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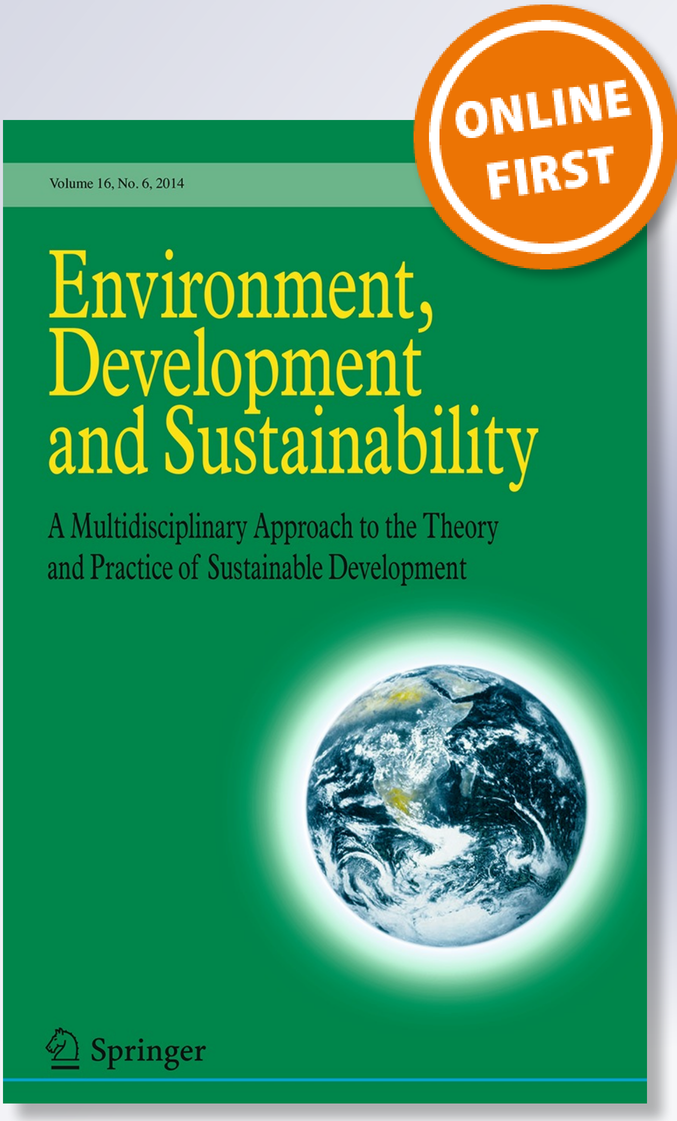

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CASE STUDY

Adaptation to climate change as social–ecological trap: a case study of fishing and aquaculture in the Tam Giang Lagoon, Vietnam

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Abstract The ways in which people respond to climate change are frequently analyzed and explained with the term "adaptation." Conventionally, adaptation is understood as adjustments in behavior either to mitigate harm or to exploit opportunities emerging from climate change. The idea features prominently in scientific analyses as well as in policy programs. Despite its growing popularity over the years, the concept has also received critique. Social scientists in particular take issue with the implicit assumptions about human behavior and "fitness advantages" (or optimal behavior) that come with the term. Clearly, not all human and animal behavioral responses are "optimal" or display "fitness advantages." To the contrary, sub-optimal and maladaptive behavior is rather widespread. Explaining the possibility of maladaptive or sub-optimal behavior led scholars to introduce the idea of "traps." Trap situations refer to a mismatch between behavior and the social and/or ecological conditions in which this behavior takes place. This paper reviews the analytical value of traps for the study of human responses to climate change. It first lays out the theoretical assumptions underpinning the concept. A case study of the Tam Giang Lagoon, in central Vietnam, is used to evaluate how well the trap concept captures the sub-optimality and variety of human responses to climate change.

Keywords Adaptation · Tam Giang · Aquaculture · Fisheries · Flooding · Social–ecological traps

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1 Introduction

Adaptation is one of the key concepts that has shaped climate change action since the 1970s (Orlove 2009). Next to its growing popularity, the concept also received critique. In particular, social scientists take issue with the implicit links between adaptation, fitness advantages, and optimality, inherited from Darwinian evolution. The close connection between fitness and adaptation clearly shows in some recent definitions: "Adaptation refers to the development of traits with a fitness advantage in a population" (Hodgson and Knudsen 2010: 237) and "Adaptations are features of organisms that are designed by natural selection to maximize inclusive fitness" (Mace and Jordan 2011: 366). In these definitions, adaptation refers to the organism adjusting to external conditions until an optimal or maximum fit is achieved.

Although adaptation is a central concept in climate change literature, scholars struggle with the Darwinian heritage that comes with it. First of all, the Darwinian legacy only considers "adaptation to," i.e., organisms adjusting to external conditions. Should it not also refer to organisms adapting the conditions (Odling-Smee et al. 2003)? Several scholars of climate change therefore include human agency in definitions of adaptation (Adger 2006). Moreover, history features numerous examples of human responses to climate change where human fitness advantages actually decreased. Are these responses adaptation? Recent studies explicitly address "limits" and "barriers" of adaptation (Adger et al. 2009; Biesbroek et al. 2013; Dow et al. 2013) or introduce related concepts, such as "maladaptation" (Barnett and O'Neill 2010) and "manipulation" (Thomsen et al. 2012).

Biologists and ecologists also have concerns about the assumed relation between adaptation and fitness. Gould pointed to the "fallacies in overzealous commitment to adaptationist explanations" (Gould, 1997: 10750) and argued that not all changes in phenotypes are adaptations, but could just as well be by-products of evolution, so-called spandrels (Gould and Lewontin 1979) or *exaptations* (Gould and Vrba 1982).[1] Gould's criticism recently received support from studies that documented suboptimal and non-adaptive behavior in animals and plants (e.g., Jump and Penuelas 2005; Sekercioglu et al. 2007). Remaining within an evolutionary framework, these studies explain maladaptation as a "mismatch" or "evolutionary lag" between slow biological evolutionary adaptation processes and rapid changes in the (natural) environments (Schlaepfer et al. 2002). They use the term "ecological or evolutionary trap" for situations in which organisms are unable to adjust to new conditions in the short term.

The concept of traps seems a promising way to highlight the more complex relation between adaptation and fitness advantages, as it leaves room for a wide variety of types of behavior and also for non-adaptive and maladaptive behavior. Nevertheless, difficulties remain. First of all, "mismatches" are hard to verify since the conditions once triggering adaptive traits may no longer exist. Secondly, "evolutionary lags" hardly exist in human responses to climate change, as cultural evolution works much faster than genetic evolution (Mace and Jordan 2011).

The aim of this paper is to explore the potential of the concept of traps for explaining human responses to climate change. The paper first reviews the ways in which traps are defined and used in the literature. It then evaluates the concept through a case study of how rural households cope with changing floods in the Tam Giang Lagoon. Based on the review

[1] Spandrels are nonadaptive by-products from earlier adaptations in organism. If these spandrels at a later stage in evolution are coopted to contribute to the fitness of the organism, they are called exaptations (Gould 1997).

and case study, the paper discusses the potential of the trap concept for studies of human responses to climate change.

