Social capital and private adaptation to climate change: Evidence from the Mekong River Delta in Vietnam

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Abstract

Farmers in developing countries often face capital constraints in adapting to climate change. Can farmers' own social capital be utilized to facilitate the adaptation? This study uses four components of social capital – formal institutions, informal institutions, trust, and cooperativeness – to examine whether social capital is systematically linked to adaptation to climate change. The results suggest, in general, that social capital at the individual level does not affect farmers' private adaptation to climate change. Yet, some forms of social capital are significantly associated with the choice of some particular adaptation measures.

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Key words: *adaptation to climate change, social capital, Vietnam*

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1. Introduction

Climate change is occurring in the low-lying Mekong River Delta of Vietnam (Wassmann *et al.*, 2004; Dasgupta *et al.*, 2007) and households in the area have developed their own adaptation strategies (Chinvanno *et al.*, 2008). Adaptation is an important way in which farmers respond to climate change (Adger *et al.*, 2003; Bradshawn *et al.*, 2004; Barbier *et al.*, 2008). The way in which affected farmers will adapt determines the scale of climate change impacts and hence their farming production and livelihoods. Knowledge of adaptation measures and factors affecting farmer households' portfolio of adaptation is important for policy makers' ability to facilitate relevant conditions for households' adaptation. Previous research on determinants of households' adaptation behavior has mainly focused on perceptions of impacts of climate change (Blennow and Persson, 2009), incentives and the ability to adapt (Hoffmann *et al.*, 2009), and environmental factors (Seo and Mendelsohn, 2008). The role of social capital in adaptation behavior has still not been investigated comprehensively (Pelling and High, 2005).

Chinvanno *et al.* (2008) report that in order to cope with the impacts of climate hazards, rice farmers in the Mekong River Delta in Vietnam have mainly used their own household resources and have concentrated their adaptation actions within their farm boundaries. Faced with limited financial capability, instead of investing in costly defensive efforts such as small scale irrigation, farming households have used alternative adaptation strategies such as adjusting the crop calendar or using alternative crops and seed varieties. Studies on to what extent social capital determines households' choice of these adaptation measures may have distinct policy relevance since available resources such as social capital can be used up given chronic problems of human and financial resource constraints.

We define social capital as social networks and social skills owned by the individual and used to facilitate particular actions.[1] We construct a set of social capital indexes that cover formal and informal social networks, trust, and cooperativeness. The first three social capital indexes are based on survey responses. The measure of

[1] This definition of social capital is in line with studies that view social capital as a person's social characteristics (Glaeser *et al.*, 2002; Carpenter *et al.*, 2004; Karlan, 2005). However, social capital can also be defined as the common property of a group that facilitates collective action for the mutual benefit of group members (Putnam, 2000; Krishna, 2004).

cooperativeness is based on actual behavior of farmers in a public good experiment. We then examine how these social capital indexes are associated with farmers' choice of private adaptation to climate change.[2]

Social capital is multi-dimensional in nature. We attempt to understand how different dimensions of social capital affect the choice of adaptation measures. A number of qualitative studies have suggested that social capital is critical to adoption decisions in mitigating exposure to climate shocks (e.g., Adger, 2003; Pelling and High, 2005; Wolf *et al.*, 2010). Most previous quantitative studies on the relationship between social capital and adaptation have used groups and networks as indicators for social capital (e.g., Deressa *et al.*, 2009; Di Falco and Bulte, 2009b). Impacts of other dimensions of social capital such as trust and cooperation on climate change self-protection measures remain largely neglected. The present study contributes to the adaptation literature by providing empirical evidence on whether social capital in the form of trust and cooperation affects farmers' adaptation decisions. Almost previous studies have used social capital in the form of a single dimension or an aggregate index and were therefore not able to show how different components of social capital can have different effects on adaptation behavior. We explore how four components of social capital can explain farmers' adaptation behavior.

Our study suggests that in general, social capital at the individual level does not affect farmers' behavior with respect to private adaptation. Some forms of social capital such as formal and informal institutions, however, are weakly associated with the choice of different climate change adaptation measures in farming activities. We find that experimentally-measured social capital in the form of cooperativeness is negatively associated with the choice of private adaptation to domestic water shortage, although the magnitude of the correlation is small.

[2] It can be argued that social networks per se can be a measure of adaptation to climate risk. Households may invest in social relationships, which in turn can act as an informal safety net mitigating the consequences of climate change, for example by risk sharing principles. However, we model social capital as an input in the adaptation process. The treatment of social capital as an adaptation measure is complicated (for example due to endogeneity problems) and is an interesting topic for future research.

