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Transformation in Coastal Livelihoods in Tam Giang Lagoon, Vietnam

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Abstract: The local livelihood systems in Tam Giang Lagoon, Central Vietnam, have shifted since the policy changes of 1986. This research set out to answer the following questions: (1) Has there been a transformation in local livelihood systems since the policy changes and subsequent development of an aquaculture industry? (2) If yes, which factors have pushed the systems across the threshold from one regime to another? The research was carried out over two years (2006-2007) and involved the use of qualitative and quantitative research methods on property rights, resource use, livelihoods, and resilience. The move from collective management to a market-oriented economy and the aquaculture development has significantly reduced the lagoon areas available for mobile-gear fishing. This change has polarized the different user groups. It has also raised the issue of inequity in resource access and led the livelihoods of some user groups to unsustainable development. The research applied a resilience approach to the analysis of the local livelihood systems. Resilience is an inherent attribute of sustainable livelihood systems, as it implies the flexibility and availability of options. If resilience is lost, livelihood systems may cross a threshold and shift to different regime or alternative equilibrium. Such a shift to a different regime seems to have occurred in Tam Giang Lagoon for the last two decades.

1. Introduction

The Tam Giang Lagoon system comprises a series of lagoons, including Tam Giang lagoon, Sam Chuon lagoon, Ha Trung-Thuy Tu lagoon, and Cau Hai lagoon. With an area of 22,000 ha, the lagoon provides livelihoods for more than 300,000 inhabitants. There are also approximately 1,500 sampan households (Provincial Department of Fishery 2003) who live on boats and fished around the lagoon for their livelihoods. They are marginalized communities and have been disconnected with land-based society. Since the historical typhoon in 1985, the Vietnamese government launched resettlement program. Together with the resettlement program, policy reforms and the development of aquaculture have caused changes in livelihood systems and resource access around the lagoon. To understand the complex livelihood systems, it is necessary to classify resource users into three groups: (1) aquaculture group; (2) mobile fishing group; and (3) non-fishing group. The classification is based on their access on lagoon resources and fishery related livelihood activities. In general, living standard of the village is much higher after the development of aquaculture. However, the aquaculture boom has reduced available water areas for mobile-gear fishing activities, polarized different user groups, and created conflicts. Mobile gear fishers, who are excluded from the fishing grounds, have suffered from difficulties in making their livings. Some of them stop fishing and depend on non-fishing activities for their livelihoods.

The research applied resilience thinking to the analysis of the livelihood systems in Tam Giang Lagoon. Resilience is defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker *et al*. 2004). It has three main characteristics: (1) the amount of change the system can undergo and still retain the same controls on function and structure; (2) the degree to which the system is capable of self-organisation; and (3) the ability to build and increase the capacity for learning and adaptation (Resilience Alliance 2009). When a livelihood system loses resilience, it becomes vulnerable to change that previously could be absorbed (Kaspersson and Kaspersson 2001) and even small changes may be devastating (Folke *et al*. 2003).

Walker *et al*. (2004) introduced the "basin of attraction" to understand the dynamics of resilience. They defined a basin of attraction as a region in state space in which the system tends to remain (Walker *et al*. 2004). A livelihood system moves around an equilibrium of a particular basin of attraction when facing disturbances. The basin of attraction is influenced by variables reflecting the systems. A livelihood system may have various basins of attraction to occupy and may experience a shift from a basin of attraction to an alternative one. The capacity to create a new stability domain when the existing systems are untenable is defined as transformability

(Walker *et al*. 2004). The shift to the new domain, in fact, is the transformation of the livelihood system.

The paper set out to answer the following questions: (1) Has there been a transformation in local livelihood systems since the policy changes and development of aquaculture? (2) If yes, which factors have pushed the systems across the threshold from one regime to another? The research identifies the essential elements that comprise local livelihood systems, providing a foundation for an analytical framework with resilience-based indicators. The analytical framework allows for an understanding of livelihood systems, as well as for assessing the resilience of these systems.

2. Study areas and research methods

The research was conducted in Thuy Dien, a village located at the southern part of Sam Chuon lagoon (Figure 1). According to government statistics, there were about 45,000 residents in 20 villages surrounding Sam Chuon Lagoon (Tuyen 2006). The social-ecological context in Sam Chuon is very complex with dense and diverse capture fishing and aquaculture activities. Approximately 1,620 ha out of the total of 1,855 ha in Sam Chuon lagoon are for aquaculture activities (Provincial government statistics 2007). The traditional fishing areas have been reduced significantly since the aquaculture boom.

