Determinants of Climate Change Adaptive Behavior in Coastal Communities in Southeast Asia

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ABSTRACT

This study sought to understand the determinants of autonomous adaptation of households in coastal communities in three countries (Indonesia, the Philippines, and Vietnam) as regards climate change. The study's main innovation is its focus on households facing a confluence of related hazards, a context that is unique to coastal communities. The study tackled the interrelated hazards of coastal erosion, flooding, and saltwater intrusion, and used a multivariate probit model to analyze the determinants. Regression results show that households adapt or respond autonomously to a combination of hazards. In fact, the econometric model of joint decision cannot be rejected by the data. Geographical differences were observed in adaptation patterns, implying that households react rationally to the degree of threats from the hazards. Like in some literature, the study found evidence that planned adaptation may crowd out private or autonomous adaptation. Likewise, trust increases the likelihood of self-insurance and self-protection, especially against extreme events that are either recurring or permanent. Finally, the households' adaptive capacity depends partly on the type of hazard and has a gender dimension. In recurrent extreme events, the abundance of male labor increases the likelihood of adaptation. In permanent and creeping hazards such as saltwater intrusion, the abundance of female labor increases the likelihood of adaptation.

Keywords: climate change, autonomous adaptation in coastal areas, multivariate probit, sea level rise coastal erosion, saltwater intrusion, flooding/typhoon
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Coastal communities face the most risk from climate change. For one, these communities are among the poorest and therefore usually less able to respond to climate-related threats. In this regard, increasing resilience of households in these communities is imperative. Increasing resilience to climate change hazards often involves household and community adaptation. This may come in the form of protection and insurance, which can be done either privately (as with autonomous household adaptation) or as local government or public-led initiatives (as with planned adaptation strategies). This study focused on autonomous adaptation of households in coastal communities.

There are numerous empirical studies on adaptive behavior of rural households. For instance, Deressa et al. (2008) looked at the effect of climate change perception on adaptation of farmers in the Nile Basin of Ethiopia. The interest of their study was more on climate change as manifested by temperature and rainfall change, not the impacts of hazards associated with climate change. Like most studies, they used univariate techniques in analyzing adaptive behavior. Nhemachena and Hassan (2007), recognizing the weakness of using univariate techniques in analyzing adaptation choices, note that univariate approaches may be prone to biases because they ignore common factors that might be unobserved and unmeasured, and might affect different adaptation measures. Instead, they used a multivariate approach to analyze the determinants of farmer adaptation to long-term temperature and precipitation changes. They considered the joint use of various adaptation strategies in agriculture-based households. Similarly, Seo and Mendelsohn (2007), who looked at the effect of climate change variables such as temperature and precipitation changes, acknowledged the issue of joint choice of livestock portfolio of households in Africa.

Surprisingly, despite the more pronounced risks in coastal communities, very little empirical study has been conducted on the adaptive behavior of households in these communities. Most studies have focused on communities in terrestrial ecosystems. For instance, Francisco et al. (2011) considered the effects of an extreme climate event for some coastal communities in China, the Philippines, Thailand, Indonesia, and Vietnam. However, they focused mostly on terrestrial systems, albeit covering some coastal communities. They adopted a multinomial logit model to study the determinants of proactive and reactive adaptation. Jarungrattanapong and Manasboonphempol (2009) studied coastal communities' adaptation strategies in Thailand to address coastal erosion and flooding. However, as is common in the literature, their study was mostly descriptive in nature.

In analyzing adaptation options in coastal communities, one needs to recognize the uniqueness of coastal ecosystems. Unlike communities in terrestrial ecosystems, coastal communities face a confluence of geophysical hazards. Among these are coastal erosion, flooding/typhoon, and saltwater intrusion. Thus, the issue of autonomous adaptation and resilience in households should be analyzed within the context of facing multiple hazards. There is still a dearth of literature on why some households self-protect and self-insure against multiple but interrelated climate hazards. This study is perhaps closest to Mahmud and Barbier (2016), which considered joint adaptation decisions to self-insure and self-protect against storm damages in southwest coastal communities in Bangladesh. However, unlike Mahmud and Barbier (2016) that categorized specific adaptation to a single hazard, this study focuses on general autonomous adaptation to a combination of hazards.