2 Traps

Social, natural, and sustainability sciences all use the concept of traps, namely as social traps, ecological traps, and social–ecological traps. Yet, each of these sciences defines traps differently.

As explained in the introduction, biologists and ecologists understand ecological traps as a mismatch between the adaptive behavior of organisms and the (changed) conditions in which they are situated.

In the social sciences, the concept was introduced as a path-dependent process: "[Social trap] refers to situations in society […], where men or organizations or whole societies get themselves started in some direction or some set of relationships that later prove to be unpleasant or lethal and that they see no easy way to back out of or to avoid" (Platt 1973: 641). More recent definitions of social traps also refer to the causes of a social trap, such as low levels of social trust. Rothstein, for example, defines a trap as "a situation where individuals, groups, or organizations are unable to cooperate owing to mutual distrust and lack of social capital, even where cooperation would benefit all" (Rothstein 2005: i).

Recently, traps have also been introduced in sustainability science as social–ecological traps, referring to the rigidity and inertia of behavior considered negative or undesirable from a sustainability perspective (Scheffer and Westley 2007). Social–ecological traps develop from sudden and abrupt changes in the structure and function of ecosystems and social systems, so-called regime shifts (Scheffer and Carpenter 2003), to which organisms then have to adjust. But organisms not only adjust, they can also try to adapt environments to their needs or simply stick to old habits. This latter strategy only works under relatively stable social and ecological circumstances, but typically creates a trap during regime shifts (Scheffer and Westley 2007). This argument resonates with recent findings that the stress of experiencing (perceived) scarcity completely focuses people's minds on the items they think they lack (Mullainathan and Shafir 2013). The resulting "tunnel vision" prevents people from thinking through new options and ideas. In other words (the feeling of) scarcity creates its own trap; it makes people focus solely on mitigating immediate problems, thus preventing them from transforming behavior that perhaps created scarcity in the first place.

In sustainability, science, social, and ecological traps meet. The mismatch between the behavior of organisms with their context generates stress because previous behavior is no longer successful. This stress consequently causes organisms to obsessively focus on short-term benefits, while disregarding long-term benefits. The stress and rigidity in behavior prevent them from adapting, and leads to rigid behavior. The remainder of this paper uses a case study to explore in more depth the potential of the concept of social–ecological traps to analyze the adaptiveness of human responses to climate change.

3 Methods

Many studies rely on quantitative methods to identify social–ecological traps (Carpenter and Brock 2008). For our purpose, a qualitative inquiry is better suited since we explicitly focus on how different social groups perceive environmental change, how they interpret its causes and impact, and how these interpretations relate to different behavioral responses. We study perceptions and responses through a case study of rural households in the Tam Giang Lagoon.

The Tam Giang Lagoon offers an instructive precedent case of human responses to climate change, since coastal systems are particularly vulnerable to effects of climate change (Nicholls et al. 2007). The lagoon is currently undergoing rapid social and ecological change that is relatively well-covered in the scientific literature (Tuyen et al. 2010; Armitage et al. 2011; Boonstra and Nhung 2012; Armitage and Marschke 2013). Nevertheless, these studies do not explicitly consider the role of climate change, which is where our case study can contribute. Moreover, a comparison between our case study and the existing literature on the lagoon allows for triangulation to validate findings.

Our case study is situated in the Quang Phuoc commune (Quang Dien district, Thua Thien Hue province). We selected this commune because this lowland area has been particularly vulnerable to recent storms, tide surges, and floods. Fieldwork was done in two villages of the commune: Phuoc Lap and Mai Duong. Phuoc Lap was established in 1985 as a settlement for sampan dwellers and currently counts 790 inhabitants and 150 households. They depend significantly on the lagoon—fishing and low-input aquaculture. Approximately there are 110 households that fish, of which 18 rely on fixed gears and 92 on mobile gears. Aquaculture has increased significantly, from 10 households in 1999 to 45 in 2001. From 2002 until 2010, aquaculture was marginalised due to harvest failures resulting from shrimp diseases and flooding. Since 2010, about 30 households started to invest again in small-scale aquaculture. Mai Duong currently counts 1,173 inhabitants and 276 households. Its residents depend on rice production and high-input aquaculture. In contrast to Phuoc Lap, all residents of Mai Duong have user rights to agricultural land, on average 500 m^2 per household. Consequently, every household is engaged in rice cultivation and over 70 % of the Mai Duong, which equals 138 households, practices aquaculture.

Our methodology consisted of four steps. First, we identified the important climate events that affected the livelihoods of people in the two villages. We wanted to know: (1) how these events changed over time in terms of frequency, intensity, duration, and predictability; (2) what losses people experienced as a result of these changes; and (3) how they responded to the losses. We employed a mixed-method approach, with questionnaires, semi-structured interviews, and focus groups, including participatory exercises. Focus group interviews were performed four times with different user groups to obtain an overview of the social and ecological history of the area. We used mapping exercises to understand the distribution and location of natural resources, residents, infrastructure and how these were affected by climate events. Social memory mapping exercises with time lines were used to indicate major climate events and how these changed over the years. We conducted 33 semi-structured interviews to discuss in more detail losses and changes in livelihood strategies as effects of these climate change events.

4 The Tam Giang Lagoon

The Tam Giang Lagoon is situated in central Vietnam (Fig. 1). With its 70 km length and 20,000 ha surface area, the lagoon is one of the biggest in Southeast Asia. It receives freshwater from several inland rivers and connects with the South Chinese Sea through the Thuan An and Tu Hien estuaries. The exchange between freshwater and saltwater in the lagoon creates geographical and seasonal salinity fluctuations from 0 to 33 ‰ (Phap et al. 2002), resulting in a variable and rich biodynamic system (Armitage et al. 2011). Salinity