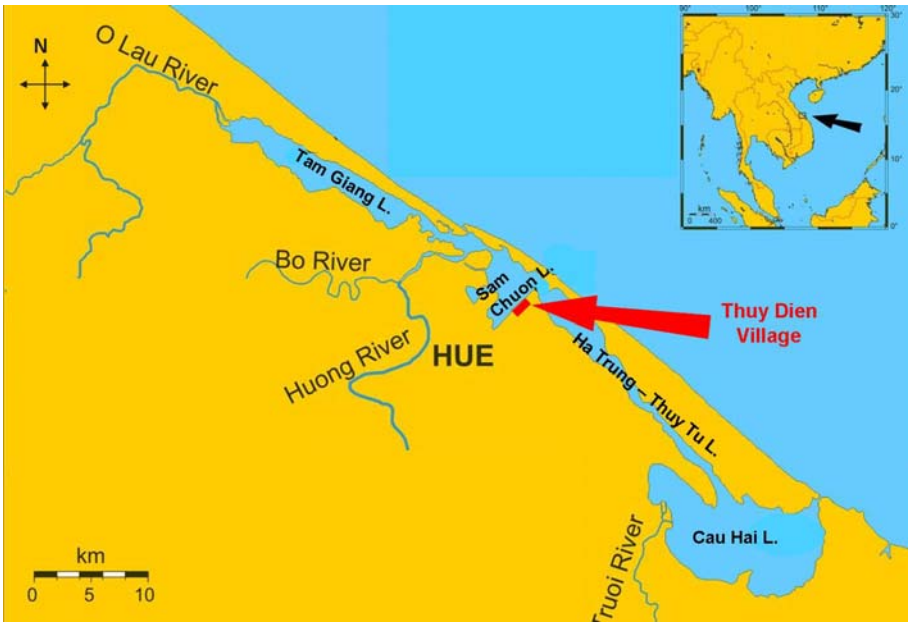


Figure 1: Research Location – Map of Tam Giang Lagoon

Thuy Dien was once a sampan community and has been associated with Phu Xuan Commune, Phu Vang District, Thua Thien-Hue Province since 1975. The village has gradually settled since 1985; however, currently, there are still eight households living on boats. The village includes 143 households with approximately 800 inhabitants. Currently more than 90% households in Thuy Dien are dependent on lagoon resources for their livelihoods. A large number of households are involved in aquaculture. The minor group of mobile gear fishers suffered from lack of fishing grounds and difficulties in making their living.

The field work was conducted in the village for more than two years (2006-2008). It made use of both qualitative (key informants; participant observation; focus groups) and quantitative techniques (questionnaires; government records) grounded in participatory research methods. Key informants were sought from the villagers, government organizations at multiple levels, and other non-government agencies concerned with resource access and livelihood development. Livelihood semi-structured questionnaires were conducted with the samples of 65 households in different groups. In open-ended interviews, local fishers were encouraged to discuss the disturbances they experienced. Collected information was verified by observation and focus group discussions. All information was verified with villagers and cross-checked with other members of the community-based resource management research team in Hue University of Agriculture and Forestry.

3. Resilience and transformation in livelihood systems

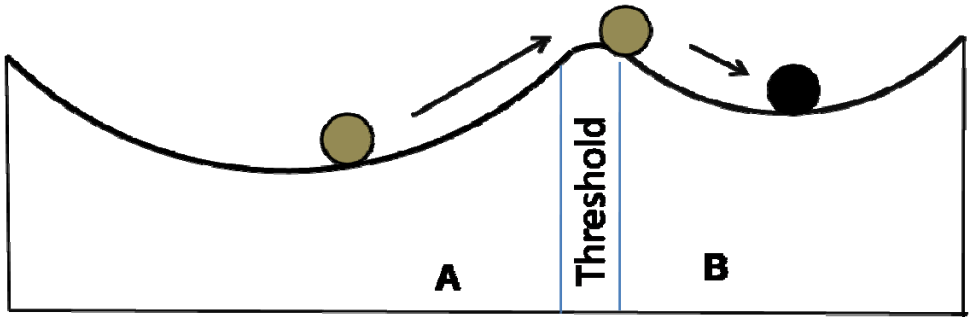
The resilience perspective emerged from ecology in early 1970s through the study of the stability in ecological systems as the ability to absorb changes (Holling 1973). It became an essential to influence various fields outside ecology, especially in interdisciplinary studies (Folke 2006) on biodiversity (Folke *et al*. 1996), property rights and common property (Hanna *et al*. 1996; Berkes and Folke 1998), cross-scale linkages (Folke *et al*. 1998), and socioeconomic systems (Levin *et al*. 1998). The resilience perspective also shifts policies from controlling change in systems to managing the capacity of social-ecological systems to cope with and adapt to changes and disturbances (Berkes 2003; Folke 2006; Smit and Wandel 2006).

Transformation has become a part of resilience theory and terminology. With an attention on transformation, resilience may be an obstacle for a livelihood system to move into a desirable stability domain. In this circumstance, resilience may not be a good thing (Walker *et al*. 2004). However, transformation toward sustainable development direction is one of the great challenges for system management. In fact, transformation may be taken as the harm or damage to a system

(Gallopin 2006). It may occur in a less resilient system to shift from the current regime into a more undesirable and vulnerable one. In some cases, the transformation may be largely irreversible (Folke *et al*. 2004). Several studies have illustrated that ecological systems can be transformed into a less productive or undesired regimes. The theoretical basis of the negative transformation in ecological systems have been extended by Beisner *et al*. 2003; Scheffer and Carpenter 2003; Scheffer *et al*. 2001; Folke *et al*. 2004.

The resilience perspectives bring attention to shocks and stresses which are inherent in livelihood systems. Stresses and shocks on local livelihoods are the result of interactions between external (e.g., national development policies, international market) and internal drivers (e.g., seasonal cycle of resource user) (De Haan 2000; Armitage and Johnson 2006; Marschke and Berkes 2006). Stress is a continuously or slowly increasing pressure (e.g., environmental degradation), commonly within the range of normal variability; whereas, shocks are major spikes in pressure beyond the normal range of variability, usually discrete in space and time (Turner *et al*. 2003; Marschke and Berkes 2006). A livelihood system is continuously buffeted by shocks and stresses, which make the system moving about within their basin of attraction. If the system moves within the regime, it is resilient. In other words, if the system crosses its threshold, it is transformed to an alternative regime (Figure 2).