The next section of this paper discusses the multivariate probit estimation, which is the main methodology of the study. This is followed by the results and discussion section, which contains a descriptive or qualitative discussion of the study sites and the patterns of autonomous adaptation and the results of the multivariate probit analysis. The final section presents the conclusion and insights from the study.

METHODOLOGY: DETERMINANTS OF CHOICE OF AUTONOMOUS ADAPTATION STRATEGIES

A discrete choice model was used to analyze the choice of autonomous adaptation strategies employed by households in the study sites. In the literature, a probit model is commonly used. However, as will be seen later, household coastal communities often face simultaneous hazards and respond to a confluence of these events. For instance, typhoons do not only bring floods but also result in coastal erosion. Thus, it is prudent to look at decisions as if they are interrelated. That is, we will model decisions to adapt to several hazards as joint decisions.

Modeling choices as related decisions require an extension of the usual probit regression model to account for correlated errors. One such model is the multivariate probit, which estimates an M-equation discrete choice model. Consider an M-equation model, wherein each equation represents a possible adaptive strategy. Each choice is modeled as a discrete choice, i.e., whether the household chooses or employs an adaptive strategy from a menu of strategies or a menu of classification of strategies. We start with the following equation:

$$V_m^* = \beta'_m X_m + \varepsilon_m$$

where:

V_m^* is a latent (indirect) utility obtained from choosing adaptation strategy m
X_m is a matrix of factors affecting utility
β'_m are coefficients

We can treat this equation as a latent indirect utility function. We cannot observe this but only the decision of whether an m^{th} autonomous adaptation strategy is chosen ($y^m = 1$) or not ($y^m = 0$). An individual (or a household) will choose adaptation strategy m if he receives positive utility from it. That is:

$$y_m = 1[V_m^* > 0]$$

Thus, the probability of observing a specific adoption of strategy m can be represented as:

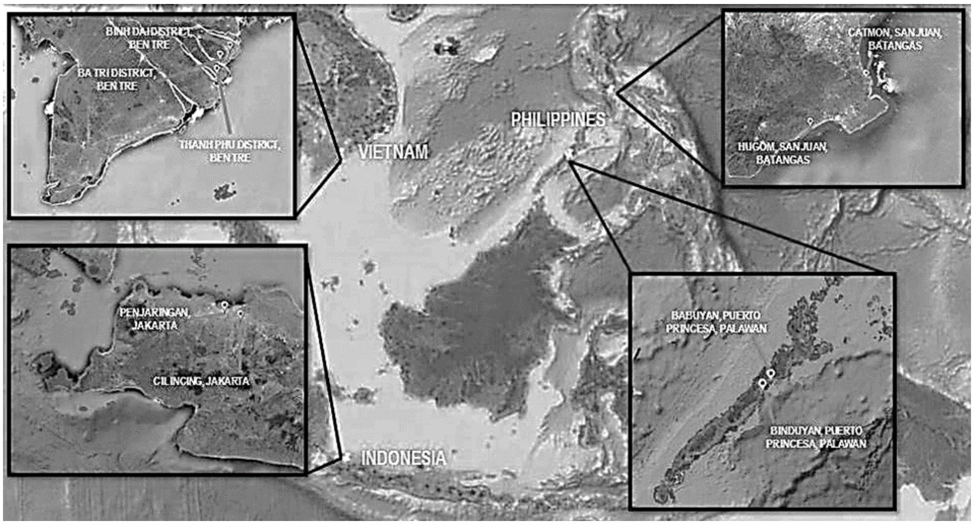
$$Pr[y_m = 1] = Pr[\beta'_m X_m + \varepsilon_m > 0]$$

Similarly, observing a combination of strategies wherein two strategies are adopted and all the other possibilities are not can be expressed as:

$$Pr[y^1 = 1, y^2 = 1, y^3 = 0 = \ldots . y^m]$$
$$= Pr\begin{bmatrix} \beta'_1 X_1 + \varepsilon_1 > 0, \beta'_2 X_2 + \varepsilon_2 > 0, \beta'_3 X_3 + \varepsilon_3 < 0 \ldots, \\ \beta'_m X_m + \varepsilon_m < 0 \end{bmatrix}$$
$$= Pr[\varepsilon_1 > -\beta'_1 X_1, \varepsilon_2 > -\beta'_2 X_2, \varepsilon_3 < -\beta'_3 X_3 \ldots, \varepsilon_m < -\beta'_m X_m]$$

Assuming that the error terms are jointly normal completes the specification that leads to a multivariate normal model, which can be estimated using simulated maximum likelihood.