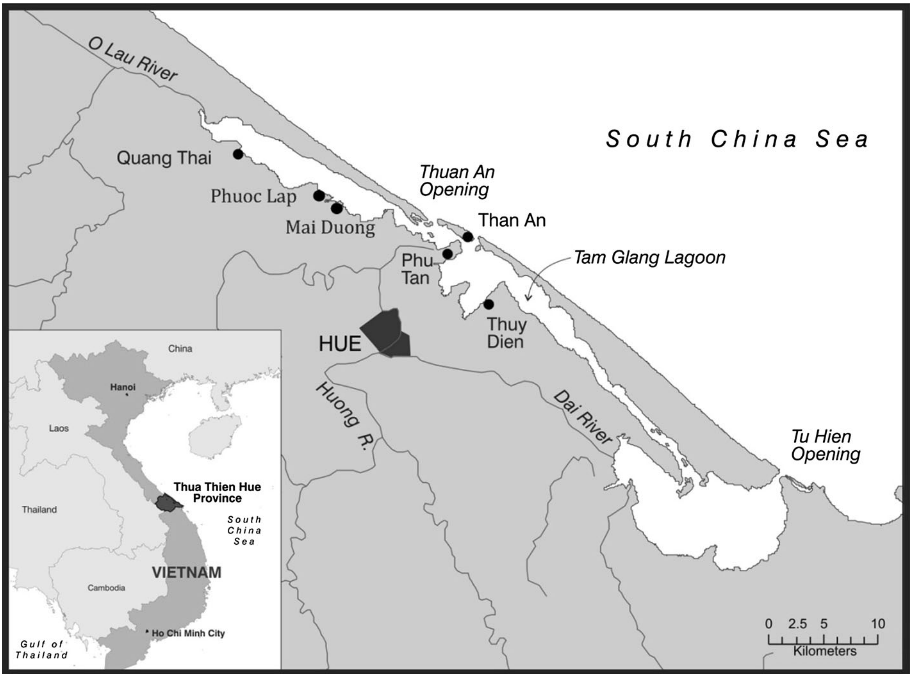

Fig. 1 Map of the Tam Giang Lagoon, with Phuoc Lap and Mai Duong (reprinted with permission of Armitage et al. 2011)

fluctuates depending on season, precipitation, floods, and tides. Floods and tides bring salt water from the sea to the lagoon in January, and salinity reaches a peak in June/July. Following the tides, marine species from the sea enter the lagoon for reproduction. These marine species represent a high economic value (Boonstra and Nhung 2012).

The local climate has two main seasons: the dry season between February and August, and the wet season between August and January. The dry season has low precipitation and air temperature peaks at 38°. The wet season has an average air temperature that lies around 20° (Nguyen Ngoc Truyen 2004). The area is nicknamed the "rain centre" since it has the highest average precipitation of Vietnam (3,000 mm/year) of which 65–70 % falls between August and December. The high concentration of heavy rain causes frequent flooding in the low areas around the lagoon. On the one hand, the flooding causes declines in fish catch, decreasing aquacultural productivity, and loss of assets. On the other hand, these "flood pulses" maintain biodiversity critical for the productivity of agriculture and fisheries (Lebel et al. 2011).

Fisheries in the lagoon differs between "Đại nghệ" ("rich households") and "Tiểu nghệ" ("poor households"). Đại nghệ households practice fisheries using stationary gears, such as traps, pots, and fish corrals that include exclusive user rights over parts of the lagoon. Tiểu nghệ households practice fisheries using mobile gears, such as nets and electric fishing devices, in the open-access parts of the lagoon (Boonstra and Nhung 2012). The dry season is most important for capture fisheries, because then economically valuable marine species can be caught. The period between February and May is high season. In June, the fish catch gradually reduces until fishers catch (on average) 50 % less compared with their catches during February–May.

Modern aquaculture has been practiced in the lagoon at least since the late 1980s when the Vietnamese government launched a policy to develop fish farming (Ton That Phap et al. 2002). Since then, the area for aquaculture increased from 2,618 ha in 2000 to 3,885 ha in 2010 (see Table 1). The considerable profits that were made explain this dramatic expansion (see also Bostock et al. 2010; Belton and Little 2011). In particular, in the 1990s farmers' yearly profits from a 1-ha aquaculture pond equaled profits from 5- to 10-year rice cultivation (Focus group interview with fish and shrimp farmers in Mai Duong). Aquaculture can be divided in high-input and low-input activities. The former is practiced in 1-ha earth ponds on the banks of the lagoon. Households often cultivate Mud crab (*Scylla serrata*), Tiger shrimp (*Penaeus monodon*), and Kinh fish (*Cyprinus centralus*) in one and the same pond. Mud crab cultivation begins during February when the salinity in the lagoon is still low (approx. 5 ‰). In March, Tiger shrimp are added to the pond when the salinity level is between 10 and 30 ‰. Lastly, Kinh fish are added in April. Shrimp is harvested from half June until half August before the salinity becomes more than 25 ‰, while crabs and Kinh fish are harvested depending on prices and household needs. In the end, all species are harvested before the floods season starts during August. Low-input aquaculture consists of permanent pens, cages, corrals, and net enclosures in the water where households mostly keep freshwater carp (Boonstra and Nhung 2012).

4.1 Changes in the water

Research shows that the pattern of variability in onsets, durations, and frequencies of floods and flood tides in the lagoon—the flood regime (Lebel et al. 2011)—is changing (MARD 2008). Changes in average climate conditions coincide with changes in the frequency and intensity of storms and floods (An and Hoang 2007), and alterations in the fluctuation of salinity levels, which affects the habitats, distribution, and mortality of marine species. The changed flood regime not only disrupts ecological cycles in the lagoon, higher temperatures also change water circulation. This in turn increases chances for the spreading of bacterial and viral infections leading to a reduction in productivity of both aquaculture and capture fisheries.

Residents of the lagoon divide the flood regime between "(big) floods" and "small floods." The latter typically occurs during the last weeks of May. Participants in the focus group interviews highlighted changes in the frequency and intensity of the "small floods"

Table 1 Area size, yield, and productivity for aquaculture in the Tam Giang Lagoon 2000–2010 (from Boonstra and Nhung 2012)

Year	Area (ha)	Yield (tons)	Productivity (tons/ha)
2000	2,618	1,467	0.6
2001	3,661	2,532	0.7
2002	3,853	3,109	0.8
2003	4,660	5,430	1.2
2004	5,165	6,408	1.2
2005	5,350	7,000	1.3
2006	4,100	4,650	1.1
2007	3,712	4,697	1.3
2008	3,749	5,659	1.5
2009	3,836	6,374	1.7
2010	3,885	6,786	1.8

that occurred after the "century flood" of 1999. They pointed out that the frequency of big floods decreased, while the number of "small floods" increased. Before 1999, "small floods" occurred perhaps three to four times a year, but since 2005, people counted between five and seven floods a year. Moreover, the participants also found that the occurrence and duration of "small floods" have become more difficult to predict. The floods normally occurred during the last weeks of May and lasted for one or two days. From 2002, however, people noticed that the "small floods" occur often earlier or later than the end of May and also tend to last longer. An overview of the changing flood regime in the Tam Giang Lagoon as interpreted by the focus groups can be found in Table 2.

4.2 Impacts

Inhabitants of Phuoc Lap and Mai Duong perceive that the impact of the "small floods" on livelihood activities has grown since 1999 (Table 2). In what follows, we will assess possible reasons for this change. First of all, it needs to be clear that the impacts of changes in the flood regime are based on the interpretations of the respondents. When respondents perceive less impact from (big) floods, it is important to realize that residents from both villages have invested a lot in making their houses "flood-proof" after the damage of the century flood in 1999. The Vietnamese state offered subsidies for the building of concrete houses and also improved flood forecasts. These measures helped to diminish the impact of big floods. The downside is that many households, despite the subsidies, had to take loans to rebuild their houses. To pay off these loans, they need cash from their fishery or aquaculture. Here, the "small floods" have their main impact.