Shocks and stresses challenge not only the livelihood systems, but also the social-ecological systems in which livelihoods are sub-systems. Changes in social-ecological systems may result in changes in the stability landscape of livelihood systems, such as changes in numbers of basins of attraction, changes in the depth of the basin, and changes in the position of threshold (Walker *et al*. 2004).



Source: adapted from Gunderson (2000)

Figure 2: A shift of a livelihood system to an alternative regime

Resilience thinking emphasizes the importance of scale and cross-scale linkages (Berkes *et al*. 2004). In fact, livelihood systems cannot be understood by examining only one scale. Livelihood

systems fit in the requirement of complex adaptive systems in the hierarchical organization. Household is the key level for livelihood analysis; however, it is actually a sub-system of the whole panarchy. Loss of resilience at small scale of organization (e.g., individual level) changes the state of household livelihood systems but may not transform household livelihood systems. Walker *et al*. (2004) also suggested a system at one scale that loses resilience at smaller scale would be more resilient than one that loses resilience at larger scale. In fact, whether a livelihood system is resilient or transformed to a new regime depends on the scale of the definition of the systems. Characterizing the transformation as positive or negative (transformed to a desirable or undesirable regime, respectively) also depends on different judgment and various scales (Gallopin 2003).

The resilience approach has been used extensively in many studies on social-ecological systems; however, resilience cannot be measured directly. In addition, it is difficult to apply the stable regime to the complex livelihood systems and to determine the threshold between two regimes (Carpenter 2003; Scheffer & Carpenter 2003; Carpenter *et al*. 2005). There have been some efforts on prediction of threshold position (Brand 2009). One way to determining key variables of a system and measuring its threshold is to focus on system identity offered by Cumming *et al*. (2005).

System identity depends on the four essential attributes (CRIC): (1) *components*, which include such things as human and non-human actors; (2) *relationships*, which describe the way in which system components interact or fit together; (3) *innovation*, which are those subsets of the system that generate change and novelty; and (4) *continuity,* which describe the ability of system's maintenance of its cohesive entity through space and time (Cumming *et al*. 2005). These four attributes are logically related, cohesive and mutually constraining (e.g., interactions among systems component constrain the types of components, or continuity constrains innovation), that are suitable for maintaining system identity (Cumming and Collier 2005). Different types of complex systems have their own identity criteria and require different kinds of relations which determine the dynamic unity of the system.

Cumming and his co-authors (2005) give an example of the eutrophication of a shallow lake from clear water regime to turbid water regime with the attention to water phosphorus. The standard deviations of total water phosphorus increase as the lake approaches its threshold. Water phosphorus is a system attribute but would not be considered as a part of system identity (Cumming *et al*. 2005). The use of system identity helps clarify the distinction between the attributes that define the system itself and the drivers that impact on the system.

The most important idea of the CRIC approach is that many attributes of the systems may change in the face of shocks and stresses, but essential attributes of system identity must be maintained if the system is resilient (Cumming *et al*. 2005). To assess the maintenance of system identity, Cumming *et al*. 2005 suggested identifying a level of change as a fixed point against which to quantify changes in resilience. That level of change, in fact, is the boundary within a basin of attraction. In other words, it is the threshold of the system before transforming to an alternative domain. The following discussions examine shocks and stresses, which impact on the livelihood system, a number of key attributes of system identity associated with their thresholds as a surrogate measure of the current resilience, and the possibility of transformation of a system.

4. Research findings and analysis

4.1. Dealing with shocks and stresses

In Thuy Dien village, both shocks and stresses occur. In open-ended interviews, local villagers in 65 households were encouraged to discuss disturbances they experienced and how they responded. Collected information was verified by observation and focus group discussions and summarized in Table 1.

Table 1: List of shocks and stresses experienced by local villagers

	Items	%[(1)]	Responses to shocks and stresses
Stresses	*Lack of access to fishing grounds:* The expansion of net-enclosures and earth-ponds has reduced the fishing grounds for mobile fishers	35	Rearrange net-enclosures to provide larger areas for mobile fishing activities and increase water flows in the area; Travel long distance for fishing in response to lack of fishing ground and resource decline
	Decline of fishery resources: Decline of fish populations and habitat degradation because of over-fishing, destructive fishing and lagoon contamination	68	Diversifying livelihood activities (e.g., trading, poultry raising, wage labour ...) to supplement income
	Destructive fishing: Illegal use of electric fishing, motorized push-net, etc.	37	Government ban of destructive gear Patrolling to minimize illegal fishing activities
	Market fluctuation: Price drops at the harvesting seasons; Increase of price of feed and nets;	40	NA
	Pressure of net-enclosure removal: Provincial and district government's strategies to remove net-enclosures	36	Apply and renew commune permission

	Increase numbers of fishers: Population growth Large number of famer-fishers	33	Travel long distance for fishing in response to lack of fishing ground and resource decline
	Large seasonal variation in fishing activities: Dry seasons and rainy seasons Fluctuation in temperature and salinity Availability of different aquatic species	68	Seasonal migrate to secure an alternative income source: Local villagers fish in peak season and go for wage labour in large cities in rainy season Intensive fishing after floods and heavy rains when productivity is said to be high
	Illness: One or more households members Illness of income generators	38	NA
	Aquatic diseases: Outbreaks of aquatic diseases lead to loss in aquaculture and fishing	46	Preventive measures to reduce the risk of aquaculture diseases (e.g., antibiotics, sedimentary ponds for water treatment) Poly-aquaculture of different species (shrimp, fish, crab, seaweed...) in response to the loss of tiger shrimp monoculture
Shocks	*Disease outbreak:* White spot syndrome virus cause high mortality and result in 70% of losses in aquaculture in the village		
	Natural disasters: Typhoons, floods, heavy rains, and other natural disasters cause damage on fishing gear, bamboo boat and aquaculture net-enclosures and earth ponds	97	Government supports and compensation: resettlement program and emergency relief after natural disasters (e.g., floods, storms...) Local households reinforce their houses before rainy seasons
	Loss of fishing gear: Fish corrals are stolen Products in fish corrals are stolen	11	Guarding to prevent theft of aquatic products
	Damage of fishing net-enclosure: Nets surrounding net-enclosures are destroyed by mobile fishers or outsiders	26	Guarding net-enclosures and earth-ponds to prevent damage