2. How can social capital affect private adaptation to climate change?

By adaptation we mean any private investment to reduce potential net damage due to climate change.[3] Farmers use self-insurance efforts to reduce the adverse effects of climate change if it occurs. An individual's adaptation behavior is triggered by his or her recognition of the need to adapt (Fankhauser *et al.*, 1999), perceived climate risk, costs of adaptation, and potential reduction in damage (Kane and Shogren, 2000). Farmers' assets of social networks and social skills can possibly affect these determinants of their adaptation behavior.

Social networks can facilitate the exchange of information about possible climate change effects, facilitate the diffusion of adaptation innovations, and therefore help reduce adaptation costs. Deressa *et al.* (2009) showed that informal institutions such as peer networks may help increase people's awareness of climate change and its effects and promote sharing of experiences of adaptation options. The authors found that having access to farmer-to-farmer extension, the service in which trained farmers act as the extension agents to the neighboring farmers, can increase the likelihood of using specific adaptation measures such as "different crop varieties" and "planting trees." Social networks can also provide a channel to informal financial sources that relax farmers' credit constraints on investments in adaptation. Individuals' strong social ties can help speed up disaster responses and reduce exposure to external risks (Carter and Maluccio, 2003).

Does trust, a farmer's social skill, affect the choice of private adaptation measures? In the present study, trust is defined, broadly, as a belief that other people are generally trustworthy and as a social orientation toward other people (Glaeser *et al.*, 2000). Trust in information from local organizations can facilitate the recognition and understanding of climate changes. A trustworthy person, or a reciprocal person, is more likely to receive information or help from his or her peer network, therefore trustworthiness[4] can facilitate the knowledge acquisition and guarantee a safety net that people can rely on to e.g. borrow money or assets in times of climatic variation or weather shocks. There have

[3] This definition is from Kane and Shogren (2000) and Mendelsohn (2000). Adaptation can also refer to actions that take advantage of new opportunities that climate change creates. In the context of this study, however, we ignore this part of the definition.

[4] Trustworthiness is assumed to imply reciprocity (Fehr and Gächter, 2000; Ostrom and Walker, 2003).

been, however, no empirical studies on links between trust and the choice of private adaptation measures.

Although social capital can facilitate collective action to overcome social dilemmas in joint adaptation projects, only a few studies have discussed this role (e.g., Adger 2000, 2003). Adger (2000) demonstrated that community social capital in the form of voluntary labor contribution has evolved to facilitate collective adaptation practices such as sea dike maintenance in the absence of governmental supports in Vietnam. It is, however, not clear how a farmer's cooperativeness affects his or her choice of private adaptation measures.

Social capital may have negative effects on adaptation in two different ways: strong social ties may create investment disincentives and strong networks may hinder adaptation through distribution of false information. Di Falco and Bulte (2009) provided evidence of negative effects of kinship linkages on investment in adaptation. The authors found that the number of kinship links is negatively and significantly associated with the probability to invest in soil conservation. The kin network functions as an informal safety net and thus reduces the need to adapt. The network also contains a sharing norm and therefore reduces the incentives for adaptation. Also Agrawal *et al.* (2008) suggested that strong institutional norms such as the labor sharing norm in farming activities may attenuate the incentive to adopt individual adaptation measures such as crop diversification or migration. Strong social networks may act as a conduit for misperception of the climate change effects – false information is easily spread in a strong network. Wolf *et al.* (2010), for example, suggested that strong bonding networks could potentially raise the vulnerability of elderly people in the UK to the effects of heat waves.

3. The village and its climate change problems

The survey and experiment were undertaken in Giong Trom village in the Mekong River Delta in Vietnam in 2009. Table 1 summarizes the socio-economic characteristics of the sampled households. Most households in the village are engaged in rice farming. A typical farmer's household has around four members, where on average less than three members are in their working age. The average household head 49 years old and has only elementary education. The average size of the land a family is currently cultivating is also small, approximately half of a hectare. The average monthly household monetary income of about 95 USD per month is less than one USD per household member per day. About 30% of the surveyed farmers claimed to be moderately informed about climate change and its impacts. More than 60% of the surveyed farmers believed that climate change will have substantial effects on their farming practices and way of life.

Table 1: Households' **characteristics description**

Variable	Definition	Mean (std.dev.)
Income	Household monetary income in million dong per month	1.81 (1.27)
Income ratio	Dependence on farming income, i.e., ratio of monetary income from farming over total monetary income	0.35
Labor	Numbers of household members who can provide labor	2.72 (1.45)
Land size	Size of farming lands in "cong" (1 cong = 1/10 hectare)	4.68 (3.12)
Age	Age of household head in year	48.90 (13.84)
Education	Highest level of education attained: 1 = No schooling (5%); 2 = Grade 1-5 (54%); 3 = Grade 6 – 9 (31.5%); 4 = Grade 10 – 12 (9%); 5 = Vocational school and above (0.5%)	2.46 (0.76)
Head	Dummy = 1 if household head is male	0.62
Children	Number of children living in household	0.57 (0.75)
Awareness	Level of information about climate change and its impacts: 1=very poorly informed (21%); 2=poorly informed (24%); 3=moderately informed (30.5%); 4=well informed (21%); 5=very well informed (3.5%)	2.62 (1.14)
Belief farming	Dummy=1 if believe that climate change will cause a decrease in rice productivity within the next 20 years	0.68
Belief water	Dummy=1 if believe that climate is changing to such an extent that it will substantially affect the family's ways of life	0.64