"Small floods" can disrupt the fishing season. When they hit early in the year, the flood can lower the salinity and turn the lagoon into a brackish state. Marine species then migrate to sea. The downside for the fishers is that they lose species with a high economic value. In addition, the floods shorten the fishing season because they concur with strong winds making fishing difficult. Moreover, the fishers explained that nowadays the need for cash income is high because they need to pay off their loans. Before 1999, the impact from the "small floods" was not particularly large since they primarily needed money to cover basic household needs (see Box 1).

Fish and shrimp farmers are also impacted by the changed flood regime. The century flood of 1999 washed away waste from the bottom of the aquaculture ponds and lowered the spreading of diseases. Consequently, the productivity of the ponds was extremely high

Table 2 Changes in the Tam Giang flood regime as perceived by respondents from Quang Phuoc commune

	Floods		Small floods	
	Before 1999	After 1999	Before 1999	After 1999
Frequency (per year)	3–4	5–7	1	1
Impact	Large	Small	Small	Quite large
Duration (days)	3–5	7–15	1–2	3–7
Timing	From August to November	From September to December	End of May	Earlier or later than end of May
Impact	More frequent but with less impact	More impact and longer duration		More impact

Box 1 Living with floods—Fisheries

"I lost my property and house twice, in the big floods of 1989 and 1999. We came here as part of the resettlement in 1986. With the little money we owned, we built a small house. The house and everything that was in it was swept away to sea by the big flood of 1989. From one day to the other we were penniless and homeless. We borrowed some money from local lenders to build a new house. But this house together with some other assets was swept away with the flood of 1999. We did not even pay off the loan. We wanted our new house to be built of concrete, to be able to withstand flooding. We received some funding from the Catholic Relief Service, and together with new loans we built a concrete house. After 1999 the floods have never reached our house, because it has a very high foundation but also because the floods have not been so big. Now we are having other problems. We pay off our loans with the profits from fishing. But due to the increase in small floodings the fishing season is shortened, and catches decline. During the flood season we earn around 400 thousand VND ($19) per month, which we need for household expenses. It's impossible to save any." (Fisher from Phuoc Lap, 54 years old)

in the years 2000 and 2001. They explain, however, that the current "small floods" are detrimental to their fish farming. If these floods are big, the banks of their aquaculture ponds may flood, allowing fish, shrimp, and crab in the pond to escape. These harvest losses reached a peak during the years 2002–2009 (Nhung 2008). Furthermore, "small floods" nowadays often occur earlier in the year and thus coincide with their harvest time. The floods may suddenly reduce salinity to such extent that whole yields are ruined. The fish and shrimp farmers also find that "small floods" are not strong enough to wash away waste from the ponds. Rather to the contrary, they argued that the small floods bring waste from residential and industrial areas into the lagoon. This pollution impairs growth of the fish and is a source of viral diseases (see Box 2).

4.3 Other reasons for declines in fish catches and yields

The interviews with the user groups in the lagoon revealed that the major impacts from flooding—loss of aquacultural harvest and decrease of fish catch—are caused by more than only changes in the flood regime. Fishers of Phuoc Lap indicated that catches started to decline sometime in the middle of the 1980s. These findings are reinforced by statistics from the Thua Thien Hue Fishery Department. The total fish catch from the Tam Giang lagoon reduced with 50 % within three decades—from 4,500 tons in 1980 to 2,500 tons in 2007. Table 3 lists the various other reasons for the declines in fish catch that fishers mentioned. Beside the technological modernization of capture fisheries, the groups also mentioned the expansion as a major factor responsible for the decline in fish stocks. The ponds, cages, and permanent fish traps destroy marine habitats necessary for fish reproduction and development, and also prevent fishers from maneuvering boats and gear (see Fig. 2).

The interviews with fish and shrimp farmers also revealed more factors to be important for the decline in aquaculture yields (see also Bush et al. 2009). As mentioned earlier, profits in aquaculture were extremely good during the 1990s, which is why more households started cultivation and established fish and shrimp farmers intensified cultivation with the profits earned. Nevertheless, aquaculture yields stagnated from 2002 to 2007 (see Table 1). Besides changes in the flood regime, Table 4 lists other factors that fish and shrimp farmers identified as causes for the declines in aquaculture yield and profit. The most important other factor according to respondents is the pollution buildup in the fish ponds. They consider the waste as a major source of disease under the shrimp population in the ponds.

Box 2 Living with floods—Aquaculture

"Since 1994 I engaged in aquaculture. The climate conditions, especially the "small floods", play an important role in determining the success or failure in aquaculture productivity. I suffered a big loss due to "small floods" in 2002. The cropping that year brought nothing. The flood water came over my pond bank and allowed all the shrimp and crab in the pond to escape into the lagoon. I did not take any precautions because I believed at that time that the "small floods" flood could never reach my pond. But I was wrong. The flood water was much higher than its normal level and rose very quickly. It flooded my pond with more than half a meter. I experienced something similar with the "small floods" in 1998, but its impact was much less severe. During that time the water in the pond rose close to the bank, allowing a small number of shrimp and crab to climb outside. But since the flooding was not so big and lasted only 1 or 2 days, I could pump the water out from the pond. The yield from the pond provided my family a profit of 30 million VND ($1,400). After 1998 I always construct a net over my pond before the small floods come. The net keeps the fish in the pond when the water rises. And since the Tieu man always only lasted 1 or 2 days the fish would survive even when the salinity was lower. But things changed after 2002. The small flood is bigger and lasts longer which makes all my preparation useless, and costs me losses of 10–20 million VND ($467–$934) per season." (Fish farmer from Mai Duong, 54 years old)

Table 3 Ranking reasons for declines in fish catches (Focus group fishers from Phuoc Lap)

Rank	Reasons
1	*The technological modernization of capture fisheries*
	Since the 1980s, fishers modernize their equipment by using of nylon nets, electric fishing gear, and bottom steel frame traps ("Chinese Lu"). In particular, the latter is an extremely efficient trap that catches fish of all sizes
2	*Expansion of aquaculture*
	The area used for aquaculture in the lagoon expanded from 579 ha (in 1998) to 4287 ha (in 2006). The ponds, cages, and permanent fish traps destroy marine habitats necessary for fish reproduction and development, and also prevent fishers from maneuvering boats and gear
3	*Changed flood regime*
	The increase in small floods disrupts the fishing season and aquaculture harvests
4	*Expansion number of fishers*
	Not only is the population in the lagoon increasing, more people are also taking up fishing as income activity due to the high prices
5	*Pollution*
	The vast area of aquaculture structures obstructs water circulation, causing the buildup of waste and contaminants that flow in the lagoon from industrial and residential areas
6	*Thao Long Dam*
	The dam was constructed to retain fresh water and to prevent salinization of agricultural lands. Fishers argue that the dam lowers the salinity level in the lagoon, which negatively affects the abundance of economically valuable marine species

To conclude, the major threats for rural livelihoods in the Tam Giang Lagoon—the decline in fish catch and aquaculture yields—stem from a concatenation of various factors of which climate change influencing the flood regime is one (see also Adger et al. 2005; Daw et al. 2009). Moreover, although respondents did not address institutional change explicitly, the literature indicates that it too had a major impact on how rural livelihoods changed over time (Beckman 2011; Boonstra and Nhung 2012; Armitage and Marschke 2013). The remaining sections of the case study highlight how households responded to these multiple changes.

