Forms and factors affecting collective adaptation: A case study of saline intrusion in the Vietnamese Mekong delta

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Abstract

Saline intrusion (SI) is a problem causing serious risks for agriculture and livelihoods in the Vietnamese Mekong Delta (VMD). Building effective adaptation is an issue concerned by both the Vietnamese government and farmers. Successful adaptation to environmental change is connected with social groups' ability to act collectively that is evident. Using ecological and social approach, this research explores forms and factors affecting collective adaptation (CA) in case of SI in this Delta. Our findings show that CA has existed and influenced by changes of environmental conditions and development process. CA in forms of coordination of activities and information sharing is found in case of SI. Farmers apply the same farming system to manage water resource and to reduce water use conflict. CA is influenced by both internal and external factors. Water resource available, farmers' active characteristic and neighbour relations are enabling factors for farmers to cooperate. The integration between the Governmental intervention and households' situation also helps CA to act well. Uncertain climate change, small farm size and lacking of technique are constraining factors which prevent some farmers to take part into group actions. Because SI will be more serious and uncertain, land use policy is needed on time. Households' relationships and ecological situations should be fully taken into account for policy decision to build CA for better adaptation in case of SI.

Keyword: ***Collective adaptatio; climate change impact; external factors; internal factors; saline intrusion; the Mekong delta.***

1. Introduction

The VMD is the last part of the country where the Mekong River reaches out into the East Sea. It borders with Cambodia to the North, Pacific Ocean to the East and gulf of Thailand to the West. The Delta is a vast wetland of four million ha representing a great potential for agricultural and aquaculture production, producing 90% of rice and 70% of aquaculture products for national exportation (IPSARD (Instituition of Policy and Strategy for Agriculture and Rural Development), 2016). SI was a natural phenomenon in the Delta, but it was recognized as a climate risk since 1998 (Dang, Nguyen, & Nguyen, 2007). SI has currently become more serious occurring with higher density and bigger magnitude (IPSARD, 2016; SIWRR (Southern Institute of Water Resources Research), 2015). SI occurs when not enough river discharge is flowing to the low-lying estuaries and instead salt water flows into the inland (Le, Chu, Miller, and Sinh (2007); Pedro Estellès, Heidi Jensen, Laura Sánchez , & Gianina Vechiu, 2012). It is not only influenced by processes within Vietnam, but also wider global climate changes and basin water resources developments (Dang et al., 2007).

During the dry season, there are about 2.1 million hectare (50% of the Delta's land) are affected by salinity (WB (World Bank), 2015). It causes extremely severe consequences influencing agricultural and aquaculture production as well as livelihoods of people in the Delta (IPSARD, 2016; C. T. Nguyen, 2016). Adaptations have been built by both the Government and farmers. Water control projects provided by the Government bring advantages in economic terms but disadvantages still exist. Farmers have changed in farming practices or non-farm activities (IPSARD, 2016). Human adaptations are needed while the Governmental interventions have not fully been in tasks. Especially, the collective actions help to build successful adaptation, contributing to make decision on natural resources management (Adger, 2003; Groot & Maarleveld, 2000; Ostrom, 1990). In the Delta, however, the ability of social groups act collectively has not been discovered that should be improved to better adapt to climate change (IPSARD, 2016; H. T. Nguyen, 2016). The issue of CA has been mentioned rarely in previous studies. None of research has been found in case of SI. The research was conducted in Kien Giang, a western province to study forms and factors affecting CA in case of SI in the Delta.

