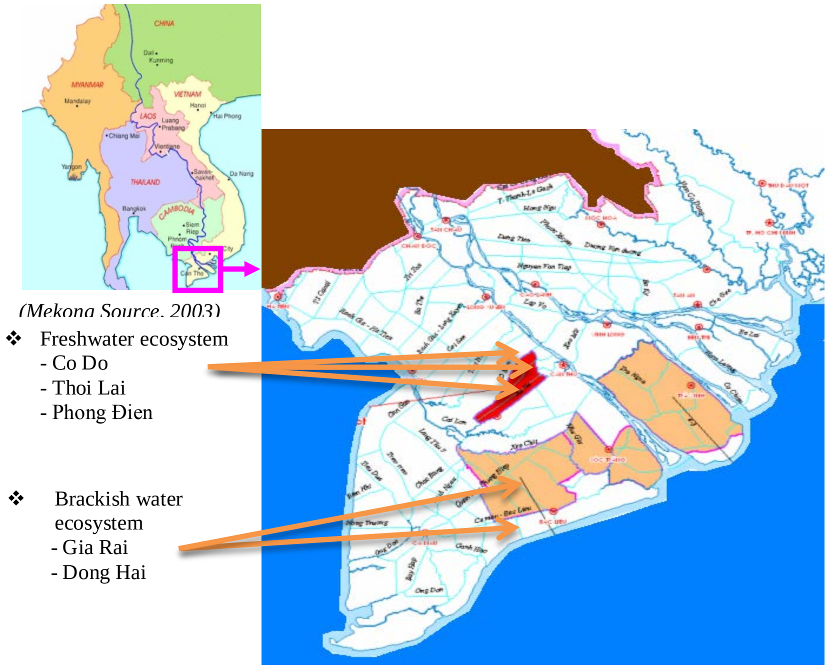

Figure 1: Map of the study areas in Ca Mau Peninsula, Viet Nam

Table 1: Structure of the survey samples in the study area

Unit: household

District	Freshwater ecosystem		Brackish water ecosystem		The whole region	
	In	**Out**	**In**	**Out**	**In**	**Out**
Dong Thang commune – Co Do district	0	60	0	0	0	60
Truong Long commune – Phong Dien district	30	0	0	0	30	0
Thoi Thanh commune – Thoi Lai district	30	0	0	0	30	0
An Trach commune – Dong Hai district	0	0	0	60	0	60
Phong Thanh Tay commune – Gia Rai district	0	0	30	0	30	0
Phong Thanh A commune – Gia Rai district	0	0	30	0	30	0
Total	**60**	**60**	**60**	**60**	**120**	**120**

Table 2: The systems of canals and dykes in the study area

Canals	Freshwater ecosystem		Brackish water ecosystem	
	Inside	**Outside**	**Inside**	**Outside**
Canals level 1 (canal)	0	0	3	0
Length of canals level 1 (km)	0	0	183.0	0
Canals level 2 and 3 (canal)	54.0	19.0	45.0	13.0
Length of canals level 2 and 3 (km)	77.6	40.8	120.2	46.5
Dykes, embankments (unit)	20.0	0	0	0
Length Dykes, embankments (km)	20.7	0	0	0

(Source: PRA and Report of new rural planning from provinces, 2015)

Table 3: Some indicators of human capital of fishing households

Unit: people/household

Indicators	Freshwater ecosystem			Brackish water ecosystem		
	Inside	outside	Total	Inside	outside	Total
No. of members in family (people)	4.7	4.2	4.5	4.4	4.1	4.2
+ Male	2.6	2.3	2.4	2.2	2.1	2.2
+ Female	2.1	2.0	2.1	2.2	2.0	2.1
Fishing experience (Years)	17.7	10.6	14.1	13.0	12.2	12.6
Fishing male labors (people)	1.3	1.2	1.3	1.2	1.2	1.2
Fishing female labors (people)	1.0	1.0	1.0	1.0	1.0	1.0
Age of fishing household leader (year-old)	51.3	47.6	49.4	44.5	47.6	46.0