Fig. 2 Density of aquaculture structures in the Tam Giang Lagoon (Photo courtesy of Hoang The Nhiem)

5 Trapped?

This section describes the responses of fisher and fish/shrimp farmer households and assesses the causal mechanisms on the basis of which one can argue that these rural livelihoods find themselves in a social–ecological trap. To reiterate, a social–ecological trap develops from a social–ecological regime shift, or transformation, which triggers people to develop rigid patterns of action focused on fulfilling short-term benefits, at the expense of long-term benefits.

Figures 3 and 4 schematize the social–ecological trap and its mechanisms for fishers and fish/shrimp farmers. The regime shift for both traps is quite similar. It consists of population growth coupled with a changed flood regime. These two conditions together change the quality and quantity of the ecological services and goods that the lagoon can provide diminish. This change in turn triggers an increased use of the lagoon to make up for the losses.

5.1 Fishers

The diversification of fishing catch methods is the most common way for fishers to respond to declines in fish catch. Fishers adjust their gears and diversify their fishing practices. For example, most meshes from nets now range between 7 and 30 mm, while meshes in older nets used to be between 17 and 30 mm. Fishers also start to use other fishing practices. Some begin diving for oysters, while others acquire more effective gears, such as electric fishing and bottom steel frame traps ("Chinese lu"). From 2004 to 2009, the number of young adults and children leaving Phuoc Lap increased dramatically from 5 to 36 % of the total inhabitants. They leave Phuoc Lap to work in cities such as Hue, Ho Chi Minh City,

Table 4 Ranking reasons for declines in aquaculture yields (Focus group fish and shrimp farmers from Mai Duong)

Rank	Reasons
1	*Pollution in the fish ponds*
	The intensification and specialization of fish farming lead to a buildup of waste and pollution in the ponds causing diseases that kill shrimp or impaired their growth
2	*Financial debt*
	It is estimated that 90 % of all households engaged in aquaculture are in debt for 50–100 million VND ($2,359–$4,717). After the good yields and profits in 1999, fish and shrimp farmers borrowed money to expand and/or intensify their ponds. Since profits were low in the subsequent years, a lot of farmers got stuck with a large debt
3	*Change in the flood regime*
	The increase in small floods disrupts the fishing season and aquaculture harvests
4	*Poor quality shrimp breeds*
	In response to the higher aquacultural activity, the number of shrimp breeding stations increased, especially illegal stations that produce low-quality breeds against low prices. These new breeds are vulnerable to infections and changes in environmental conditions
5	*Market fluctuations*
	Vietnamese aquaculture is integrated in a global market, which means that fluctuations in these markets directly affect the local prices for aquacultural products
6	*Pollution of the water in the lagoon*
	The vast area of aquaculture structures obstructs water circulation, causing the buildup of waste and contaminants that flow in the lagoon from industrial and residential areas
7	*Erosion and damage of the ponds due to flooding*
	The changing flood regime (i.e., more frequent and irregular “small” floods) destroys the pond banks and helps shrimp and fish to escape

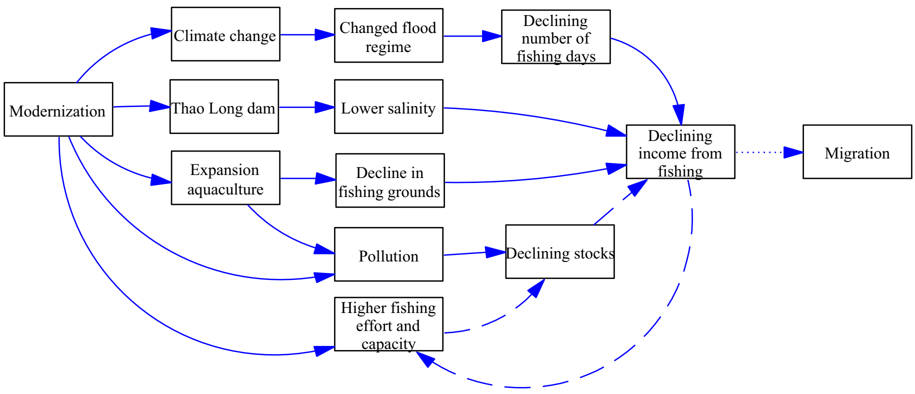

Fig. 3 A causal loop diagram of responses of fishers to social and ecological change in the Tam Giang Lagoon. The *dashed arrows* indicate the trap dynamics, while the *dotted arrow* indicates the responses that could potentially avoid the social–ecological trap

and the Binh Duong industrial zone as house cleaners, factory workers, street vendors, or in other unskilled jobs. Every month, these migrants send home approximately 300.000 VND ($14). From the interviews, it becomes clear that the remittances that labor migrants send

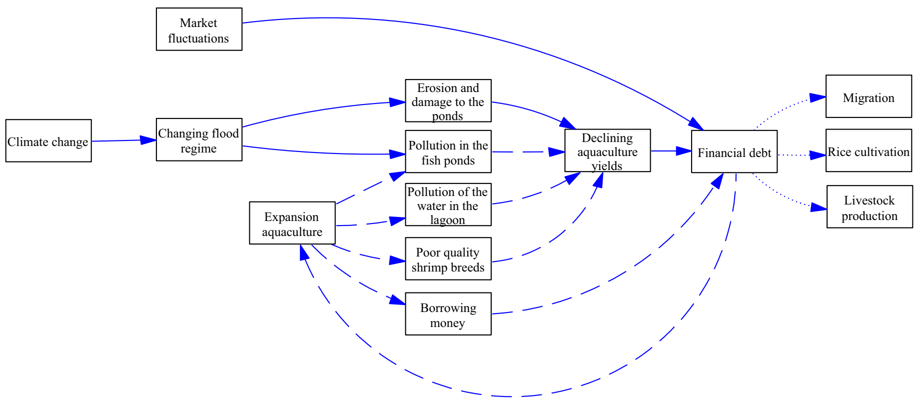

Fig. 4 A causal loop diagram of responses of fish/shrimp farmers to social and ecological change in the Tam Giang Lagoon. The *dashed arrows* indicate the trap dynamics, while the *dotted arrows* indicates the responses that could potentially avoid the social–ecological trap

home to their parents fluctuate considerably. Since migrants work as unskilled laborers, they can easily be fired. Moreover, living expenses in the cities are high, which reduces the amount of remittances. Still, even when migrants are not able to send remittances, the fact that they do not live at home lowers livelihood expenses for the Tam Giang households. It can be concluded from this information that fishers primarily try to maintain their catches by increasing fishing intensity or diversifying their catching methods. This response then results in overfishing and, consequently, a further decline in fish stocks, which is how the social–ecological trap comes to exist (Fig. 3).