2. Methodology

- ***Research size***

Research was carried out in Kien Giang, a province locating on the western coast of the Delta. It borders with Ca Mau and Bac Lieu provinces to the South, An Giang province, Can Tho City and Hau Giang province to the East, the Gulf of Thailand to the West and the with Kingdom of Cambodia to the North with a 56.8 kilometers long border line. The area had been affected seriously by SI in the year 2016. Totally there were more than 92.000 ha of rice had been damaged in 8 provinces in the VMD and 34.000 ha locating in Kien Giang province (UN Vietnam (United Nation), 2016). Agriculture is an main economic sector accounting for 38.26% of provincial gross domestic product (Kien Giang Statistical Office, 2016). It is also the country's second largest aquaculture production center (ADB (Asian Development Bank), 2013). It has the biggest areas of shrimp rice crop (AMDI (United States Agency for International Development), 2016). Due to the climate change impacts, agriculture and livelihoods this province have been affected. The main climate hazards relate to combined effects of increased temperature, flooding and inundation, salinity and sea level rise (ADB, 2013). Salinity has not only affected farming but also the daily life activities of local people. The water is too salty for domestic activities. This situation has rarely been encountered in these areas before (SEA - CCAFS (Climate Change - Agriculture and Food Security - Southeast Asia) 2016)

An Bien district, a district locating on the west coast of Kien Giang province was chosen to be research site as it had been predicted to be affected more by sea level rise (Figure 1). In sea level rise scenarios, if it will increase 1m, Kien Giang province is predicted to be submerged by 76.90% of total land. In this case an area of 95.46% of An Bien district will be under seawater (MONRE (Ministry of Natural Resources and Environment), 2016). The research was carried out at two communes, Nam yen (near the sea) and Tay yen A (about 15 km far from the sea), following transect from the sea to inland.

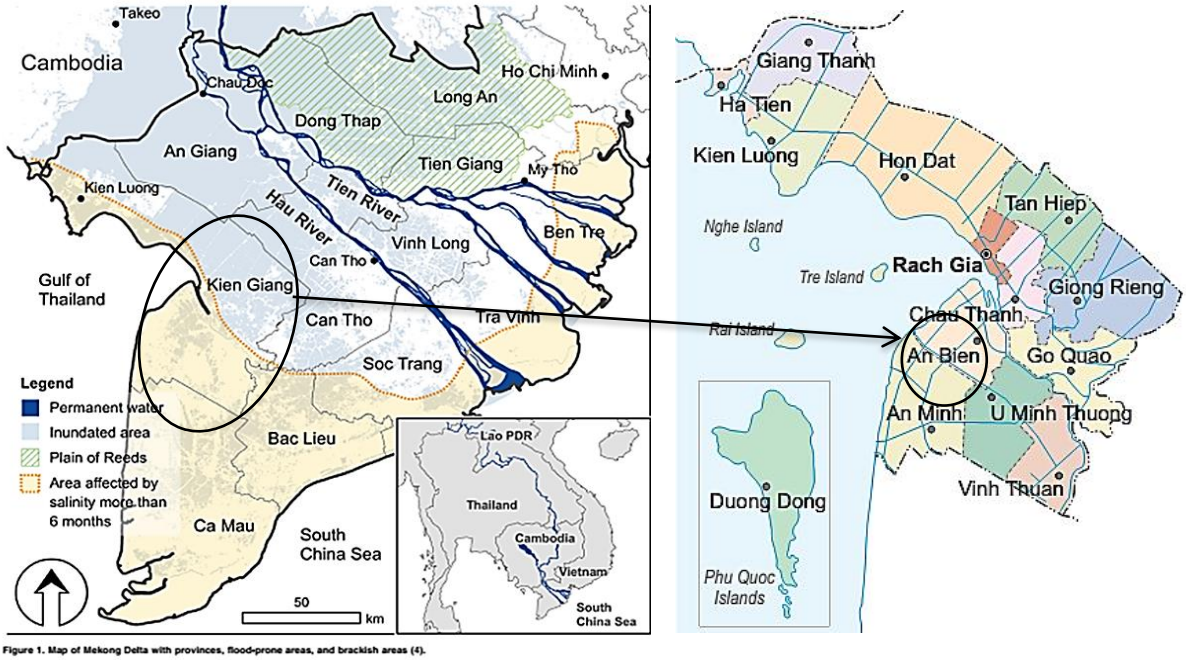

Figure 1. Map of Mekong Delta with provinces, flood-prone areas, and brackish areas (4).