The low-lying land of the village is subject to tidal flooding and saltwater intrusion from the coastline and the Mekong River. The village is also vulnerable to tropical storms and cyclones. Rural households within the study site have been severely affected by climate change (Oxfam, 2008) partly because of their dependency on climate-based resources such as domestic water, irrigation water, and soil for cultivation. The impacts of climate change on rice farming in the studied area could be severe in the dry season by the prolonged midseason dry spell (Chinvanno *et al.* 2008) or saline water intrusion because of sea level rise and low flow in the Mekong River, which can result a reduction of about 25% of rice yield (Nguyen *et al.* 2008).[5]

4. Measurement of social capital and adaptation choices and econometric approach

Adaptation variables

The study focuses on private adaptation measures adopted in farming practices and domestic water usage. We separately examine impacts of social capital on each practice. The division is necessary because of crucial differences between these activities: the motivations for adaptation in productive activities may differ from those related to domestic water usage efforts. One practical challenge was to disentangle the responses to the climate stimulus from those linked to other stimuli such as the market, family condition, and public policy. We tackled this by asking farmers to report only measures their family had implemented in response to climate change in the past 5 years. The three questions asked were: "What have you done to adapt to unpredictability of weather and unusual timing of the seasons?", "What have you done to adapt to longer periods of drought?", and "What have you done to adapt to saline intrusion?"[6] Enumerators had a list of possible adaptation options, but to avoid framing bias, they did not present it to the respondents. Instead, the respondents verbally described their adaptation measures and the enumerators checked the corresponding options in the list.

Table 2 presents the statistics of the main adaptation measures.[7] A household can take several measures in response to climate change. We are able to identify three main adaptive responses in farming practices.[8] The most common response is "Different

[5] While Yu *et al.* (2010) projected a decline in rice yield by 4.3- 8.3 percent by 2050 for the whole Mekong River Delta, mainly because of a higher sea level rises and changes in temperature and precipitation.

[6] To identify adaptation measures adopted in farming practices, enumerators asked these three questions. However, adaptation measures adopted in domestic water usage, they did not ask the question "What have you done to adapt to unpredictability of weather and unusual timing of the seasons?" since unpredictability of weather and unusual timing of the seasons do not affect domestic water usage.

[7] All these measures are individual, meaning that all implementations, costs, and benefits are made, borne, and gained by individual households.

[8] The observed adaptation pattern is consistent with Chinvanno *et al.* (2008), who surveyed adaptation measures adopted by farmers in the Mekong River Delta in Vietnam in 2005. The seven-month long rainy

planting dates," which consists of activities such as varying planting or harvesting dates by adjusting planting techniques and use of water and fertilizers to ensure that critical growth stages do not coincide with uncomfortable climate conditions. The "Different varieties or crops" measure is a set of activities such as growing a number of different crops to reduce the risk of crop failure or using several varieties that are drought-tolerant or resistant to saline water. "Changing management practices" includes activities such as changing the use of capital, labor, chemicals, and fertilizers, or increasing the use of water conservation techniques. For domestic water issues, the climate change problems of the studied area relate mainly to the shortage of water in the dry season because of a prolonged drought period and intrusion of saline water. Villagers respond to the pressure by investing more in water storage equipment or changing water use practices.

Table 2: Main adaptation measures

Variables	Description	Mean
Farming practices		
Different planting dates	Dummy = 1 if adopted "Different planting dates" measure; 0 otherwise	0.60
Different varieties or crops	Dummy = 1 if adopted "Different varieties or crops" measure; 0 otherwise	0.43
Changing management practices	Dummy = 1 if adopted "Changing management practices" measure; 0 otherwise	0.40
Domestic water usage		
More water storage	Dummy = 1 if adopted "More water storage" measure; 0 otherwise	0.74
Changing water use practices	Dummy = 1 if adopted "Changing water use practices" measure; 0 otherwise	0.51

Social capital indicators

We define social capital as the social networks and social skills possessed by individuals and used to facilitate particular actions. In particular, social networks or associational social capital are defined as a person's social relationship that enables him or her to benefit from interactions with others. Social skills, or behavioral social capital (Carpenter *et al.*, 2004; Grootaert *et al.*, 2004), are propensities of individuals to trust and cooperate with other individuals for mutual benefits. We use four indexes to reflect the

season in the studied area allows for flexibility in adjusting the crop calendar. The two-crop cycle allows farmers to be flexible when selecting rice varieties.

multidimensional concept of social capital: a formal institution index and an informal institution index as associational social capitals, and a trust index and a cooperativeness index as behavioral social capital. We conducted a survey to measure social capital in the form of social networks and trust, and an economic experiment to measure social capital in the form of cooperativeness. We also used the survey to collect data on adaptation measures, farmers' awareness of and beliefs about climate change, and socio-economic characteristics of the farming households.