Figure 1. Location of the study sites in Indonesia, the Philippines, and Vietnam



RESULTS AND DISCUSSION

The Study Areas and Adaptation Patterns to Climate Change Related Hazards

The study covered three Southeast Asian countries: Indonesia, the Philippines, and Vietnam (Figure 1). These countries have been identified as vulnerable to climate change impacts and significantly affected by climate change (Yusuf and Francisco 2009). Within each country, several sites were selected based on key informants as well as review of secondary sources regarding the sites' vulnerability to three potential coastal hazards: typhoon/flooding, coastal erosion/sea level rise, and saltwater intrusion. Respondents for the household survey were chosen randomly from these sites. The number of respondents in each village was determined based on proportional population weights.

Indonesia. Five villages around Jakarta Bay were chosen: three in Cilincing (Rorotan, Marunda, and Kalibaru) and two in Penjaringan (Kamal Muara and Muara Angke). These villages represent a concentration of Jakarta Bay's most vulnerable communities that engage in different types of resources-based livelihood.

Vietnam. Three coastal communes were chosen: Thua Duc in Binh Dai District, An Thuy in Ba Tri District, and Giao Thanh in Thanh Phu District. These communes are all located in Ben Tre province, which is one of the 10 provinces in Vietnam most vulnerable to climate change (Yusuf and Francisco 2009). Eight of these 10 provinces, including Ben Tre, are in the Mekong River Delta.

Philippines. Four coastal villages (barangays) were chosen, two in Batangas province (Catmon and Hugom) and two in Palawan province (Binduyan and Babuyan). The Palawan sites are located northeast of Puerto Princesa City, facing Honda Bay.

Tables 1 and 2 present the adaptation patterns in the different study sites. Specifically, Table 1 shows the total number of households adapting to a specific hazard and Table 2, the combination of adaptive strategies. Most households adapted to saltwater intrusion; 86 percent of them used some form of autonomous adaptation to saltwater intrusion. In comparison, only 38 percent and 15 percent adapted to flooding and coastal erosion, respectively.

The households mostly responded to a combination of hazards. Thirty-four percent

Table 1. Patterns of household adaptation in study sites in Indonesia, the Philippines, and Vietnam (n=1203)

Hazard	Did Not Adapt	Adapted
Saltwater intrusion	165	1038
Flooding/Typhoon	745	458
Coastal erosion	1017	186

Table 2. Patterns of combination of adaptation against flooding, saltwater intrusion, and coastal erosion of households in study sites in Indonesia, the Philippines, and Vietnam (n=1203)

Hazard	Did Not Adapt	Adapted
Saltwater intrusion	165	1038
Flooding/Typhoon	745	458
Coastal erosion	1017	186

of the households simultaneously adapted to both flooding and saltwater intrusion. Only 9 percent were affected and simultaneously adapted to the three hazards. Only six (0.5%) households adapted to the joint effects of flooding and coastal erosion. On the other hand, 10 percent of the households did not use any adaptation strategy.

Autonomous adaptation based on the timing of action can be classified as reactive or proactive. Reactive adaptation is usually action done in response to actual climate change. That is, action is done either during or after a climate-related event. In contrast, proactive adaptation is action done in anticipation of a climate-related event. This categorization is relevant to adaptation to recurrent extreme events or hazards like typhoon and flooding.

Tables 3 and 4 show the common proactive and reactive adaptation measures observed in the various study sites. One notable observation is that households tended to react to, rather than anticipate, the impacts of flooding and typhoons. In general, "improving the resilience of houses" is the most common proactive measure, which 19.92 percent of the households used. The most common reactive strategy is "save money" (59.81%) followed by "improving the resilience of houses" (29.83%).

The different country sites showed differences in households' preference for autonomous adaptation to the three hazards. The most common proactive measures are "evacuate to a safe place" and "undertake improvements to make the house more resilient to flooding" for Vietnam; "dig canals around the house" for Indonesia; and "undertake improvements to make the house more resilient to flooding" for the Philippines. Interestingly, the Indonesian and Vietnamese respondents indicated the same measures ("dig canals" and "improve house resiliency," respectively) as their most common reactive strategies, while for the Philippines, it was "save money."