5.2 Fish and shrimp farmers

After the decline in aquaculture yields, the fish and shrimp farmers were stuck with high debts that needed to be repaid (Armitage and Marschke 2013). Despite these debts, fish and shrimp farmers were reluctant to quit aquaculture. As they explained themselves, "We already invested a lot of money—more than 100 million VND [$4,717]—to make the shrimp ponds. The failures left us with a debt of more than 50 million VND [$2,359]. We have to continue to farm fish with the expectation that we will get some profit to clear the big debt and to get returns on our investments. We cannot leave them [the ponds] empty." (Focus group interview fish and shrimp farmers Mai Duong village). Although they continue fish farming, they stop producing monocultures of shrimp and instead return to the mixed aquaculture schemes of crab, shrimp, and fish that were common before 2007 (see also Armitage and Marschke 2013). Moreover, they refrain from making large investments. "The profit from mixed-culture is many times smaller compared to monoculture. Before we could get 50–100 million VND [$2,359–$4,717], but now it is only around 10–15 million [$472–$708]. The profit is not enough for our household expenditures such as paying the school fee, electric fee, health care… let alone repayment of the loans. However, a little profit from mixed-culture, is better than nothing. The mixed-culture can reduce the pollution in the pond to give germs little opportunity to thrive. Besides, since crab, shrimp and fish cannot get the same diseases, we can always harvest something." (Focus group interview fish and shrimp farmers Mai Duong village).

Other fish and shrimp farmers fell back on their rice cultivation to compensate the losses suffered in aquaculture. During the 1990s, many fish and shrimp farmers invested their labor and money in the ponds, and employed others to cultivate their rice field, or simply rented out the land. Rice cultivation used to be the main livelihood activity for the fish and shrimp farmers in Mai Duong. In 1993, these households were allocated user rights of land with a 20-year tenure contract. Each household gained then access to approximately 500 m^2 agricultural land, while no user rights after 1993 have been issued. The secure ownership stimulated farmers to intensify the production, using fertilizers and modern rice varieties. According to the farmers, making profits with rice cultivation has become more difficult, partly because their households have expanded, i.e., more mouths are to be fed, and partly because it is more difficult to increase yields. Reasons for low yields are increases in the price of fertilizer and that the rice crop suffered from floodings and droughts during recent years. Other diversifying income activities that farmers turned to include livestock breeding, especially poultry and pigs, and manual labor.

Some fish and shrimp farmers started to work in the highlands in the coffee production during the flood season. But it is more common that the parents stay and that the children leave the village to find jobs in cities as construction workers, hairdressers, or small entrepreneurs. Compared with the fisher households of Phuoc Lap, these children leave their home at an older age, around 18 years of age. Typical for the migrants from Mai Duong is that they eventually end up in skilled labor jobs generating higher incomes. They are able to get these jobs because many finished their education. Farmers consider migration the best way to pay off debts from the failed harvests in aquaculture. The number of migrants in Mai Duong increased from 9 to 42 % during 2004–2009.

From this information, it can be concluded that the fish and shrimp farmers in general hold on to their aquaculture businesses but switch over to more diverse breeding schemes. Compared with fisher households in Phuoc Lap, the fish and shrimp farmers from Mai Duong seem to be able to fall back on a more diverse portfolio of income activities. Many have long-term access to land on which they produce rice or they try to raise livestock. Moreover, just as the households in Phuoc Lap, fish and shrimp farming households are also engaged in migratory labor. Due to their more diverse livelihood portfolio, it is harder to argue that fish and shrimp farmers are caught in a social–ecological trap. Nevertheless, a trap dynamic can certainly be distinguished in the way that these farmers are forced to earn money to pay off their loans. The primary way to obtain cash income is through aquaculture, which means that the pressure on the lagoon in terms of waste and pollution buildup is not reduced, and farmers continue to be dependent on loans (see Fig. 4).

As the above descriptions highlight, there are two important reasons why these responses can be understood as a social–ecological trap. First, it is clear that the Tam Giang Lagoon is undergoing a social–ecological regime shift (Armitage and Marschke 2013) from a combination of climate change, a changing flood regime, population growth, and an urbanization/modernization of the wider Vietnamese society. These remote factors trigger a variety of responses from people that directly depend on the natural capital and ecosystem services of the lagoon. Some of these households—particularly the ones that are engaged in fish and shrimp farming and rice cultivation and located in Mai Duong—have the possibility to maintain their livelihoods relatively independent of lagoon resources. Nevertheless, most fisher households—especially in Phuoc Lap—can only respond through a more intensive use of the lagoon, and, in doing so, further deteriorate its natural resources. It can be argued that this latter category of households is “trapped” since their responses exacerbate the social–ecological regime shift that the lagoon is currently undergoing.

6 Discussion

The foregoing showed in detail the ecological changes in the lagoon and the response of different groups of users to these changes. Most users stick to old habits and continue doing what they already did, only perhaps in more different ways (see also Tran Thi Phung Ha and van Dijk 2013). So, despite all the material and cultural differences between these groups, they all display a certain degree of rigidity in the ways they respond to effects of changes in the flood regime. Families practicing capture fisheries diversify the ways in which they catch fish and in so doing increase fishing effort. Fish and shrimp farmers, despite the high risks involved, continue aquaculture albeit with more diverse cultivation systems. The prospects for fish and shrimp farmers to adapt look somewhat better compared with fishers, since the former traditionally have access to a more diversified portfolio of resources (access to land, skilled jobs). These types of response, together with other climatic and non-climatic factors, will contribute to further ecological deterioration of the lagoon. The current structure of interactions between the ecology of the lagoon and its inhabitants therefore seems to warrant the claim that the different user groups of the Tam Giang Lagoon are caught in a social–ecological trap (Armitage et al. 2011; Armitage and Marschke 2013).

As we pointed out in the introduction to this paper, discovering traps is used to show how adaptive processes and mechanisms are dysfunctioning and instead produce maladaptation (Barnett and O'Neill 2010) and suboptimalities. The idea of traps then implicitly promises that the identification of traps helps discovering leverage points for facilitating climate change adaptation. Based on our case study, we believe that there is reason to remain skeptical of such claims. First of all, the findings make clear that the most pressing problems—declining fish catch and yield failures in aquaculture—stem from a complex causal interaction between a number of processes and events (see also Adger et al. 2005). Much of the literature on human responses to climate change still assumes relatively simple cause and effect relations between ecological and social domains. A useful alternative way of studying adaptation would be not to think of it as originating from a single cause, but to perceive it as stemming from a cluster of causes that reinforce and interact with each other (Boonstra and de Boer 2014).