Formal institution index

The formal institution index captures the extent of a household member's participation in various types of non-governmental local organizations.[9] A person's participation in formal institutions may help him or her access formal information on climate change or new adaptation technologies. The diversity of membership, i.e., the number of formal associations participated in by family members, is used as a proxy indicator for formal institution in the estimation of adaptation in domestic water usage, whereas membership in the Farmers' Association is used as a proxy indicator for formal institution in the estimation of adaptation in farming practices.

Informal institution index

We use the size and usefulness of the network to proxy informal institution (Grootaert *et al.*, 2004). We asked a question addressing the size of the network, "About how many close friends do you have these days? These are people you feel at ease with, can talk to about private matters, or call on for help," and a question to assess the usefulness of the network, "If you suddenly needed a small amount of money enough to pay for expenses for your household for one week, how many people beyond your immediate household could you turn to who would be *willing* to provide this money?" The answers to the question on the usefulness of the network strongly correlate with number of close friends in the question on the size of the network, so we decided to choose the number of close friends as an indicator of informal institution in the econometric analysis.

[9] Formal institutions in the surveyed area include the Farmers' Association, the Women Association, the Red Cross, the Veterans' Association, the Elderly' Association, the Youth Union, and microcredit and religious groups.

Trust

We measure trust based on respondents' level of agreement on a 5-point scale with each of the following statements: "Most people who live in this village can be trusted," "Most people in this village are willing to help if you need it," and "In this village, people generally do not trust each other in matters of lending and borrowing money." The first statement focuses on generalized trust and the other two on the extent of trust in the context of specific transactions. Later in the econometric analysis, since these three indexes of trust are strongly correlated and yield similar results, we only report generalized trust, i.e., responses to the statement "Most people who live in this village can be trusted." Trust in this study, therefore, implies a generalized trust in people living relatively nearby.

Cooperativeness

Cooperativeness in this study can be understood as the degree to which a participant in an experiment contributes voluntarily to the provision of public goods. To measure social capital in the form of cooperativeness, we use results of the natural field experiment in Carlsson *et al.* (2010). The experiment concerned funding a bridge for the village, devised as a threshold public good experiment in which villagers received an endowment from us and could opt to either keep the money or contribute some or everything to the bridge. There are about 200 households on both sides of the bridge that would probably benefit from the concrete bridge construction. They were all included in the experiment.

The public good experiment presents a social dilemma for the participating households since they have monetary incentives to free ride on the contributions of others. In standard public good experiments, contribution levels are normally considered as measurement of the cooperative behavior of participants. In the experiment, we need to control for heterogeneous demands for the public goods and for different contextual factors. We therefore construct the cooperativeness variable by running a regression on actual contributions against experimental context factors and household traits; see equation (1). Residuals of the regression, which equal actual contributions minus predicted contributions, will contain all components of the cooperation behavior. We use the residual values [10] as a measure for cooperation behavior or cooperativeness ($\hat{\varepsilon}$ in equation (2)).

$$x_i = \alpha + \beta G_i + \varepsilon_i \qquad (1)$$

$$\widehat{\varepsilon_i} = x_i - \widehat{x_i} \qquad (2)$$

where x_i is the contribution of household i in the experiment and G_i is a set of parameters controlling for the contexts of the experiment such as treatments, experimenters, and days of the experiment and for the socio-economic characteristics of household i. Included in G are variables representing household i's demand for the public good in the experiment. The full list of variables in (1) and their parameters can be seen in Appendix 1. The descriptive statistics of social capital indicators and their correlations can be seen in Tables 3 and 4.

Table 3: Descriptive statistics of social capital indicators

Variables	Description	Mean	Std. dev.	Min	Max
Formal institution					
Number of institution	Number of formal associations participated in by family members	0.91	1.09	0	6
Farmers' Association	Dummy = 1 if a member of the household is a member of the Farmers' Association	0.12	0.32	0	1
Informal institution	Number of close friends	3.91	5.05	0	40
Trust	Trust in people who live in the same village	3.18	1.21	1	5
Cooperativeness (scaled)	Scaled cooperativeness	5.50	2.28	0	10
Cooperativeness (raw)	Contribution residuals before scaled	-8.4e-07	111.56	-269.82	220.36

Table 4: Correlation coefficients of social capital indicators

	Number of institution	Famers' Association	Informal institution	Trust	Cooperativeness (scaled)	Cooperativeness (raw)
Number of institution	1.00					
Farmers' Association	0.36	1.00				
Informal institution	0.19	0.08	1.00			

[10] To be consistent with other social capital indicators in the analysis, we rescaled the residual values into a range from 0 to 10.