The same categorization, however, may not be applicable to hazards like coastal erosion and saltwater intrusion since these two hazards create more permanent impacts than flooding and typhoons. Furthermore, their impacts are "creeping"—that is, they are slowly felt through time. Tables 5 and 6 present the common adaptation measures associated with coastal erosion and saltwater intrusion, respectively. In general, compared with saltwater intrusion, only a handful of households undertook adaptation measures against coastal erosion.

Table 3. Proactive autonomous adaptation strategies against flooding/typhoon of households in study sites in Indonesia, the Philippines, and Vietnam

Adaptation Strategy	Vietnam (n=66) (%)	Indonesia (n=119) (%)	Philippines (n=128) (%)	Whole Sample (n=313) (%)
Undertake improvements to make house more resilient to flooding	13.00	44.54	18.50	19.92
Evacuate to a safe place	13.33	26.05	5.17	10.01
Dig canals	0.00	80.67	3.67	11.58
Plant trees along perimeter of property	0.67	5.04	6.33	4.51
Harvest crops or fish early	0.33	10.92	2.33	2.75
Apply flood resilient farming methods	0.00	1.68	0.00	0.20
Avail of crop insurance	0.00	3.36	0.00	0.39
Reinforce ponds/fish cages/animal pens	1.00	9.24	1.17	2.06
Move fishing or farming equipment to safe place	2.00	2.52	3.33	2.85
Join savings-credit group/cooperative	0.33	2.52	0.83	0.88
Pursue other means to generate additional income	0.00	11.76	3.00	3.14
Build an underground shelter	0.33	0.84	1.00	0.79
Prepare food	0.33	0.00	1.50	1.11
Detach properties from the ground	0.00	0.00	0.50	0.33
Undertake other preparations to protect household from potential damages	2.00	0.00	1.00	1.33

The most common adaptation measure against this hazard across the three countries is "diversification of income sources," which was undertaken by only about 8.62 percent of the 186 households that adapted against this hazard. In contrast, a significantly greater number of households undertook autonomous adaptation measures against saltwater intrusion. About a third of the households indicated "build sand dikes around farms" (35.08 %) and "tap a different water source" (30.83 %) as their common adaptation strategies.

Similarly, the respondents from the three countries indicated differences in preference for adaptation measures against coastal erosion and saltwater intrusion. The majority of Vietnamese households indicated "harvest rainwater as alternative source of drinking water" as an adaptation measure against saltwater intrusion. Indonesian respondents did not indicate this adaptation measure. Vietnamese households also preferred to reinforce ponds and other aquaculture structures to address coastal erosion. This might be due to the prominence of the aquaculture industry in this part of Vietnam. While Vietnamese households were mainly concerned with their livelihood, Indonesian households were more concerned with protecting their houses against coastal erosion. Most Indonesian respondents preferred to construct floating houses and put up permanent protective structures against coastal erosion. Only very few households in the Philippine study sites indicated adaptation measures against coastal erosion. Those who did commonly indicated "prepare for evacuation but did not evacuate."

The variables used in the regression are described in Table 7. Table 8 provides the

Table 4. Reactive adaptation strategies against flooding/typhoon of households in study sites in Indonesia, the Philippines, and Vietnam

Adaptation Strategy	Vietnam (n=187) (%)	Indonesia (n=122) (%)	Philippines (n=101) (%)	Whole Sample (n=410) (%)
Undertake improvements to make house more resilient to flooding	57.00	44.54	13.33	29.83
Evacuate to a safe place	18.67	26.05	4.83	11.38
Dig canals	0.00	80.67	3.50	11.48
Plant trees along perimeter of property	1.00	5.04	3.00	2.65
Replant farm	3.33	10.92	0.50	2.55
Replace fish stock	3.33	1.68	0.17	1.28
Replace livestock	0.00	3.36	0.00	0.39
Avail of crop insurance	0.00	9.24	0.00	1.08
Reinforce ponds/fish cages/animal pens	11.33	2.52	0.67	4.02
Join savings-credit group/cooperative	0.33	2.52	1.00	0.98
Pursue other means to generate additional income	0.33	11.76	3.00	3.24
Withdraw from savings to undertake repairs/deal with additional expenses	0.00	0.84	0.00	0.10
Borrow money to cope with income losses and damages	10.33	0.00	2.50	5.11
Move to the underground shelter	0.00	0.00	2.27	0.65
Save money	25.09	0.00	81.88	59.81
Undertake other activities during/ immediately after a flooding	28.52	0.00	93.22	0.00

results of the multivariate regression for the decision to adapt to multiple hazards. Likelihood ratio tests rejected the hypothesis that the correlation of error terms across the three probit equations is equal to zero. This confirms the validity of using a multivariate probit, which leads to more efficient estimates.