Fig. 1. Areas affected by SI in Mekong delta (*left)* and Kien Giang province (*right)*
Source: MRC - Mekong River Commission, 2005, adapted from (Käkönen, 2008)

- ***Research method***

We assume that human adaptation is highly context specific (Agrawal, 2010; Bowyer, Bender, Rechid, & Schaller, 2014; Burton, Diringer, & Smith, 2006). Adaptations especially groups actions are human response to environmental changes varying from system to system and over time. These are influenced by ecological and social factors. The integrated framework is applied to get a complete understanding local adaptation to environmental changes. The mixed method approach integrates both qualitative and quantitative data is used in this research framework (Miller et al., 2010). Research methodology is described in the flowchart below (Figure 2).

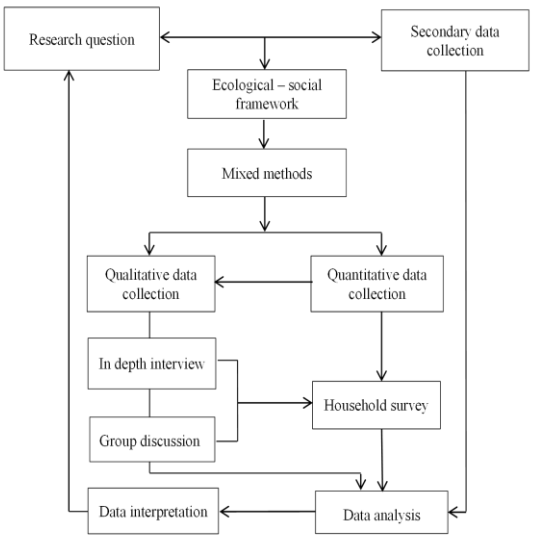

Fig. 2: Flowchart of research methodology
(Source: the Authors 2017)

Data collection: the research used both secondary and primary data. Secondary data (in the period 2000 – 2016) is collected to gain the annual archives at governmental institutions and scientific reports relevant to SI. Primary data was gathered in 2017 following those methods below:

- Qualitative data was collected through in - depth interview and group meetings (Vaus, 2002). Seven meetings with key people at three levels province, district and commune; 15 meetings with acknowledge farmers to collect information about current situations of SI and adaptation patterns were conducted. Two group meetings *(one group applying community base management program and one group do CA by themselves)* were done to get information of factors affecting CA. Participants (from 5-7 people for each meeting) are farmers affected by SI.
- Qualitative data was gathered by questionnaire (Kothari, 2004). Totally, 60 questionnaires (30 for each commune) were conducted to survey those coastal farmers who have been living in these areas for more than ten years. Questionnaire searches for farmers' perception of SI; current adaptation; forms of CA and the factors affected

***Data analysis*:** Qualitative data were recorded, transcribed and grouped following four elements of the ecological and social framework. They are resource; resources users; public infrastructure providers and public infrastructure (Anderies, Janssen, & Ostrom, 2004). Quantitative data is coded and analysed using descriptive analysis to indicate farmers' perception and adaptations practices.

3. Findings

- *Saline intrusion as climate hazard and its impacts*

There are two areas in An Bien district, western and eastern regions. In the east, land is issued for two crops of rice per year. In the west, there is a mixture of two crops of rice and rotational shrimp rice systems.

Most of farmers (96.50%) give idea to judge that SI was a natural phenomenon in this area. It had changed since 2000. It is more serious and uncertain. Causes of SI are mainly climatic reasons including the rainy season coming late and uncertainly (32.16%), more droughts (29.24%) and more sunshine (25.73%), unsuitable infrastructure is also one of a causes of SI *(Table 1).*

Table 1: **Causes of saline intrusion**

Causes	Frequency (%)
Less rain and uncertain rainy season	32.16
More drought (rain coming late)	29.24
More sunshine during a day	25.73
Canal size is small and uncompleted building sluices	11.11
Others (sea level rise, commune locates near the sea…)	1.75

(Source: Households interview, 2017); (n= 60)

SI impacts can be both positive and negative depending on the salt concentration *(Table 2).*