Trust	0.07	0.07	0.07	1.00			
Cooperativeness (scaled)	-0.12	0.03	0.01	-0.12	1.00		
Cooperativeness (raw)	-0.12	0.03	0.01	-0.12	1.00		1.00

Sampling and econometric approach

Our data is a combination of experimental data and survey data. Subjects who participated in the economic experiment were also respondents in the survey. The experiment and the survey were conducted with all 200 households in the village.

As discussed in Section 2, an individual's adaptation behavior is determined by his or her knowledge of impacts of climate change and adaptation technology, perceived climate risk, costs of adaptation, and potential damage reduction. We can express the relationship in the simple model: $x^j = f(K^j, z^j, e)$, where x^j is the adaptation level of farmer *j*, K^j is his or her knowledge function, z^j represents the farmer's ability to adapt, which implies a cost of adaptation, and e is an environmental factor. In turn, knowledge is a function of social capital and other socio-economic characteristics $K^j = g(sc^j, s^j)$,[11] and ability to adapt is also a function of social capital and household characteristics $z^j = h(sc^j, s^j)$. Combing the equations yields a reduced form $x_j^* = f\left(sc^j, s^j, e\right)$.[12] We assume that the functional form of x is linear in the explanatory variables and that the error term ε^j is identically and independently distributed as the normal distribution over the population, i.e.,

$$x^j = \alpha + \sum_{i=1}^{4} \beta_i sc_i^j + \sum_{i=1}^{8} \gamma_i s_i^j + \varepsilon^j \quad . \qquad (3)$$

We estimate two models: one for adaptation in farming practices where the dependent variables are "Different planting dates," "Different varieties or crops," and "Changing management practices" and one for adaptation in domestic water usage where the dependent variables are "More water storage" and "Changing water use practices." In each model, we estimate two sub-models: a model with social capital variables as shown in equation (3) and a model with awareness and belief variables replacing social capital

[11] See Isham (2002) for a detailed model on how social capital enters in knowledge functions.

[12] Climate-related variables such as temperature and salinity can be inevitable arguments in the adaptation function. We, however, will not include these variables in the regressions since the sampled households in this study are in the same village and have relatively similar climate conditions.

variables. The purpose of the second sub-model is to confirm the robustness of results in the first sub-model through the direct effects of knowledge on adaptation behavior.

We estimate the models using a multivariate probit model, which allows unobserved disturbances in adaptation measures to be freely correlated by simultaneously modeling different adaptation choices as a function of a common set of explanatory variables.[13]

5. Results

Table 5 provides estimated results of multivariate probit models for farming practices, and Table 6 is for domestic water issues.[14, 15] To quantify the marginal effects of each social capital indicator and other explanatory variables on each of the unconditional probabilities of adaptation, we use the formula $\partial E(y_i|\boldsymbol{x})/\partial x_j = \varphi(\boldsymbol{x}'\widehat{\beta_\iota}) \times \widehat{\beta_{\iota J}}$ (Greene 2003, p. 668), where φ is the univariate standard normal density function and $\widehat{\beta_{\iota J}}$ is the coefficient estimate of variable x_j on each adaptation measure y_i. Standard errors of marginal effects are calculated using the delta method. To gain insight on cross-adaptation relationships, we also calculated marginal effects of the explanatory variables on joint and conditional probabilities of adaptation. The estimated marginal effects are not consistently different from those for the unconditional probability. For the sake of simplicity, we do not report the marginal effects of the cross-adaptation.[16]

[13] A binary choice model such as a probit or a logit model may be used. Each adaptation measure is modeled individually as discrete choice dependent variables and acts as a function of a set of explanatory variables. The approach is based on the assumption that discrete choices are competing, i.e., a farmer cannot choose two adaptation measures at the same time. Table 2, however, shows that a farmer household can choose more than one measure, so a binary choice model may not be appropriate.

[14] We also estimated univariate probit models for each of the adaptation measures. We then use the log-likelihood values of the multivariate and univariate probit models to do likelihood ratio tests and cannot reject the hypothesis of error correlations ($\chi^2(3)$=42.71, p-value<0.001, and $\chi^2(3)$=12.54, p-value<0.005, for the multivariate models for farming practices and domestic water in Tables 5 and 6).

[15] For each model, we first estimate a model with all forms of social capital and then another model without social capital in the forms of institutions and trust that could be correlated with the cooperativeness. The results are similar in two regressions so we only report results of the full model, which contains all social capital indicators. Correlation coefficients of social capital indicators can be seen in Table 4.