Adaptation to Flooding and Typhoons

Table 8 indicates that the following factors significantly increased the likelihood of adapting to flooding: household size, percent of fishing income to total income, value of damages from the worst flooding incidence, and the number of people from whom the household can surely borrow money.

Bigger households tended to adapt more to flooding than the other hazards, probably because they can meet the labor demands of frequent or recurring adaptation. We note that flooding and typhoons, unlike coastal erosion and saltwater intrusion, are extreme events that occur regularly. Often, they occur up to 20 times in a year. The negative sign on the number of female household members supports this contention. Since men are often more involved in preparations for typhoons and flooding, households with more females are less likely to pursue adaptation strategies against flooding and typhoon.

In terms of site location, the Vietnamese respondents are more likely to adapt to flooding and typhoons compared with

Table 5. Autonomous adaptation against coastal erosion of households in study sites in Indonesia, the Philippines, and Vietnam

Adaptation Strategy	Vietnam (n=102) (%)	Indonesia (n=28) (%)	Philippines (n=56) (%)	Whole Sample (n=186) (%)
Install permanent protective structures	1.33	53.57	1.67	3.13
Install temporary and semi-permanent protective structures	10.00	32.14	1.67	5.28
Construct floating houses	0.00	57.14	0.00	1.72
Prepare for evacuation but did not evacuate	0.33	3.57	4.00	2.80
Evacuate/migrate to a safe place temporarily	0.33	14.29	2.00	1.83
Evacuate/migrate to a safe place permanently	1.33	0.00	0.67	0.86
Plant mangrove trees along the shoreline	2.33	3.57	2.17	2.26
Reinforce ponds/fish cages/animal pens	23.33	0.00	0.67	7.97
Pursue other means to generate additional income	22.00	7.14	2.00	8.62
Avail of crop insurance	22.00	0.00	0.33	7.33
Join savings-credit group/cooperative	22.33	7.14	0.83	7.97
Undertake other coping activities to protect house from potential damages from coastal erosion	22.67	0.00	1.17	8.08

respondents in coastal communities in Batangas, Philippines (the base location variable). People residing in the coastal communities in Palawan, Philippines are also less likely to adapt to flooding, since this province is not located along the common path of typhoons in the Philippines, unlike Batangas. A related variable is value of damages from the worst flooding. Households who experienced and had vivid memories of large damages from the worst case of flooding are also more likely to adapt to this hazard.

The presence of mangroves in front of the house decreases the likelihood of households employing autonomous adaptation strategies. This seems to point to a "crowding out" effect of natural barriers systems. Mahmud and Barbier (2016) found a similar result in their study of autonomous adaptation to cyclones in Bangladesh.

Also evident in Table 8 is the negative sign of the coefficient of the variable representing distance from creeks and rivers. Excessive rains often cause rivers and creeks to overflow, leading to flooding. This makes houses near these bodies of water more prone to the effects of flooding, thus, their more urgent need to adapt to such hazard. This result implies that households rationally react to the degree of the perceived threat. Another result that supports this is that full-time fishermen or households that depend

Table 6. Autonomous adaptation against saltwater intrusion of households in study sites in Indonesia, the Philippines, and Vietnam

Adaptation Strategy	Vietnam (n=284) (%)	Indonesia (n=303) (%)	Philippines (n=451) (%)	Whole Sample (n=1,038) (%)
Harvest rainwater as alternative source of drinking water	90.00	0.00	2.33	23.61
Tap from different water source	10.67	100.00	6.00	30.83
Treat water	0.00	0.00	6.00	2.99
Pump freshwater into ponds/rice fields to reduce salinity level	0.00	0.00	0.00	0.00
Switch to livestock or plants that are more compatible with salt contaminated water	0.00	0.00	0.00	0.00
Buy bottled water/fresh water from vendors	45.67	0.00	2.00	12.39
Build sand dikes around farms	5.67	0.00	67.50	35.08
Undertake other coping mechanisms to protect house from potential damages from saltwater intrusion	9.79	0.00	97.84	45.67

more on fishing than other livelihoods are also more likely to use various adaptation strategies against flooding. Fishermen often live close to the shore. Households located in areas where risks are higher are more compelled to protect or insure themselves against loss or damages.