Note: (1) is Frequency of mention (%)

Although shocks and stresses were categorized, the line between them may be blurred (Marschke 2005). A shock for one household may be a stress for the others. Illness, for example, may be an on-going stress for some households with multiple members pursuing different livelihood activities, but may be a shock to other households with a few working members, especially if it happened with main income generator in peak seasons. Similarly, tiger shrimp diseases are one of the on-going stresses with most of aquaculture households, but WSSV may be a shock as it causes high mortality (50-70% in two to three days and up to 100% after 4-5 days of infection) (Phuoc, pers. comm. 2007).

Some socks and stresses were mentioned in all fishing households, whereas some others were related to specific user groups in the village. Lack of access to fishing grounds and decline of

fishery resources were concerned by most of mobile fishing interviewees (80 and 87%, respectively). Indeed, more than 80% of lagoon areas in the Sam Chuon were occupied with aquaculture. Mobile gear fishers have to travel further to the lagoon for fishing but get lower daily catches and smaller size of products. For example, greasy-back shrimps (Metapenaeus ensis) were about 80 units/kg in 2003, but in 2006, they were about 100-120 units/kg products.

> *I prefer to fish in water-way systems; however, it is more and more crowded and the water-ways has been smaller and smaller. I have to go further to fish. It takes an hour to go out of the culturing areas; but sometimes we could only get some for our own consumption. We have three kids and hundreds of things to pay. Fishing seems more and more difficult now (a mobile-gear fisher in Thuy Dien village, March 2007).*

37% of interviewees in Thuy Dien village reported that destructive fishing was an on-going stress. An increasing use of fine mesh size gillnets has significantly reduced the productivity of large and medium mesh size gillnets. Destructive fishing, in fact, is an important factor in the decline of fishing resources in the area. According to a member of the Fishery Association, the number of households engaged in electric fishing has recently decreased significantly; however, it remained a considerable problem in the Sam Chuon Lagoon. Households engaged in destructive fishing were mostly poor households in Thuy Dien, as well as in other neighbouring villages. The use of destructive fishing together with the more fishers competing over declining resources was an ever-increasing pressure to mobile gear fisher in the village.

In the village, almost 70% reported that the seasonal cycle of the fishery resource availability and 40% reported that market fluctuation were also a concern. Seasonality is the nature of fishery activities; therefore, incomes from fishing activities were unstable. Aquaculturists complained that the price of fingerlings and feed was increased at the beginning of aquaculture seasons, whereas prices of aquatic products decreased at the harvesting stage. An earth-pond owner explained that they had to sell their products before the flooding seasons that pressure reduced the prices in the whole area.

> *Life is always not easy. It has been much better now since we do aquaculture. However, there are a lot of related concerns. At the beginning of the season, we have to borrow money for investment on pond preparation, fingerlings and feeds. And then we always have to check for diseases. If we are lucky, we could harvest at the end of season. However, the price is always up and down. We do not have*

time to wait for higher price because we may lose everything if early floods or high floods happen (an earth-pond aquaculturist, September 2006)

Besides these on-going stresses, shocks may intensively affect livelihoods of a household or of the whole village. Shrimp diseases outbreaks (e.g., white spot, blind eye, yellow head …) are problems for s aquaculture households in almost every aquaculture season. Over 90% of farmers have experienced aquatic diseases, of which more than 70% cases were caused by white spot syndrome virus (WSSV) (livelihood survey 2007). Other shocks that particularly affected net-enclosure owners were the losses of fishing gear and the damage of net-enclosures. These losses happened mostly in net-enclosures which are located next to large water-ways. Fishers operating mobile gear in water-way systems, unintentionally or intentionally, destroyed net layers of the net-enclosures.

Typhoons and floods occur every year. In fact, about seven to eight floods a year were recorded (An and Hoang 2007). In 1999, severe floods considered the worst flood in a century in Vietnam happened in eight central provinces. It caused 622 deaths, including 373 people in Thua Thien Hue province, and losses valued of about US$270 million. In November 2004, floods and landslides from heavy rain following Typhoon Muifa caused 56 deaths in Central Provinces. In 2006, Typhoon Xangsane caused losses of approximately US$630 million and another biggest torrential rain in the mid-dry season in 30 years made 2,400 ha on-going farming in flood. Floods and Typhoon Lekima in 2007 killed more than 20 people in the province (Dartmouth Flood Observatory 2009).

How do households, local community and government cope with and adapt to these shocks and stresses?

At the household level, there were various ways of dealing with shocks and stresses depending on their access to livelihood assets. Diversification of livelihood activities is the most common answer from local interviewees in Thuy Dien village with approximately 90% of frequency of mention. Having multiple incomes sources reduced their dependence on lagoon resources. Seasonal or permanent migration was another option for households who have fewer opportunities to diversify their livelihoods within the village. Almost 80% of interviewees mentioned that they depend on government emergency relief after typhoons, floods and other natural disasters. Some households' responses were effective and positive; some others negatively affected long-term livelihoods. For example, because of decline of fishery resources, the frequencies of using fine mesh size gillnets was increased. Indeed, destructive fishing was directly proportional to the decline of lagoon resources.