[16] The estimated marginal effects can be provided upon request.

The bottom part of Table 5 shows that all correlation coefficients between each of the three adaptation measures in farming practices are statistically significant, positive, and substantial in both model 1 and model 2, suggesting that the null hypothesis of independence across error terms of the three latent equations can be rejected. Specifically, in model 1, the error terms for "different planting dates" and "different varieties and crops" have the correlation coefficient of 0.52; for "different planting dates" and "changing management practices" it is 0.41 and for "different varieties and crops" and "changing management practices" it is 0.33. The significant correlation coefficients also mean that unobservable factors that increase the probability of adapting "different planting dates" also increase the probability of adapting "different varieties or crops" or "changing management practice."

The multivariate probit estimation results show that social capital in various forms does not explain adaptation to climate change. The formal institution index, i.e., participation in the Farmers' Association, is not associated with choosing "different planting dates" and "changing management practices." The informal institution index does not explain the choice of "different planting dates" and "different varieties and crops." Trust does not affect the choice of adaptation measures either. Social capital in the form of cooperativeness does not influence the likelihood of farmers choosing a specific adaptation measure in their farming activities. However, we still observe that the "different varieties or crops" measure is more likely among farmer households who belong to the Farmers' Association; i.e., they possess more social capital in the form of formal institution. The average marginal effect suggests that if family members join the Farmers' Association, the probability of adopting "different varieties or crops" increases by approximately 24%. Households that possess more informal social capital are more likely to adopt the "changing management practices" measure. For each additional friend that family members have, the probability of adopting "changing management practices" increases by approximately 2%.

Table 5: Multivariate probit estimate of adaptation in farming practices

Dependent variable	Model 1			Model 2		
	Different planting dates	Different varieties or crops	Changing management practices	Different planting dates	Different varieties or crops	Changing management practices
	Marg. effect (std. err.)	Marg. effect (std. err.)	Marg. effect (std. err.)	Marg. effect (std. err.)	Marg. effect (std. err.)	Marg. effect (std. err.)
Social capital						
Farmers' Association	0.164 (0.131)	0.243** (0.121)	0.018 (0.124)	-	-	-
Informal institution	-0.011 (0.008)	-0.009 (0.008)	0.020** (0.009)	-	-	-
Trust	0.027 (0.033)	-0.027 (0.033)	0.026 (0.033)	-	-	-
Cooperativeness	-0.030* (0.017)	-0.017 (0.017)	-0.025 (0.017)	-	-	-
Awareness and beliefs						
Awareness	-	-	-	-0.010 (0.036)	0.028 (0.036)	0.010 (0.035)
Belief farming	-	-	-	0.013 (0.085)	0.207** (0.086)	-0.044 (0.082)
Socio-economic characteristics						
Income ratio	0.390** (0.152)	0.198 (0.152)	0.288* (0.147)	0.287* (0.147)	0.176 (0.151)	0.261* (0.145)
Income	0.057 (0.035)	0.017 (0.033)	0.027 (0.033)	0.043 (0.033)	-0.002 (0.033)	0.029 (0.032)
Land size	-0.009 (0.015)	-0.023 (0.016)	-0.007 (0.015)	-0.001 (0.015)	-0.021 (0.016)	-0.005 (0.015)
Labor	0.070** (0.030)	0.096*** (0.029)	0.015 (0.029)	0.076*** (0.029)	0.110*** (0.030)	0.017 (0.028)
Age	0.004 (0.003)	0.005 (0.003)	0.004 (0.003)	0.004 (0.003)	0.006* (0.003)	0.003 (0.003)
Education	0.099* (0.059)	0.097* (0.057)	-0.005 (0.056)	0.094 (0.057)	0.072 (0.055)	0.033 (0.055)
Head	0.001 (0.083)	-0.102 (0.083)	-0.045 (0.083)	-0.012 (0.084)	-0.135 (0.086)	-0.052 (0.083)
ρ_{12} = 0.524***				ρ_{12} = 0.545***		
ρ_{13} = 0.407***				ρ_{13} = 0.392***		
ρ_{23} = 0.332***				ρ_{23} = 0.317***		
Likelihood ratio test of dependence:			33.026			34.211
p-value:			0.000			0.000
Number of obs. = 182						
Number of draw = 200						

The choice of adaptation measures in farming activities is statistically significantly associated with several socio-economic characteristics of farmers' households. Adoption of "different planting dates" and "changing management practices" such as change in use of fertilizer or pesticide is more likely among farmers who depend on income from farming activities to a large degree. The number of available laborers in the household positively and significantly affects the likelihood of choosing "different planting dates" and "different varieties or crops." For each additional laborer in a household, the probability of adopting "different planting dates" and "different varieties and crops" increases by approximately 7% and 10%, respectively. Education level of the household head has a positive and significant impact at the 90 percent confidence level on the likelihood of choosing "different planting dates" and of choosing "different varieties and crops."