The social capital variable—number of people from whom one can borrow—also increases the likelihood of employing adaptive measures against flooding and typhoon. This factor measured the level of trust of the respondent. In some ways, trust increases the household's capacity to autonomously adapt to these extreme events.

Adaptation to Coastal Soil Erosion and Sea Level Rise

As with the earlier results on adaptation to flooding, the study sites differed in terms of their likelihood to adapt to coastal erosion and sea level rise. In the Philippines in particular, Palawan coastal communities are less likely to adapt to these hazards compared with those in Batangas. The Vietnamese households, however, are more likely to adapt relative to coastal communities in Batangas. Again, these results likely reflect the difference in the severity of the threats in these countries. Similarly, spatial factors also affect the decision to privately adapt to this bio-geophysical impact. Households located farther from riverbanks and streams are less likely to adapt. Further, household size and the social capital variable both increase the likelihood of autonomous adaptation to coastal erosion.

Regression results also show that households with roofing materials made of very light materials are also less likely to autonomously adapt. This may have to do with the wealth level of these households. Wealthier households (i.e., those who can afford more permanent roofing structures) are in a better position to meet the financial requirements of adaptation.

Table 7. Description of variables used in the regressions

Variable	Description
Age of HH head	Age of HH head in years
Years of schooling	Number of years HH head was in school
HH size	Number of household members
Dependency ratio	Ratio of number of working HH members to non-working HH members
Number of female	Number of female HH members
Palawan	Dummy variable (if respondent is from Palawan=1; 0 otherwise)
Vietnam	Dummy variable (if respondent is from Vietnam=1; 0 otherwise)
Indonesia	Dummy variable (if respondent is from Indonesia=1; 0 otherwise)
Presence of mangrove	Dummy variable (if there are mangrove areas in the site=1; 0 otherwise
Distance from creek/rivers	Distance from inland body of waters (in meters)
Type of roofing materials	Type of roofing material (1=permanent materials [galvanized iron, aluminum, tile, concrete, brick stone, asbestos]; 2=light materials [thatch roof, sawali, salvaged/makeshift materials]; 3=mixed but predominantly permanent materials; 4=mixed but predominantly light materials)
Owns pigs	Dummy variable (1= HH owns pigs; 0 otherwise)
Income from gifts, relief, support, etc.	Net income in cash from cash receipts, gifts, supports, relief, and other income (in USD)
% of fishing income in total income	Proportion of income from fishing
Value of damages	Value of damages from worst incidence of flooding/typhoon (in USD)
No. of people from whom you can surely borrow	Social capital question
Perception on climate change	HH head's perception of future climate change events (1=impacts will be more severe than in the past; 2=impacts will be about the same as in the past; 3=not sure)
Presence of riverbank rehabilitation	Dummy variable (1=there is a riverbank protection present in the site; 0 otherwise)

Interestingly, income from gifts, relief, and support operations reduces the likelihood of adaptation to coastal erosion. Coastal erosion often accompanies severe typhoons, which frequently prompt disaster relief operations. This means that disaster and relief "dole outs," which are common local government initiatives during calamities, can crowd out adaptive behavior.

Adaptation to Saltwater Intrusion

The third major hazard in the study areas is saltwater intrusion. Again, geographical differences are evident in the results. Saltwater intrusion is a major problem in Vietnam, as cited during the focus group discussions. Hence, as expected, Vietnamese households have a higher probability of employing adaptive strategies against this hazard. Ownership of pigs, which is a liquid asset, is a positive determinant of adaptation.