> *An Bien is a coastal district. Salt water intrusion happened yearly but it was not serious as it is today. If the salt level is lower than 28 (g/l), it is okay for farming systems. If the level of salt is higher than 28 (g/l), it is recognized as climate hazard event. It had been very serious since three years ago including more droughts, uncertain rainy season. As the result, the amount of fresh water was not large enough to push the salt water back to the sea that leads to SI. It affects seriously on agricultural and livelihoods (In- depth interview, 2017).*

The damages are economic loss of rice yield (37.56%) and reducing families' income (25.49%). On the other hands, SI brings good chance to apply shrimp rice (SR) which has been practiced for seven years in Nam Yen commune and three years in Tay yen A commune giving farmers a better income source. Farmers have enough money for community activities (party, meetings…) (25.18%).

Table 2: Positive and negative impacts of saline intrusion

Negative	**Frequency (%)**
Rice dead, low rice yield	37.56
Reduce family income	25.49
Lack of fresh water	18.22
Shrimp grows slowly	11.13
Others (migration, health effect)	7.60
Total	**100**
Positive	
Apply SR *(replying two crops of rice)*	39.21
Have enough money for family expenditure	25.18
Family income is stable	24.82
Reduce pollution (*less chemical used for rice)*	10.79
Total	**100**

(Source: Households interview, 2017); (*n=60)*

- ***Current adaptations to saline intrusion***

Both the Government and farmers have adapted to SI. Water control projects (dams, sluices,…) have been provided by the Government to prevent salt water. The 28 dams were constructed to protect for an area of 2,336 ha of Winter – Spring[1] and Tradition[2] rice crop in 2016. 23 sluices have been decided to be built in An Bien district. But they are not started due to lack of budget (An Bien Department of Agriculture and Rural Development, 2016).

Because the Governmental supports are not completed yet, farmers have built their own adaptations (Figure. 3). Farmers build their adaptations based either on learning from neighbor (61.18%) or following the Governmental land use policy (25.88%). Most of farmers have shifted from two rice crops to SR system[3] (46.09%). The area of SR system has been

[1] Seasonal calendar for two rice crops: Winter – Spring (Dec – Mar); Summer – Autumn (May - Oct)

2 Tradition rice crop occurs in rain fed area, only crop of rice per year from Aug to Dec

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increased rapidly from 8.879 ha (2009) to 12.381 ha (2015) and 14.691 ha in 2016 (An Bien Department of Agriculture and Rural Development, 2016). Shrimp culture relying on saline water in the dry season (January to July) is followed by rice culture depending on rainwater in the wet season (August to December) (Figure 4). In addition, fields are decided to be uncultivated due to high salt concentration (18.75%). Building border dyke, applying tolerant rice variety are other adaptations.

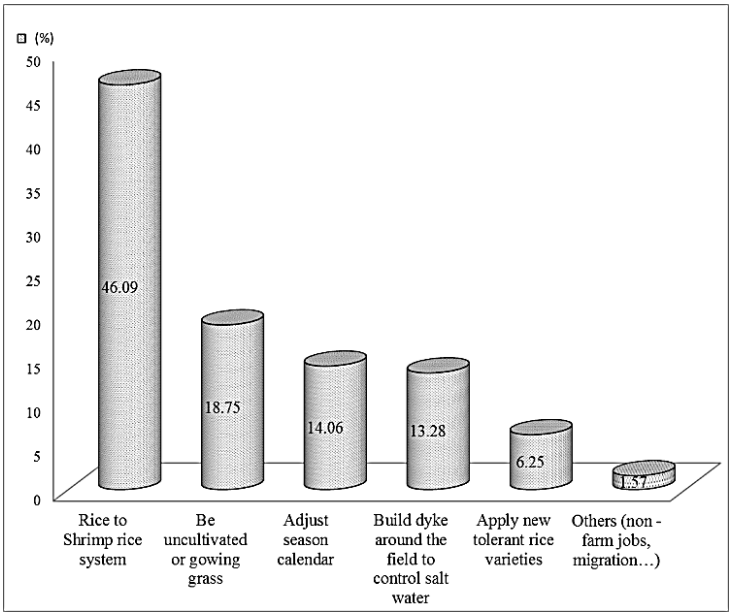

Fig. 3: Farmers' adaptations to SI in An Bien district
(Source: households interview, 2017) (n=60)