Each household had their own way to cope with and adapt to shocks and stresses. However, the mechanism and strategies for dealing with shocks and stresses are broadly consistent. Learning from previous experiences, some strategies are classified as preparation for shocks and stresses. For example, some households reinforce their houses and harvest all aquatic products in net-enclosures and earth-ponds before rainy seasons. All aquaculture households guard their ponds and net-enclosures all day, especially at night-time. Virtually, any communities and households will face a series of challenges (Gardner *et al.* 2002) and people cannot adapt to all shocks and stresses, given the constant change communities do face. Some of interviewees replied that a lot of shocks and stresses were unavoidable and they did not know how to respond. Nonetheless, people are continuously 'doing something' in response to these stresses and shocks (Marschke 2005).

Local social networks play an important role supporting households in dealing with shocks and stresses. Personal savings were not available in most households. Making a loan from formal sectors was a long and challenging process and only available for some households with collateral. Most of households relied on social networks and borrowed money from relatives, neighbours or middlemen to deal with shocks and stresses. Several associations (Fishery Association, Women Association...) also supported local people to get loans from semi-formal credit factors. The Women Association supported some alternative options for livelihood diversification. Collaborating with development projects and government levels, the Fishery Association effectively maintained and enlarged water-way systems for mobile gear fishing in a pilot, and patrolled illegal fishing in the area. Government levels, in some instances, were quite helpful in supporting local households dealing with shocks and stresses, especially to overcome destruction related to floods, storms and typhoons.

4.2. Livelihood system identity

As described in the previous section, system identity depends on the maintenance of four attributes: components, relationships, continuity, and innovation. Local livelihood systems are integrated of social and biophysical components and affected by external and internal drivers. It is impossible to study all aspects of the complex livelihood systems. Besides, some of variables may not represent the identity of local livelihood systems. Therefore, for each of these attributes, a set of specific variables, which reflects changes in local livelihood systems in response to shocks and stresses, were selected for assessment (Table 2). These variables represent the livelihood systems. For example, the dependency on lagoon resources is not only the key

relationships, but also the most important attribute to define the local livelihood systems. If the livelihood systems no longer depend on lagoon resources, the livelihood systems are qualitative different systems.

Table 2: Characteristics of system identity

Attributes of system identity	Key variables in local livelihood systems
Components	Households: The primary economic unit in Thuy Dien village Resource user groups: Livelihood assets: especially lagoon resources Cultural groups: sampan vs. land-based communities Skills and knowledge of local villagers to engage in different activities
Relationships	Dependence of livelihood systems on lagoon resources Conflict between user groups on lagoon access Conflict among different surrounding livelihood activities Biophysical relations within the lagoon Access to land-based activities, market, and credit sectors
Innovation	Diversity of fishery related activities (aquaculture, multiple gear) Diversity of non-fishing activities (wage labour, out-migration, poultry raising ...) Ability to join social organizations
Continuity	Traditional institutions governing commons Local knowledge and social memory (fishing activities, predicting the possibilities of floods, typhoons and other disasters)

Note: The community livelihood system is described according to four types of elements (CRIC) that comprise its identity. C*omponents* are human and non-human actors of the system. *Relationships* are the way in which system components interact or fit together. *Innovation* are those subsets of the system that generate change and novelty. *Continuity* are system's abilities to maintain its cohesive entity through space and time (Cumming *et al*. 2005).

Although livelihood systems depend on fishery resources in Tam Giang Lagoon, there is probably no single fish or any specific aquatic species which may define the local livelihood systems. On the other hand, fishery resources as the whole are the central of the resource-dependent livelihood systems. It is unable to imagine how local livelihood systems are without fishery resources. Other resource attributes such as pH, salinity, sedimentation are important indicators of lagoon ecosystems and directly influence the availability of fishery resources; however, these attributes are not a part of system identity.

Some of the most important variables of system components are households and resource user groups. Households have become the primary economic units in Thuy Dien village, as well as in other parts of Vietnam after the policy changes of 1986. Households in the village used to belong

to only two lagoon user groups: fixed gear and mobile gear groups. After the development of aquaculture, there have been multiple resource user groups: earth-pond aquaculture group, net-enclosure aquaculture group, mobile fishing group, and non-fishing group. Some households are involved in both earth-pond and net-enclosure aquaculture and fishing as well. The relative classification of lagoon user groups depends on their livelihood activities and their access to lagoon fishing grounds. Other main variables of components include cultural groups of local villagers. Villagers in Thuy Dien were once sampan people, which distinguished them from the other surrounding land-based communities. The sampan people have been resettled on land; however, they lack of skills and knowledge to get involved in the diversity of non-fishing activities. The main non-fishing activities in the villages are trading, poultry raising, and other local services.