Second, our study also clearly shows the important role of socially constructed interpretations of threats and risks that people respond to. From the focus groups discussions and interviews, it became clear that people consider the changed flood regime of the so-called Tieu man floods as having the greatest impact on their livelihoods. But why are these small floods having such an impact, compared with the big floodings? The answer, here as well, is a combination of climate change and other social and ecological factors. Big floods do no longer have such devastating impact because many people now live in more secure houses and are generally better prepared due to improved information and infrastructure. These improved living conditions are often paid for with loans. People require cash to pay off these loans and therefore try to catch fish over and above subsistence needs or to engage with aquaculture. Since they depend so much on the availability of wild fish and aquaculture yields, they are hit most by the small floods. The timing of this type of flood has become unpredictable; they last longer than normal and are often bigger, i.e., involve more water (see Table 2). These findings illustrate a point that was also made by the sociologist Max Weber with reference to floodings in the Dollard, a Dutch–German wetland that is part of the Wadden Sea. He argues that the explanation of the impact of flooding (losses of life and property) can not only be based on an understanding of the environmental event itself, but has to take account of how the people living in the Dollard culturally interpreted these events and acted on them (Weber [1922] 1978, p. 7; see also Foster and Holleman 2012: 1632). For Weber, there was no doubt that an objective environmental reality (such as climate change) outside human consciousness existed, but it was also evident for him that this reality can only be known through human intersubjective interpretation. Weber's argument is reiterated in recent studies that highlight that limits to climate change adaptation not only refer to hard, biophysical limits, but also need to include social and cultural perspectives of these limits (Adger et al. 2013).

One way to incorporate these insights[2]—causal complexity and the role of human interpretation—in the trap concept would be to pay more attention to the temporality and history of social–ecological traps. Instead of considering traps as an unfortunate mismatch, they could be represented as a path-dependent process or involution (Geertz 1963; Boonstra and de Boer 2014). With involution, rigidity is not produced genetically but culturally, i.e., it resides in habits, norms, or institutions that are reproduced through (both reflective and unreflective) learning and imitation (Hodgson and Knudsen 2010). Nevertheless, rigidity is never total; there is always space, however small, for human agency and creativity that can be used to overcome traps (Adger et al. 2009: 344). The question then becomes how we can explain why certain organisms become more rigid in their behavior as a response to unfavorable changes, while for others such outcomes induce creative and innovative modes of action. Does scarcity indeed "capture" thoughts and actions (Mullainathan and Shafir 2013), or is it—as the proverb has it—the mother of invention and ingenuity? More research is needed to understand how interaction between structural conditions and behavioral dynamics of organisms leads to the one or the other.

7 Conclusion

Some time between September and December 1920 Franz Kafka wrote the following story: "Alas," said the mouse, "the whole world is growing smaller every day. At the beginning it was so big that I was afraid, I kept running and running, and I was glad when I saw walls far away to the right and left, but these long walls have narrowed so quickly that I am in the last chamber already, and there in the corner stands the trap that I must run into." "You only need to change your direction," said the cat, and ate it up." (Kafka [1920] 1946). This *"little fable,"* as Kafka titled it, not only features traps (a mousetrap and a world getting smaller) it is also structured as a trap. Its fatalistic ending is for the reader impossible to escape: Although the mouse avoids the mousetrap, it nevertheless ends between the cat's teeth. What makes the story so weird and counterintuitive is that the cat helps the mouse to escape the trap, but then the same cat finishes the mouse. The only possible moral of the story seems to be "damned if you do; damned if you don't" (Gray 2005: 162). The story is a trenchant parable of the suboptimalities of adaptation. As the cat says, adapting "only needs a change of direction," but adaptation inevitably leads into new traps.

Climate change adaptation is defined as the (human) responses that try to adjust to harm or exploit opportunities from climate change. Framed within Darwinian principles of evolution adaptation refers to changes in organisms' behavior that make it *fit better* with changed conditions. Understandings of climate change adaptation that endorse (implicit) assumptions about the relation between adaptation and fitness often fall short of

[2] Other social issues not explicitly addressed in the trap concept but nevertheless requiring inclusion are issues of justice and responsibility (Kates 2000; Sovacool 2013).

recognizing the existence of suboptimality, maladaptation, manipulation, and the variety of human responses to climate change.

This paper studied how well the concept of social–ecological traps succeeds in capturing suboptimality and diversity in human responses to climate change through a case study of how inhabitants of the Tam Giang Lagoon respond to the effects of flood regime changes. The situation for the different users of the lagoon, fishers and fish/shrimp farmers, has been identified previously as a social–ecological trap (Armitage et al. 2011). Our case study highlighted that there is indeed evidence to represent the interactions between ecological change in the lagoon and the behavior of fishers and fish/shrimp farmers as a trap. The ecology of the lagoon is rapidly deteriorating, resulting in declining fish stocks and frequent harvest failures in aquaculture, while the responses of fishers and fish/shrimp farmers clearly display rigidity and inertia. A primary response of these groups is to diversify their fishing methods or the species that they breed in their ponds. But the bottom line is that they keep doing what they do, which reinforces the negative ecological changes.

Does this conclusion mean that the trap concept is a useful way to investigate the suboptimality and variety of human responses to climate change, since it can be used to avoid or unlock adaptive capacity? The results of our study cannot quite support this inference. The case of the Tam Giang Lagoon shows that the variety of human responses, whether qualified as adaptation or maladaptation, come into existence from a complex interaction between changes in remote, structural, social and ecological conditions, and changes in proximate, human dispositions, and behavior (Boonstra and Österblom 2014). An important aspect of this interaction between remote and proximate factors is human intersubjective interpretation of risks and threats. To account for these dynamic interactions, we proposed considering traps as a process, instead of a mismatch, using Geertz' idea of involution. Nevertheless, despite these new insights, questions remain concerning the production and reproduction of rigid behavior. How does the interaction between structural conditions and behavioral dynamics trigger rigidity? And why do some individuals, or groups, fall prey to rigidity while others succeed in imagining ways to escape traps? With some imagination, one could even have Kafka's mouse escape.

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References

Adger, W. N. (2006). Vulnerability. *Global Environmental Change, 16*(3), 268–281.

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change, 15*(2), 77–86.

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change, 3*(2), 112–117.

Adger, W. N., Dessai, S., Goulden, M., et al. (2009). Are there social limits to adaptation to climate change? *Climatic Change, 93*(3–4), 335–354.

An, V. L., & Hoang, H. D. T. (2007). *Climate change effects in Tam Giang and Cau Hai lagoon region*. Hue City: IMOLA.

Armitage, D., & Marschke, M. (2013). Assessing the future of small-scale fishery systems in coastal Vietnam and the implications for policy. *Environmental Science & Policy, 27*, 184–194.

Armitage, D., Marschke, M., & Tuyen, T. V. (2011). Early stage transformation of coastal marine governance in Vietnam? *Marine Policy, 35*(5), 703–711.

Barnett, J., & O'Neill, S. (2010). Maladaptation. *Global Environmental Change, 20*(2), 211–213.

Beckman, M. (2011). Converging and conflicting interests in adaptation to environmental change in central Vietnam. *Climate and Development, 3*(1), 32–41.

Belton, B., & Little, D. (2011). Immanent and interventionist inland Asian aquaculture development and its outcomes. *Development Policy Review, 29*(4), 459–484.