- ***Collective adaptation and factors affecting***

To apply SR system, there are several difficulties because water management for shrimp is different from rice. For shrimp, two types of canal system are needed (one for taking water in and one for releasing water out). The existed canal system has been designed just for rice (only one canal system). In this case, if one shrimp field gets disease, it can be spread out following water exchange from this field to others. As the result, the whole area will be affected. If all farmers do not apply the SR together, there is the conflict between rice and shrimp farmers due to a different request of water quality. Rice farm needs fresh water and shrimp farm needs brackish water. Brackish water from shrimp ponds can be released into rice fields and either reduce rice yield or destroy it. In addition, the fresh water coming from the rice field is not good for shrimp. In this case CA can be seen as a pathway to solve problem. CA has been found in two forms of collaboration activities and sharing information. The two stories below tell how farmers have worked together with and without the Governmental intervention to manage water resource and to reduce water use conflict.

Case study 1: The story in Nam Yen commune: CA based on the integration between the Governmental support and households' actions to manage water resource

Nam Yen commune has been affected by SI since 2000. Most farmers have changed to SR system and facing several difficulties. Since 2007, a program called "Water community base management- WCBM" has been created by the

Agricultural Extension Office in Kien Giang province. The main aim is to help farmers to manage water resource for SR system. A group from 5 - 10 households meeting those criteria such as having farm size from 1- 2 ha; locating near each other; be able to access water and willing to participate are chosen to be members. To do it, these farmers agree to apply rotational system, rice in the rainy season and shrimp in the dry season. They do these activities together for example to buy post larval at the same farm; to raise at the density from 1- 2 per post larval/ m^2; to set the same time for starting, harvesting and pumping in or out water. In order to control disease, if one field gets disease, the owner should let others know to stop taking water in. To take part into this program, farmers are supported in terms of techniques and budget (up to 60% cost of post larval and rice seed). At the harvest time, all products belong to farmers. The program's process is observed and helped by the governmental officer. In each group, however, they also vote a group leader, a person having knowledge and prestige for scheduling time activities. Although, these farmers are not supported by the program they keep to work together because they know that many benefits have been brought by collective actions.

Case study 2: The story in Tay Yen A commune: Local farmers work together to avoid the water use conflict

Until 2011, some rice fields in Ray Moi village in Tay yen A commune had been affected by SI. 16 farmers started SR system facing various difficulties due to the water use conflict. At this time, cultivated lands have been planned for two crops of rice untill year 2020. These farmers submitted their expectations to the commune headquarter, but they were not successful since many people in this area did not agree to stop growing rice. Farmers who want to raise shrimp had to sign in a document that they would give compensation if the rice fields were damaged. Three years later, the commune had policies shifting to shrimp rice system since SI became seriously. It is not suitable for the second crop of rice (rice cannot grow well if salt concentration is more than 4 (g/l)). The Water community base management program has not been implemented in this area. CA exists differently. Farmers living closely support others in terms of sharing techniques. Technique is very important and it is different from shrimp to rice. They give techniques to others who want to start the shrimp culture. In addition, some fields cannot access to water from canals, so they cannot apply SR system. In this case, they allow those farmers to get water through their fields. They realized that they have to work together and the rotational system has to be kept. Both shrimp and rice, they support each other in their own ways. Without the rice crop, next shrimp crop will not be well. They know that farmers living near to others should apply the same farming system to avoid water use conflict. They meet others in the fields and make decision on times for starting crops and for pumping water in or out. Groups of farmers (from 10 – 15 households, about 20-30 ha) work together. It seems that no disease has attacked this area. They manage themselves to adapt well to SI.

There are number of factors affecting CA which are classified into two groups: internal factors *(resource, resources user and local infrastructure)* and external factors (*Governmental intervention and market opportunities*) (Table 3).