System identity also focuses on the non-linear relationships between the above variables of system components. Changes in these relationships directly lead to changes in the livelihood systems' attributes. One of the most important relations in local livelihood systems is the social connection and local interaction. The resettlement of the sampan people provided opportunities to strengthen the social network, especially with neighbours and friends, and access to local markets and different credit sectors. However, in the village, the resettlement of sampan household has combined with the aquaculture development and policy change. The privatization of lagoon resources for aquaculture has increased the conflict between different user groups. The conflict over fishing grounds between mobile gear fishers and aquaculturists is an example. Mobile gear fishers have been excluded from fishing grounds, which has been converted to be aquaculture ponds and net-enclosures. The extension of aquaculture has made livelihoods of mobile fishers more and more marginalized. Besides, wastewater discharged from aquaculture ponds and agriculture farms contains different kinds of chemical residues which may contaminate the lagoon resources. In fact, conflicts among different livelihood activities (fishing, aquaculture, agriculture) and resource users (fishers, aquaculturists, farmers) have also become more critical in the lagoon.

Biophysical relationships are important because the availability of fishery resources in the lagoon is seasonal. The location of Sam Chuon next to Thuan An opening and Huong river estuary makes lagoon resources more fluctuated. One other important relationship is the dependence of local villagers on lagoon resources for their livelihoods. In fact, both fishing and aquaculture activities are dependent on the biophysical dynamics of the lagoon. However, the over exploitation of lagoon resources such as destructive fishing (electric fishing, intensive use of fine mesh size gillnet...), or discharge of wastewater from aquaculture ponds into the lagoon without

treatment, have influenced the multiple biophysical attributes leading to resource decline. According to Thanh *et al.* 1998, the number of fishers has almost doubled in the period of 1977-1997; however, fisheries yield period in Tam Giang lagoon have declined from 3,600 tons to 2,000 tons over a ten year (Hoi *et al.* 1998). Electric fishing gear is more common and combined with other gear to be more destructive. The lagoon is polluted by the residuals and chemical use, and shrimp diseases from aquaculture activities; solid waste and waste water from settlement areas; pesticide and fertilizer from agriculture farms around the lagoon; and other pollutants from many different activities in surrounding areas (Tuan *et al.* 2009). These activities, in fact, threaten the lagoon resources and go beyond the carrying capacity, recovery and self-purification of lagoon systems. The over-exploitation, consequently, may push the lagoon resources closer to the threshold of the regime.

One important source of continuity that deserves mention is social and ecological memory. Memory is maintained through and the oral history (e.g., proverb) and the continuance of fishing activities. For example, ants building their nest at higher places or gulls flying from the sea to mainland are some indicators for heavy flood that year. Traditional institutions as "a subset of social memory" (Folke *et al*. 2003: 366) are an essential source of continuity. The traditional institutions of "*Vạn*" and villages were responsible for resource use and management in Tam Giang Lagoon. "*Vạn*" was self-management units of fishers using similar types of fishing gear. There is several "*Vạn*" in a village including "*Vạn đại nghệ*" of fixed gear fishers and "*Vạn tiểu nghệ*" of mobile gear fishers. Each local institution had its own rules in resource access; however, there were some common rules among all "*Vạn*" in Tam Giang Lagoon. For example, village authorities auctioned off rights to fishing grounds and controlled the access and use of these fish corrals. Mobile fishers in all "*Vạn tiểu nghệ*" were not allowed to fish at the mouth of fish corrals. Government institutions may influence local institutions to some extent but are not some patterns of local livelihood system identity.

An important source of innovation in local livelihood systems is the engagement of villagers in different social organizations at the local level after settlement. These institutions somewhat empower local fishers to participate in decision-making processes and build a bridge between local fishers and government institutions (e.g., Fishery Association). Some organizations (e.g., Women Association, Farmer Association) provide opportunities for villagers to access semi-formal credit sectors and to get involved in some non-fishing activities.

Another feature that contributes to both innovation and continuity is the diversity of fishery-related activities. The livelihood diversification is a part of their coping strategies responding to the resource decline and increasing numbers of fishers. Aquaculture is not only an alternative

livelihood activity but also a new adopted technology. Local fishers get involved in aquaculture in different ways: earth-ponds, net-enclosure, or cage aquaculture. A net-enclosure is the combination of aquaculture and traditional capture fishing in a specific fishing ground. In capture fishing, local fishers also take the advantages of new technology to improve their fishing gear, such as electric lagoon seine, motorized push-net. The improved gear provides higher production, but negatively impact on lagoon resources.

4.3. Livelihood system thresholds

Cumming and his co-authors (2005) suggested focusing on the elements of system identity in order to overcome the difficulties of measuring resilience in particular cases. It is able to measure different elements of the components, relationships, innovation and continuity that distinguish the system and determine thresholds for those elements based on the specific circumstance of each system. Rather than attempting to measure the width and depth of the regime and the resistance of the livelihood systems, one can examine whether these attributes go beyond their threshold values. This section discusses a small set of system variables identified above and considers quantitative values for the thresholds (Table 3). For the most part, the discussion below stops short of suggesting particular quantitative values for the thresholds.

One critical threshold of system components relates to the number of households in aquaculture groups. If the numbers of aquaculture households go beyond half of the village, the livelihood systems depend more on aquaculture rather than the traditional fishing activities. In 2006, more than three quarters of households in Thuy Dien village were involved in aquaculture. Aquaculture groups are larger in number than fishers and stronger in economic sectors. The size of aquaculture areas is particular important. When the aquaculture areas are very large, fishing ground for mobile gear fishers will certainly be reduced. In this case, the threshold for aquaculture areas could be determined at 50% of total Sam Chuon areas. Government statistics in 2007 showed that more than 80% of Sam Chuon areas have been converted to be aquaculture. The expansion of aquaculture has indeed gone beyond the threshold of the number of aquaculturists, as well as the size of aquaculture areas in the village. Consequently, the mobile fishing group is more marginalized and gets less attention in government development strategies. The access of mobile groups to Tam Giang lagoon is also another variable of livelihood system identity. In Sam Chuon areas, mobile fishers claim less than 20% of lagoon areas including waterways for their fishing. One of the purposes of open-ended questions on livelihood challenges is the number of mobile fishers mentioning the issues of lack of fishing ground. The

quantitative value of this threshold has been identified at 50% mobile gear interviewees. However, result analysis has shown that lack of fishing grounds were concerned by approximately 80% of mobile gear fishers.