Biesbroek, G. R., Klostermann, J. E., Termeer, C. J., & Kabat, P. (2013). On the nature of barriers to climate change adaptation. *Regional Environmental Change, 13*(5), 1119–1129.

Boonstra, W. J., & de Boer, F. W. (2014). The historical dynamics of social–ecological traps. *Ambio, 43*(3), 260–274.

Boonstra, W. J., & Nhung, P. T. H. (2012). The ghosts of fisheries management. *Journal of Natural Resources Policy Research, 4*(1), 1–25.

Boonstra, W. J., & Österblom, H. (2014). A chain of fools: Or, why it is so hard to stop overfishing. *Maritime Studies, 13*(1), 1–20.

Bostock, J., McAndrew, B., Richards, R., et al. (2010). Aquaculture: Global status and trends. *Philosophical Transactions of the Royal Society B, 365*(1554), 2897–2912.

Bush, S., Khiem, N., & Sinh, X. (2009). Governing pangasius for sustainable rural livelihoods and environmental performance: A review. *Aquaculture Economics and Management, 13*(4), 271–293.

Cao Thi Hong Nhung. (2008). A survey on losses caused by flood in 2007 and the solutions of the people around Tam Giang lagoon. Unpublished MSc. thesis. Hue City: Hue university of agriculture and forestry.

Carpenter, S.R., Brock, W.A. (2008). Adaptive capacity and traps. Ecology and Society, 13, 40. http://www.ecologyandsociety.org/vol13/iss2/art40/. (Accessed August 24, 2014.

Daw, T., Adger, W.N., Brown, K., Badjeck, M.C. (2009). Climate change and capture fisheries: potential impacts, adaptation and mitigation. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. Fisheries and Aquaculture Technical Paper 530. Rome: FAO.

Dow, K., Berkhout, F., Preston, B. L., Klein, R. J. T., Midgley, G., & Shaw, M. R. (2013). Limits to adaptation. *Nature Climate Change, 3*(4), 305–307.

Foster, J. B., & Holleman, H. (2012). Weber and the environment: Classical foundations for a postexemptionalist sociology. *American Journal of Sociology, 117*(6), 1625–1673.

Geertz, C. (1963). *Agricultural involution: The process of ecological change in Indonesia*. Berkeley: University of California Press.

Gould, S. J. (1997). The exaptive excellence of spandrels as a term and prototype. *Proceedings of the National Academy of Sciences, 94*(20), 10750–10755.

Gould, S. J., & Lewontin, R. C. (1979). The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 205*(1161), 581–598.

Gould, S. J., & Vrba, E. S. (1982). Exaptation—A missing term in the science of form. *Paleobiology, 8*, 4–15.

Gray, R. T. (2005). *A Franz Kafka encyclopedia*. Westport: Greenwood Publishing Group.

Ha, Tran Thi Phung, & van Dijk, H. (2013). Fishery livelihoods and (non)compliance with fishery regulations—A case study in Ca Mau Province, Mekong Delta, Vietnam. *Marine Policy, 38*, 417–427.

Hodgson, G. M., & Knudsen, T. (2010). *Darwin's conjecture: The search for general principles of social and economic evolution*. Chicago: University of Chicago Press.

Jump, A. S., & Penuelas, J. (2005). Running to stand still: Adaptation and the response of plants to rapid climate change. *Ecology Letters, 8*(9), 1010–1020.

Kafka, F. (1946 [1931]). The great wall of China. New York: Schocken Books.

Kates, R. W. (2000). Cautionary tales: Adaptation and the global poor. *Climatic Change, 45*(1), 5–17.

Lebel, L., Manuta, J. B., & Garden, P. (2011). Institutional traps and vulnerability to changes in climate and flood regimes in Thailand. *Regional Environmental Change, 11*(1), 45–58.

Mace, R., & Jordan, F. M. (2011). Macro-evolutionary studies of cultural diversity: A review of empirical studies of cultural transmission and cultural adaptation. *Philosophical Transactions of the Royal Society B: Biological Sciences, 366*(1563), 402–411.

MARD. (2008). *Impacts of climate change on agriculture and rural development*. Ho Chi Minh City: Vietnamese Ministry of Agricultural and Rural Development (MARD).

Mullainathan, S., & Shafir, E. (2013). *Scarcity: Why having too little means so much*. New York: Times Books.

Nguyen Ngoc Truyen. (2004). Agricultural meteorology syllabus. Department of Extension and Rural Development, Hue City: Hue University of Agriculture and Forestry.

Nicholls, R. J., Wong, P. P., Burkett, V. R., et al. (2007). Coastal systems and low-lying areas. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability* (pp. 315–356). Cambridge: Cambridge University Press.

Odling-Smee, F. J., Laland, K. N., & Feldman, M. W. (2003). *Niche construction: The neglected process in evolution*. Princeton: Princeton University Press.

Orlove, B. (2009). The past, the present and some possible futures of adaptation. In W. N. Adger, I. Lorenzoni, & K. O'Brien (Eds.), *Adapting to climate change: Thresholds, values, governance* (pp. 131–163). Cambridge: Cambridge University Press.

Platt, J. (1973). Social traps. *American Psychologist, 28*(8), 641–651.

Rothstein, B. (2005). *Social traps and the problem of trust*. Cambridge: Cambridge University Press.

Scheffer, M., & Carpenter, S. R. (2003). Catastrophic regime shifts in ecosystems: linking theory to observation. *Trends in Ecology & Evolution, 18*(12), 648–656.

Scheffer, M., Westley, F.R. (2007). The evolutionary basis of rigidity: locks in cells, minds, and society. Ecology & Society 12(2), 6 http://www.ecologyandsociety.org/vol12/iss2/art36/. Accessed August 24, 2014.

Schlaepfer, M. A., Runge, M. C., & Sherman, P. W. (2002). Ecological and evolutionary traps. *Trends in Ecology & Evolution, 17*(10), 474–480.

Sekercioglu, C. H., Loarie, S. R., Oviedo, B. F., Ehrlich, P. R., & Daily, G. (2007). Persistence of forest birds in the Costa Rican agricultural countryside. *Conservation Biology, 21*(2), 482–494.

Sovacool, B. K. (2013). Adaptation: The complexity of climate justice. *Nature Climate Change, 3*, 959–960.

Thomsen, D.C., Smith, T.F., Keys, N. (2012). Adaptation or manipulation? Unpacking climate change response strategies. Ecology and Society, doi:10.5751/ES-04953-170320.

Ton That Phap, Le Van Mien, Le Thi Nam Thuan. (2002). Sustainable development of aquaculture in Tam Giang lagoon. http://idlbnc.idrc.ca/dspace/bitstream/10625/32101/1/121938.pdf. Accessed March 5, 2014.

Tuyen, T., Armitage, D., & Marschke, M. (2010). Livelihoods and co-management in the Tam Giang Lagoon Vietnam. *Ocean and Coastal Management, 53*(7), 327–335.

Weber, M. (1978 [1922]). Economy and society: An outline of interpretive sociology. Berkeley: University of California Press.