Table 3: Factors affecting collective adaptation

(LO: local officers; F farmers; EW: commune extension worker; GD group discussion

Factor	Explanation and quotations	Ideal conditions
Internal factors		
Resource	- Water resource is scarcity and uncertain. This is a rain - fed area. Rice crop replies on rainfall. Climate change causes more drought and changes time of the rainy season (LO). Because of lacking of rain water, rice cannot be sown at the right time. "Water is too salt or too fresh is not good for shrimp" (F). Seasonal calendar of crops is changed (GD).	Climatic information is broadly given to local farmers on time.
	- The rotational SR system requires the same source of water at the same time to avoid conflict of water use. "Adaptive solutions to SI focus on building infrastructure" (LO). "Canal systems have to build in right way to meet special demands for irrigation and drainage of SR system" (GD).	Proper infrastructure is needed
	- The SR system is good for environmental and economic terms. "If no rice crop, the next shrimp crop will have no natural food" (F). "I spend no money for shrimp food, they can eat rice straws left from the previous rice crop" (F). "I use less fertilizer and pesticide for rice" (F).	The rotational SR system is kept.
Resource user	- Local farmers are very active and friendly. They learn from what they have observed to make their own decisions (LO). "My neighbour is very successful, I try to follow him" (F). "I did not know how to raise shrimp. By talking with my neighbour, they tell me how to do the SR" (F). "Every day, I spend one or two hours to visit my field and test water. I can talk and share what I have found with my neighbours" (F).	Neighbours relations good for CA
Local infrastructure	- Farm size larger enough is needed to run shrimp farm. "Some farmers they have several pieces of land, but the size of each is not larger enough for shrimp farm. So they exchange land location with their friends" (GD). "Group of rice farmers who are poorer (less land, no money…) are more vulnerable. They are vulnerable not only from SI but also from their neighbor decisions"	More adaptive options for the poor.

	(LO). “I have no money to raise shrimp” (F).	
Local institution	Other social organizations support CA. “Agricultural extension office, Farmer union and cooperation convince farmers believe in effects of CA” (LO). “These organizations help to ask for the Governmental supports on irrigation and drainage system” (GD).	Cooperation among institutions gives better conditions for CA
External factors		
Governmental intervention	Extension workers are important to support CA. “Local officers are very friendly, they are our friends” (F). “They move to almost places to deliver the Governmental plan to farmers and also to get farmers’ opinions” (LO). “I understand livelihoods of local farmers. What I tell them is suitable with their current life”. (EW).	Better relationship between farmers and local officers support CA
	There is no specific policy for SR system. Most of policies for agriculture focus on rice (LO). Land use plan established on time is good to avoid conflict of farmers (F)	Appropriate policies for SR system
Market opportunities	For long term solutions, the SR system will be main activity in this district (LO). Shrimp price is high and stable (F). “It is very easy to sell shrimp. When I need money, I catch and sell it at local markets” (F). “SR helps us to deal with the situation of unstable market prices. If one fails, another can support our families to survive”. (GD).	Stable market of shrimp needs to be maintained.

4. Discussion

Collective actions had been found in An Bien district in the past. At the beginning of the XX century, forests placed almost areas in the district. The first groups of inhabitant came to collect forest products and later they chose areas building village, changing wild land into cultivated land. They could not live alone, some families lived together building village (Anh Dong, 1994). After the south of Vietnam become independent (1975) - the socialist Government gave land ownership to local people and encouraged local farmers working together. They exchange labour for transplanting, building houses, repairing roads and bridges that are example of collective actions (Ha & Nguyen, 2004). It helps local people to respond to difficulties of environmental conditions and development process. This customs is also good for today while farmers adapt to SI. However, Vietnam has a different background concerning collective actions under socialist regimes. Previous collective experiences in Vietnam that were unsuccessful have been seen to discourage farmers from joining new community-based initiatives (Joffre & Sheriff, 2011). The need is to demonstrate that current cooperation is different from the past. WCBM supported by Government are important to illustrate the integration between the Governmental intervention and farmers’ circumstances

are necessary. In fact, existed customs and appropriate supports from the Government are needed for building CA to respond to environmental changes especially in case of SI.