The pattern of the results of model 2, where the social capital variables are replaced with awareness and belief variables, is similar to the results of model 1. In general, knowledge variables do not influence the choice of adaptation measures. Only the belief variable is significantly associated with the "different varieties or crops" measure. More specifically, if farmers believe that climate change will cause a decrease in rice productivity within the following 20 years, their households are more likely to adapt the "different varieties or crops" measure. The magnitude of the effect is close to the effects of membership in the Farmers' Association on the choice of "different varieties or crops" in model 1.

Table 6 reports multivariate probit estimation results for adaptation related to domestic water shortage. The estimated correlation coefficients, i.e., unobserved factors influencing the decision to adopt "more water storage" and "changing water use practices," are significantly correlated at the 5% level in both model 1 and model 2. The correlation between these unobserved factors is positive and statistically significant, implying that the unobserved factors that increase the probability of adopting "changing water use practices" will also increase the probability of adapting "more water storage" or vice versa. The correlation also suggests that multivariate probit is a better model for the domestic water issue data. Most of the social capital measures cannot explain the choice of adaptation measures related to domestic water shortage problems. However, cooperativeness is negatively associated with "more water storage" at the 5% level. Choosing this adaptation measure is less likely among farmer households with a higher propensity to cooperate. The estimated marginal effects suggest that on a 10-unit scale, for every 1 unit increase in cooperativeness the probability of adopting the "more water storage" measure decreases by approximately 3.5%. Most of the socio-economic variables have insignificant impacts on the likelihood of adopting a measure, yet number of children is negatively associated with "changing water use practices." In model 2, neither knowledge variable is associated with choice of adaptation measures, confirming the results for model 1 – The forms of social capitals that are expected to facilitate knowledge accumulation do not influence private adaptation.

Table 6: Multivariate probit estimate of adaptation in domestic water usages

	Model 1		Model 2	
Dependent variable	More water storage	Changing water use practices	More water storage	Changing water use practices
	Marg. effect (std. err.)	Marg. effect (std. err.)	Marg. effect (std. err.)	Marg. effect (std. err.)
Social capital				
Number of institutions	0.025 (0.035)	-0.011 (0.039)	-	-
Informal institution	0.003 (0.007)	0.008 (0.008)	-	-
Trust	0.001 (0.025)	0.019 (0.031)	-	-
Cooperativeness	-0.035** (0.014)	-0.016 (0.017)	-	-
Awareness and beliefs				
Awareness	-	-	0.015 (0.029)	0.046 (0.034)
Belief water	-	-	-0.006 (0.068)	-0.054 (0.081)
Socio-economic characteristics				
Income ratio	-0.028 (0.112)	-0.214 (0.136)	-0.060 (0.112)	-0.203 (0.137)
Income	0.033 (0.031)	-0.010 (0.034)	0.033 (0.031)	-0.016 (0.033)
Land size	0.001 (0.012)	-0.001 (0.014)	0.004 (0.012)	-0.001 (0.014)
Labor	0.029 (0.024)	0.017 (0.027)	0.033 (0.024)	0.018 (0.027)
Age	0.001 (0.003)	-0.000 (0.003)	0.001 (0.003)	-0.001 (0.003)
Education	0.059 (0.050)	0.015 (0.055)	0.060 (0.049)	0.029 (0.054)
Head	-0.017 (0.067)	-0.025 (0.080)	-0.019 (0.067)	-0.034 (0.080)
Children	-0.043 (0.045)	-0.154*** (0.055)	-0.035 (0.045)	-0.153*** (0.054)
		ρ_{12}= 0.303**	ρ_{12} = 0.304**	
Likelihood ratio test of dependence:		5.932	6.261	
p-value:		0.015	0.012	
Number of obs. = 200				
Number of draw = 200				

6. Discussion and conclusion

Our study suggests that social capital at the individual level generally does not affect farmers' private adaptation to climate change. We, however, do observe that some forms of social capital are associated with some particular adaptation measures in farming activities and in domestic water issues. The magnitudes of these significant social capital coefficients are small, except the effect of Farmers' Association membership on "Different varieties or crops."