Table 3: Selected variables of livelihood systems and examples of thresholds in comparison with the current value in Thuy Dien village

Attributes	Example of Thresholds	Current situation
Components		
Aquaculture households	≥ 50% households involved in aquaculture	76.2%
Resources	≥ 50% interviewees mentioning resource decline	68%
Relationships		
Access of mobile groups to Tam Giang Lagoon	≥ 50% mobile fishers mentioned the issues of lack of fishing grounds	80%
Size of aquaculture areas	≥ 50% Sam Chuon for aquaculture	87.3%
Innovation		
Use of destructive gear	≥ 50% interviewees mentioned	37 %
Aquaculture diseases	≥ 50% aquaculturists mentioned	75%
Continuity		
Traditional fishing activities	≤ 50% households involved in one or more traditional fishing activities	92%
	Income from traditional fishing activities ≤ 50% total income of aquaculture households	25-30%
Permanent migration	≥ 20% permanent migration	2%

In the previous section, lagoon resources have been considered as one of the most important components of resource-dependent livelihood systems in Thuy Dien village. One critical threshold is therefore 50% of interviewees. In fact, resource decline has become a major problem and concerned by 68% total interviewees. Significantly, almost 90% of mobile gear interviewees mentioned this variable as one of the most challenging and another 30% of the non-fishing groups claimed that resource decline is one of the reasons why they stopped fishing.

Diversity of livelihood activities has been considered as an important element to provide supplement al income building a diverse portfolio of livelihood activities (Marschke and Berkes 2006). However, some alternative activities negatively impact local livelihood systems. For example, the use of destructive fishing gear has become an emergent problem in Sam Chuon area. It seems to be difficult to determine the quantity of this destructive gear in current use (e.g.,

electric fishing, electric lagoon seine ...). However, the threshold of this pattern might be defined according to the number of interviewees who mentioned this problem.

In the face of changes in government policies and the boom of aquaculture, elements of continuity have been vital for maintenance of the identity of local livelihood systems (Cumming *et al*. 2005). To understand the thresholds of variables in continuity, it is important to note that if the systems cross their thresholds, the livelihood systems lack their continuity. In other words, those variables will show the discontinuity of the local livelihood systems. Income from traditional fishing activities somewhat shows the continuity of capture fishing in local livelihood systems. If income from capture fishing drops dramatically, it may cause the discontinuity of traditional fishing in aquaculture households. The quantitative value of this threshold has been given 50% of income from traditional fishing activities in the total income of aquaculture households. The current situation shows that in most aquaculture households, income from traditional fishing has dropped to about 25-30% of their total income.

Another quantitative value for the continuity or discontinuity of livelihood system is permanent migration. Migration is one way of livelihood diversification, which has been considered as an innovation. However, if too many local villagers permanently out-migrate to other cities, it may cause a lack of labour doing fishing activities in the peak season and a discontinuity in social and ecological memory related to traditional fishing. The threshold for livelihood system continuity is to have less than 10% of population permanently migrating to other areas. In Thuy Dien village, most of permanent out-migrants are at working age; however, the number of out-migrant is only 2% of population. This variable, in fact, does not cross its threshold.

Thresholds of local livelihood systems in Thuy Dien village are a relative quantitative value. Examples of thresholds in Table 3 have been estimated based on the specific context of the research. It is somewhat subjective with the researcher's viewpoints. However, in most cases, there are a long distance between the examples of threshold and current situation. If the real threshold is little higher or lower than the estimated threshold, it does not cause a large effect. For example, a threshold was estimated at 50% of Sam Chuon area for aquaculture activities. Even if the real threshold may be lower at 40% or higher at 60%, the current situation of with 87.3% certainly goes beyond its threshold.

Another important feature of local livelihood systems mentioned above is the institutions governing lagoon commons, including rules and customs regulating resource access and management, and decision-making processes. Various factors could undermine, or have undermined these institutions, especially changes in government policies. The threshold of the

institutions is unable for quantitative measurement. Instead, qualitative measurement is applicable (Robinson 2009). Threshold of institutional patterns in livelihood systems might be the effectiveness of traditional institutions in regulating the equitable access and the proper ways of resource exploitation. In Thuy Dien village, the traditional institutions have been undermined and are mostly mentioned in traditional ceremonies (Mien 2006). Some other local institutions governing resource access and management have been built up to empower local fishers to participate in decision making processes. Local institutions, in fact, have crossed the threshold and shifted to an alternative regime.

5. Discussions

5.1. Livelihood system transformation

As discussed in the above section, a number of the thresholds have been crossed. The most two important attributes of livelihood system identity - resource user groups and open fishing grounds - have been changed. More than three quarters of the village have been involved in aquaculture. The size of mobile gear fishing grounds has fallen below a minimum threshold. Lack of fishing grounds together with resource decline has forced a large number of households find other ways to support their livelihoods. The expansion of aquaculture has created a large income disparity between aquaculture households and non-aquaculture households. In many cases, income from all activities in most of mobile gear fishing households is lower than income from only aquaculture activities of a net-enclosure household. Conflicts between different user groups on resource access have become an emergent problem. On the other hand, the issue of aquatic diseases has pushed a number of aquaculture households into immense debts. As many attributes have crossed their thresholds, the livelihood system may shift into an alternative domain which is associated with many social-ecological and economic related problems. The shift of livelihood systems between two domains is visualized in Figure 3.