(Source: Author's field survey 2015)

Table 4: Knowledge on aquatic resources protection regulations Unit: %

Information	Levels	Freshwater ecosystem			Brackish water ecosystem		
		Inside (n=60)	Outside (n=60)	Total (n=120)	Inside (n=60)	Outside (n=60)	Total (n=120)
Regulations about exploitation species, fishing gears, mesh sizes, fishing grounds and fishing seasons.	Un-known	25.4	25.0	25.2	30.0	26.7	28.3
	Less known	59.3	66.7	63.0	63.3	73.3	68.3
	Well-known	15.3	8.3	11.8	6.7		3.3

(Source: Author's field survey 2015)

Table 5: The causes of the natural aquatic resources depletion reported by fishermen Unit: %

Reasons	Freshwater ecosystem			Brackish water ecosystem		
	In (n=57)	Out (n=54)	Total (n=111)	In (n=49)	Out (n=51)	Total (n=100)
IWS prevented migratory routes of fish, shrimp	56.1		28.8	51.0		25.0
Use destructive fishing gears	29.8	40.7	35.1	63.3	64.7	64.0
Closed flood-prevention dykes	29.8	24.1	27.0			
IWS polluted the water environment	17.5		9.0	26.5		13.0
Low floodwater level	36.8	37.0	36.9			
No breeding ground due to 3-rice crops	35.1	25.9	30.6			
Using agrochemicals	36.8	14.8	26.1			
Increase in fishermen	5.3	22.2	13.5	18.4	64.7	42.0
Fishing juveniles and broodstocks in prawning season	29.8	27.8	28.8	42.9	56.9	50.0
Fishing baits for snakehead aquaculture		68.5	33.3			
Waste from aquaculture ponds		14.8	7.2	22.4	47.1	35.0
The climate changes	8.8	16.7	12.6	28.6	19.6	24.0

(Source: Author's field survey 2015)

Table 6: Occupation adaptability by genders when aquatic resources decline Unit: %

Occupation adaptation for male	Freshwater ecosystem		Brackish water ecosystem	
	Inside (n=59)	Outside (n=60)	Inside (n=59)	Outside (n=54)
Agricultural employees	32.20	61.67	52.54	38.89
Vegetable cultivation	15.25	5.00	1.69	
Rice cultivation	35.59	33.33	3.39	
Shrimp farming			33.90	33.33
Factory workers	8.47	8.33	3.39	20.37
Livestock	40.68	43.33	27.12	38.89
Aquaculture	18.64	13.33	5.08	
Vehicle fixer			1.69	1.85

Small-scale business			18.64	9.26
Continuing fishing	1.69		13.56	12.96
Unknown	10.17	5.00		3.70
Occupation adaptation for female	**Freshwater ecosystem**		**Brackish water ecosystem**	
	Inside (n=48)	**Outside (n=46)**	**Inside (n=44)**	**Outside (n=51)**
Livestock	60.42	58.70	52.27	76.47
Vegetable cultivation	14.58	6.52	4.55	
Rice cultivation	37.50	43.48	4.55	
Continuing fishing		2.17	6.82	7.84
Aquaculture	12.50	13.04	4.55	
Shrimp farming			38.64	33.33
Traditional occupations	2.08		4.55	5.88
Small-scale business	2.08	2.17	27.27	15.69
Factory workers	8.33	8.70	4.55	7.84
Agricultural employees	10.42	28.26	13.64	15.69
Unknown	8.33	2.17		

(Source: Author's field survey 2015)