Our findings raise a question: Why do a number of social capital measures not explain the choices farmers make with respect to private adaptation measures? As discussed in Section 2, the main roles of social capital in private adaptation are to facilitate information transfer and labor/financial transfer. We argue whether these roles depend on the nature of adaptation measures. If the adaptation requires only low-end technology or less effort, social capital may not be an important factor. Our research results support this argument. Saline intrusion that affects household's domestic water usage is relatively easy to detect. Implementation of adaptation measures such as "more water storage" and "change water use practices" is not a matter of high-end technology such that a household relies on a formal organization for instructions or needs a friend network to confirm the reliability of the measure. In addition, these adaptation measures require only limited labor and money. In farming practices, since the "changing varieties or crops" measure may require some special expertise, formal institutions appear to play a role. "Changing management practices," which involves changes in the use of capital and labor, may require the ability to network to share capital and labor – in our case proxied by the number of close friends. Otherwise, social capital in the form of formal and informal institutions does not play an important role in private adaptation.

We also show that trust, defined in this study as the extent to which one trusts people in general, is not associated with farmers' choice of any private adaptation measures in farming practices or in domestic water issues. We propose some reasons for the rejection of the null hypothesis that trust can facilitate both the recognition of changes in the climate and an understanding about climate risk. The choice of adaptation measures is a process that depends on the recognition of the need to adapt, the incentive to adapt, and the ability to adapt (Frankhauser *et al.*, 1999). The recognition element of the adaptation decision, where trust is hypothesized to play a role, is empirically proven to be affected by social capital in the form of social networks. Since networks and trust seem to be associated, possible effects of trust on the adaptation decision become blurred. In addition, whether trust is associated with adaptation also depends on the nature of the adaptation measures. Besides the role of trust or cooperation in the recognition element, the propensity to trust and cooperate is often needed for joint adaptations. In the present study, adaptation investments in farming practices are undertaken to secure private income. It is privately rational to respond to climate change also in the absence of social skills such as trust and cooperation. As the present study does not measure trustworthiness, the relationship between trustworthiness and the choice of private adaptation is open for future research.

Empirical research related to collective action and climate change adaptation has suggested that cooperation is necessary for joint adaptation measures to occur (Adger, 2003). So far, however, there has been little discussion about the role of cooperativeness in individual adaptation choices. We show evidence that a farmer's higher propensity to engage in cooperation, which is measured by a public good experiment, in some specific contexts can deteriorate the likelihood of choosing an individual adaptation measure; in our case it slightly reduces the probability of adopting the "more water storage" measure in response to domestic water shortage due to a salinity problem. In our specific case, we observe that joint adaptation solutions to the problems of domestic water shortage can potentially be achieved by using collective action to build a common water storage tank or to dig to find water for a public well.[17] We argue that a person with a higher cooperativeness index may have a stronger belief in joint adaptation solutions and therefore reduce investments in private measures. Our measure of cooperativeness is context free since we took out the experimental context effects such as the effects of treatments and demand for the public good when constructing the cooperativeness index. The result is in the line with a set of empirical evidence about adverse effects of social capital on economic behavior (Anderson and Francois, 2008; Baland *et al.*, 2009; Di Falco and Bulte, 2009a, b). While these studies elaborated the concept of "extended family," which is one of the key components of social capital in developing countries, our results provide evidence regarding another key form of social capital – individuals' propensity to engage in cooperation. However, these negative sides of social capital do not imply that it is useless in adaptation management processes. It clarifies to policy

[17] The village's ground water geology makes private wells almost impossible to build due to high costs.

makers which types of incentives to use in attempting to cope with future changes in climate. For example, in villages where villagers are prone to engage in collective action, i.e., they have a high propensity to engage in cooperation, incentives should target joint adaptation measures rather than private solutions.

Although private adaptation is a key measure in dealing with climate change, this paper's findings do not support the arguments for developing rural institutions in order to enhance private adaptation to climate change in rural Vietnam, especially with low-end adaptation technologies.

Appendix 1: OLS estimate of equation (1)

Variable	Coeff.	P-value
High social information (treatment dummy)	-15.45	0.58
Low social information (treatment dummy)	-66.37	0.02
Default at full contribution (treatment dummy)	-19.35	0.48
Default at zero contribution (treatment dummy)	-53.59	0.06
Household size (number of people living in the household)	5.21	0.38
Age (age of household's head)	0.12	0.87
Education (years in school of household's head)	15.89	0.25
Income (household monetary monthly income in million dong)	8.10	0.30
Land size (size of farming land in "cong", 1 cong = 1/10 hectare)	0.93	0.76
Communist party member (=1 if being a member, 0 otherwise)	32.59	0.31
Association (=1 if a member in an association, 0 otherwise)	12.78	0.52
Gender of household head (=1 if male)	-7.58	0.68
Use the bridge (=1 if everyday)	118.65	0.00
Use the bridge (=1 if maximum 3 times a week)	81.37	0.02
Use the bridge (=1 if 2 times a month)	65.12	0.02
Use the bridge (=1 if 1 time a month or less)	32.35	0.19
Day of experiment (treatment dummy)	-15.88	0.41
Constant	107.44	0.14
Experimenter dummy variables	Included	Included
No. of obs.	200	
Adj. R2	9.35%	

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