The transformation of livelihood systems resulted from not only the dynamics of system identity, but also the changes of stability domain. The changes of government policies and aquaculture development have created challenges to the conventional domain and probably have changed the "depth" of the basin of attraction and the position of threshold (Walker *et al*. 2004). These changes have made the conventional domain of livelihood systems (regime A in Figure 6.3) more and more tenable and the alternative domain (regime B in Figure 6.3) more and more viable. In other words, these changes have undermined resilience of livelihood systems in the conventional domain.

In the case of Thuy Dien village, the conventional domain is associated with the traditional fishing based socio-economic and ecological systems; whereas the alternative domain is based on aquaculture development. An emergent question which should be raised is which one is more desirable. In fact, the expansion of aquaculture areas has created new mechanisms of distributing resource access excluding non-aquaculture households out of traditional fishing grounds. The distance between fixed gear households and mobile gear households were replaced by the polarization between aquaculture households and mobile fishing households and the increasing tensions between these groups. Aquaculture diseases which lead to immense debt in aquaculture households were also not expected. Crossing the threshold, household livelihoods fall into the circle of livelihood problems. In comparing two domains, the alternative domain is clearly undesirable and more problematic.

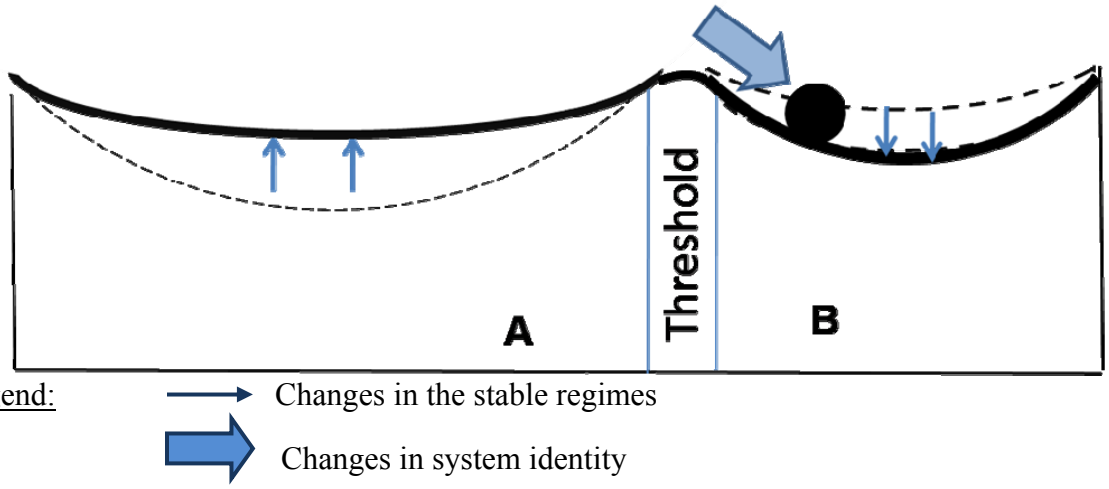


Figure 3: The transformation of livelihood systems in Thuy Dien village

Note: Figure 3 shows the two possible domains for livelihood systems. A is the conventional basin of attraction; whereas, B is the challenging trap associated with privatization, debts, inequity, and other shocks and stresses that livelihood systems have to cope with.

5.2. The use of system identity in resilience assessment

The occurrence of alternative basins of attraction and thresholds has been developed for further understanding the system transformation and specified the meaning of resilience more precisely (Brand 2009). This notion of resilience as "staying in the same basin of attraction" can be subdivided into four aspects: latitude, resistance, precariousness and panarchy. These aspects are inter-related and define the resilience level of a system (Walker *et al*. 2004). However, it is

difficult to measure these aspects for resilience assessment. The implication of system identity with four essential elements: components, relationships, sources of innovation and sources of continuity and the determination of thresholds for each of these elements provides a framework for developing an analytical assessment of resilience in livelihood systems. The four elements are strongly connected with each other defining the livelihood systems. It is clear that some elements and their devising thresholds are measureable, or in some cases, are obvious. For example, one possible indicator might be the size of aquaculture area which covers more than 80% of Sam Chuon area. However, these indicators are only measureable after the transformation has happened. The framework also does not describe how the transformation occurs and how resilience was reduced. On the other hands, the CRIC approach does provide an analytical description of what is happening within the system (Cumming *et al*. 2005). Identifying and measuring the four elements and their thresholds also contribute to an understanding of the ongoing evolution of the livelihood systems and measuring resilience changes in the system over time (Robinson 2009).

The aspect of attractor-based resilience is important to understand the dynamics of local livelihood systems, as well as to examine the livelihood systems as a whole. The approach of system identity adopted in this paper helps clarify how resilience is reduced in livelihood systems. Many aspects of system identity provide the conceptual link between resilience and those that focus on identity. The combination of these approaches is useful to identify the dynamic mechanisms within the livelihood system, describing how the system functions, and measuring thresholds of system attributes. If the livelihood system shifts to an undesirable regime, it is important to pay more attention on resilience at the post-threshold regime (Briske *et al*. 2006). There is a need to strengthen resilience in livelihood system, so that the system does not shift again to a lesser desirable regime. System identity may be used as important indicator for resilience building in livelihood systems.

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