Table 7: The main financial indicators of fishery exploitation

Unit: 1,000 VND/year

Indicators	**Freshwater ecosystem**		
	Inside (n=60)	**Outside (n=60)**	**Total (120)**
Fix cost	1,412.5±1,004.4	1,697.9±1,591.0	1,555.2±1,332.6
Variable cost	442.8±646.0	1,576.0±1,807.3	1,009.4±1,466.3
Total cost	1,274.2±1,441.2	1,703.1±2,949.2	1,488.7±2,321.3
Revenue	8,717.2±8,633.5	17,983.4±17,220.1	13,350.3±14,339.5
Net profit	7,443.0±7,994.3	16,280.3±16,588.5	11,861.6±13,704.3
Indicators	**Brackish water ecosystem**		
	Inside (n=60)	**Outside (n=60)**	**Total (120)**
Fix cost	1,012.2±1,073.3	1,578.1±1,978.2	1,295.1±1,610.0
Variable cost	928.3±1,457.2	1,447.7±3,031.0	1,188.0±2,382.4
Total cost	1,108.7±729.0	1,779.3±1,745.7	1,444.0±1,374.0
Revenue	9,321.4±14,710.1	26,097.8±21,916.6	17,709.6±20,405.6
Net profit	8,212.7±14,766.9	24,318.5±21,475.3	16,265.6±20,054.0

(Source: Author's field survey 2015)

Table 8: Livelihood strategies of fishing farmers in freshwater ecosystem

Capital	**Livelihood Strategies**	**Livelihoods Results**	**Implementation**
Natural capital	Restoring resources	Diversifying and conserving aquatic resources	Farmers; Local authority; Non-governmental organizations; Agricultural enterprises
	Improving the natural environment through the IWS operation	Operating IWS reasonably and well awareness of environmental protection	
	Fishing natural resources sustainably	Reducing natural fishing pressure	
		Enhancing farmer income	
Human capital	Appropriate devising labor by age and sex	Reasonable using family labors and increasing labor productivity	Farmers; Local authority; Non-governmental

	Investing in education and training	Improving income Improving literacy levels and enhancing ability to access to employment for labors	organizations; Government
Physical capital facilities	Managing effectively the rational usage of fishing gears	Protecting aquatic resources sustainably; Raising income.	Farmers; Local authority; Non-governmental organizations; Government
	Improving efficient usage of the IWS	Improving the production efficiency and transportation of goods. Reducing fishing pressure	
Financial capital	Diversifying livelihoods activities for farmers	Creating sustainable livelihoods	Farmers; Government; Non-governmental organizations; Local authority
	Increasing ability to access to financial capital	Investing to reproduce and improving income	
	Increasing ability of accumulation	Reducing poverty; Improving living and sustainable development	
Social capital	Enhancing participation of social organizations and unions	Being easy to access to information on product markets, improving life	Farmers; Government; Non-governmental organizations; Local authority
	Strengthening roles of community in managing water resources and fisheries	Reducing vulnerability through policies implementation	

Table 9: Livelihood strategies of fishing households in brackish water ecosystem

Capital	Livelihood Strategies	Livelihoods Results	Implementation
Natural capital	Restoring resources	Diversifying and conserving aquatic resources	Farmers; Local authority; Non-governmental organizations; Enterprise
	Improving the natural environment through the IWS operation	Operating IWS reasonably and well awareness of environmental protection	
	Fishing natural resources sustainably	Reducing natural fishing pressure	
		Enhancing income	
Human capital	Appropriate devising labors by age and sex	Reasonable using family labors and increasing labor productivity	Farmers; Local authority; Non-governmental organizations; Government
	Investing in education and training	Improving income Improving literacy levels and enhancing ability to access to employment for labors	
Physical capital	Managing effectively the rational usage of fishing gears	Protecting aquatic resources sustainably; Enhancing income.	Farmers; Local authority; Non-governmental organizations; Government
	Improving efficient usage of the IWS	Improving production efficiency and avoid fresh-brackish water dispute.	

		Supporting shrimp-rice intercropping model for community livelihoods sustainably.	
Financial capital	Diversifying livelihoods activities for farmers	Creating sustainable livelihoods	Farmers; Government; Non-governmental organizations; Local authority
	Increasing ability to access to financial capital	Investing to reproduce and improving income	
	Increasing ability of accumulation	Reducing poverty; Improving living and sustainable development	
Social capital	Enhancing participation of social organizations and unions	Being easy to access to information on product markets, improving life standards	Farmers; Government; Non-governmental organizations; Local authority
	Strengthening roles of community in managing water resources and fisheries	Reducing vulnerability through policies markers	