Development of the VMD based on the building canals, new villages are established on the canals banks which is a typical cultural characteristic in this Delta. Farmers' relationship is close. Many generations have lived in the same places, they make friends to others living nearby. They work together to overcome difficulties. People in the South are creative and acceptable (Tran, 2006). They also learn from others. If one farmer is successful, it is a good lesson to be given to others. Farmers learn quickly by observation others. It is also good for old people often self- opinionated. In Vietnamese culture, the older people in the family are respected and most of decision based on his or her decision. Thus, "seeing is believing" is an appropriate approach to support CA building process.

In the case of the SR system, local farmers now go back to traditional system which had been existed in these areas more than 40 years ((AMDI) Asian Management and development Institute, 2016). SR system which can be seen as the sustainable system which can give more money to farmers while the natural resources are maintained (*Appendix 1*). It is more important because rice farmers in the coastal zone earn a lower income than those on alluvial soil and irrigated areas of the delta, due to water and land constraints (Clayton, 2003; Dang et al., 2007). This system is good as a biological energy exchange. The residue from the previous shrimp crop is a natural fertilizer source for rice. And the rice straws left on the field can be shrimp food. Another condition for this system being applied popular in this area is farm size larger enough. About 25- 30% of the field surface is transferred to be trench (Figure 4). The average farm size per household is larger than other areas 2,04 ha compared with 1.15 ha for the Mekong Delta and 0.72 ha for Vietnam as a whole (Hossain et al, 2006) adapted from (Nguyen, Le, Nguyen, & Miller, 2007).

Figure 4: Shrimp rice system; the rice crop *(left)* **and the shrimp crop** *(right)*
Source: the Authors 2017

In addition, it needs to note that not all farmers are able to move from rice to shrimp crop because they have no money for investment or farm size is not big enough for changing into shrimp farms. A lot money is needed in first year (about 40 million Dong per ha) for preparing farm, ditching pond… and also learning techniques. Group of rice farmers who are poorer (less land, no money…) are more vulnerable (Kip interview, 2016). In the future, the

canal system should be repaired to make sure that farmers can manage shrimp disease and others opportunities should be given to the poor.

The research has found the form and factors affected CA in Kien Giang province. CA exists in SR system since this area has larger farm size which is needed for farmers to change into SR system. For the future research, there is need to find out additional forms of CA which may exist in other types of livelihood adaptations in the VMD. In addition, factors affect those types of CA; to what extent households capitals affect to CA? The roles of formal and informal institution; the levels of collaboration will be learnt. By studying various cases of CA, the answer of the question that "do interaction between the Governmental intervention and farmers' adaptation adapt well to SI in the VMD?" can be achieved.

6. Conclusion

SI has been realized to be climate risk since 2000 causing mainly by climatic reasons. It will be more serious and uncertain in the future. In farmers' knowledge, the impacts of SI are different from year to year due to salt concentration. Too salt or too fresh is not good for current farming's. SI brings both damages and benefits. Both government and farmers have adapted to SI. Infrastructure (dams, sluices) are provided by the Government. Because these are not completed yet, farmers have built their own adaptations related to changing farming and other technique actions. CA has been found in two forms of collaboration activities and sharing information. Farmers and local government have been in a interaction playing better roles to build the groups capacity to manage water resource. CA is influenced by both the internal and the external factors. Water available, farmers' active characteristic, neighbour relations and support from the Government are good to farmers to adapt together. Uncertain climate change, lacking of land and unappropriated land use policy are constraining factors. For future, land use policies should be built on time. Social and ecological situation should be fully taken into account for making decision related to adapt well SI.

7. Appendix

Appendix 1: Cost and profit from shrimp crop and rice crop **–** (Unit: Dong*/ha)

	Rice culture	**Shrimp culture**
Cost (including family labour)	13,807.700	11,203.100
Turnover	21,808.116	44,393.933
Profit	8,000.416	33,190.833
Profit /cost	0.58	2.96

** 1 Euro = 25.368 Dong (date 18/06/2017)*

8. Acknowledgements

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