Table 8. Results of multivariate probit on adaptation to multiple hazards

	Flooding	Coastal Soil Erosion/ SLR	Saltwater Intrusion
Age of HH head	0.002 (0.003)	0.001 (0.004)	0.015*** (0.004)
Years of schooling	0.002 (0.002)	0.000 (0.003)	0.067*** (0.018)
HH size	0.066** (0.031)	0.061* (0.034)	-0.061 (0.041)
Dependency ratio	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Number of female	-0.102** (0.044)	-0.055 (0.051)	0.189*** (0.066)
Palawan	-1.202*** (0.142)	-0.433*** (0.161)	-0.190 (0.133)
Vietnam	0.457*** (0.146)	0.755*** (0.126)	0.745*** (0.183)
Indonesia	16.827 (12.843)	-3.393 (14.645)	34.604*** (12.863)
Presence of mangrove	-0.004** (0.002)	0.000 (0.003)	0.005 (0.004)
Distance from creeks/rivers	-0.000*** (0.000)	-0.000** (0.000)	0.000 (0.000)
Type of roofing materials	0.052 (0.034)	-0.075* (0.040)	0.058 (0.041)
Owns pigs	0.168 (0.129)	-0.036 (0.148)	0.233* (0.128)
Income from gifts, relief, support, etc.	0.000 (0.000)	-0.000* (0.000)	0.000 (0.000)
% of fishing income in total income	0.008** (0.003)	-0.010* (0.006)	-0.047** (0.021)
Value of damages	0.000* (0.000)	0.000 (0.000)	0.000 (0.000)
No. of people from whom you can surely borrow	0.006*** (0.002)	0.005** (0.002)	-0.004 (0.008)
Perception on climate change	-0.015 (0.047)	-0.020 (0.052)	-0.032 (0.058)
Presence of riverbank rehabilitation	0.003 (0.002)	0.003 (0.003)	-0.331*** (0.115)
Constant	-0.540** (0.214)	-1.144*** (0.252)	-0.489 (0.348)
Observations	1203		

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Since saltwater intrusion is a permanent risk, it requires permanent strategies like having piped water connection. Such permanent strategies require financial capital; thus, those with more liquid assets like livestock are more likely to be in a position to adapt to saltwater intrusion.

Unlike the result on adaptation to flooding, the number of female household members increases the likelihood of adapting to saltwater intrusion. A common adaptation behavior against saltwater intrusion is to get water from other sources. Women commonly perform this household chore, which explains the direct relationship between the number of female household members and probability of adaptation.

We also found out that riverbank rehabilitation results in lower probability of adaptation against saltwater intrusion, which is another crowding-out effect of planned adaptation strategies.

CONCLUSION AND RECOMMENDATIONS

This study sought to understand the determinants of autonomous adaptation of households in coastal communities to hazards due to climate change. The study's main innovation is its focus on households facing a confluence of related hazards, a context that is unique to coastal communities. The study tackled the interrelated hazards of coastal erosion, flooding, and saltwater intrusion. It used a multivariate probit model to analyze the determinants of autonomous adaptation of households in three countries: Indonesia, the Philippines, and Vietnam. The following insights were gained from the results of the regression analysis:

a. **Geographical location matters.** Obviously, less adaptation can be expected in areas or countries where a hazard is less of a threat. Coastal communities still rationally insure and protect themselves against nature. Site differences, such as households' distance from coastline and other bodies of water, lead to differences in autonomous behavior. This underscores the need for hazard mapping and communicating risks indicated in the hazard maps to coastal communities.

b. **The nature of the hazard matters and adaptation to it has a gender dimension.** For recurring and often passing extreme events such as flooding and typhoons, household male labor is essential in implementing recurrent or repetitive adaptation strategies. On the other hand, for permanent but creeping or slowly occurring hazards like saltwater intrusion, female labor is essential because adaptation takes the form of a common household chore (e.g., getting drinking water from other sources).

c. **Government projects or interventions may crowd out autonomous strategies.** Natural protection such as mangroves and planned adaptation such as riverbank rehabilitation were found to be substitutes for self-protection and self-insurance. Likewise, income from disaster and relief operations reduces the probability of adaptation to extreme events such as coastal erosion. This is clearly shown by the negative coefficients associated with these variables in the regression. This means that the likelihood of adaptation, as discussed earlier, is reduced with the presence of these government interventions.

d. **Increasing trust in a community increases the likelihood of autonomous adaptation.** This is shown by the positive coefficient of the proxy social capital variable, which is the number of people whom the respondent can surely borrow from. This social capital variable represents the community's level of trust on the respondent. Thus, it can be a contributing factor to adaptation to coastal erosion and flooding.

e. **Finally, in terms of methodology, there is gain in modeling adaptation options as joint decisions in the case of coastal communities.** The significance of the error correlation across the different decision equations attests to this conclusion.

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