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Abstract

This paper empirically examines whether and how experiencing climate-related disasters can improve the rural poor's adaptation to climate change through community-based resource management. Original household survey data in Fiji capture the unique sequence of a tropical cyclone and the establishment of community-based marine protected areas as a natural experiment. The analysis reveals that household disaster victimization increases its support for establishing marine protected areas for future safety nets. Under Fijian traditional consensual institutions, social learning from disaster experience among community members facilitates their collective decision-making for conservation to enhance community resilience to climate shocks.

Keywords: community-based resource management; climate change adaptation; social learning; natural disaster; marine protected area; Fiji

JEL classification: O13; Q22; Q54

1. Introduction

Poor populations in rural developing areas are particularly vulnerable to increasingly frequent and extreme weather events, as they rely heavily on weather-dependent livelihood activities, such as agriculture and fishery (e.g., Adger et al., 2003; Pelling, 2003; Paavola and Adger, 2006; Eriksen and O'Brien, 2007). How the rural poor can cope with climate-related disasters is a central issue in climate-adaptation policy. Although the rural poor's limited coping capacity and the adverse welfare consequences of disasters are commonly emphasized (e.g., Smit and Pilifosova, 2001), some researchers pay significant attention to their potential adaptation for systemic improvements. In particular, those working within a social-ecological resilience framework emphasize the trigger role of disaster (e.g., Pelling and High, 2005; Westley et al., 2011): "In a resilient social-ecological system, disturbance has the potential to create opportunity for doing new things, for innovation and for development" (Folke, 2006, p253). Agrawal (2010) stresses the critical role of local institutions in facilitating adaptation to climate change. Recent empirical works provide supportive evidence: In an Amerindian community in Honduras, Hurricane Mitch triggered institutional changes in land management, which led to sustained social-ecological improvement (McSweeney and Coomes, 2011); in colonial Mexico, improved adaptation through learning and innovation followed a series of extreme weather events and wealth-related events (Endfield, 2012).[1]

[1] Although most macroeconomic studies highlight adverse consequences of natural disasters, Skidmore and Toya's cross-country analysis (2002) shows that climate-related disasters can positively influence long-run economic growth because of the substitution of physical-capital accumulation with human-capital accumulation and triggered technological progress (see, for example, Hallegatte and Dumas, 2009 for related theoretical work).

These findings on a positive side of disaster (Agrawal, 2011) suggest that "future interventions should foster local capacities for endogenous institutional change to enhance community resilience to climate shocks" (McSweeney and Coomes, 2011, p5203). Although this bottom-up approach is an important alternative to conventional targeted external assistance, which policies can foster local capacities is unknown; the institutional change in Honduras, for example, neither was facilitated by aid organizations nor resulted from the community's explicit collective decision, but occurred virally among households (McSweeney and Coomes, 2011). Some researchers see such potential for fostering local capacities in the bottom-up nature of community-based resource management. In particular, using an example from Trinidad and Tobago, Tompkins and Adger (2004) discuss the advantage of community-based resource management in its inclusionary communication/deliberation, institutional mechanisms for social learning, and networks connecting local and external actors (see also Adger et al., 2005; Pomeroy et al., 2006). As community-based resource management is a mainstream conservation policy in rural developing areas, this potential warrants systematic inquiry. Using original household survey data in Fiji that capture a unique sequence of a tropical cyclone and the establishment of community-based marine protected areas (MPAs) as a natural experiment, this paper examines whether and how disaster experience can enhance local coping capacity through community-based conservation.

The paper serves as a benchmark case for studying the potential role of community-based resource management in fostering community adaptation to climate change, because if it has such potential, we can expect that this would be so for Fiji's MPAs for the following reasons. First, Pacific island states have well adapted their traditional marine resource-management practices to contemporary circumstances, and as a result, community-based marine resource management is more widespread in Oceania than in any other tropical region in the world (Johannes, 1978, 2002). In particular, Fiji recently expanded community-based MPAs across the country (Aalbersberg et al., 2005; Techera, 2008; Govan, 2009). Second, as customary marine tenure is well established in Fiji, incomplete property rights that can preclude investments in local public goods (conservation) (Otsuka and Place, 2001) are unlikely to be a major concern. Third, although tropical cyclones are among the most important climate-related disasters in island states (Pelling and Uitto, 2001), some researchers criticize the deterioration of islanders' indigenous mechanisms in coping with cyclones because of their increasing dependency on external aid (e.g., Campbell, 1984), and such concerns about local coping capacity underlie the recent expansion of MPAs in Fiji (e.g., Veitayaki, 2006).[2]

The paper explicitly addresses two lines of major critiques against extensive studies on conditions facilitating successful community-based resource management, such as group size and inequality (e.g., Wade, 1988; Ostrom, 1990; Baland and Platteau, 1996): 1) those studies

[2] In the economics literature on the poverty-environment nexus, small-scale fisheries receive relatively limited attention, as discussed by Béné (2003, though his review focuses on Asia and Africa); indeed, systematic empirical studies on community-based marine resource management, such as MPAs, in the developing world are scarce. As exceptions, Gjertsen (2005) examine how MPA characteristics influence welfare and environmental outcomes among MPAs in the Philippines (see also Pollnac et al., 2001), and Silva (2006) investigates how alternative income alters the choice of fishing gear among households in Tanzanian villages with MPAs. Descriptive analyses are common in the broad literature on coastal management. For example, Crawford et al. (2006) show various factors correlated with the establishment of community-based MPAs in Indonesia without paying attention to natural disasters.

neither address the issue of identification of causality (omitted variable bias),[3] nor show why and how such conditions matter (Agrawal, 2001); and 2) they treat the community as a small spatial unit with a homogeneous social structure consisting of common interests and shared norms and do not directly address political economy issues, such as multiple interests/actors within the community, decision-making processes, and institutional arrangements (Agrawal and Gibson, 1999). To illustrate the first critique, suppose that sufficient across-communities variations exist in disaster shocks and the adoption of conservation measures following the disaster. Although a community-level regression analysis to estimate the disaster effects on conservation involves far fewer identification problems than previous works on group characteristics,[4] such an inquiry has not received attention in the literature because disaster experience has not been considered as a facilitating condition.[5] Even if the disaster's impacts on conservation are identified, such

[3] Ferraro and Pattanayak (2006) and Ferraro (2009) highlight the critical importance of identifying causality in evaluating biodiversity conservation programs and environmental policies, respectively.

[4] Identification may be still hampered by unobserved community factors correlated with disaster shocks, such as post-disaster external support for conservation. The proposed analysis requires community-level exogenous shock measures (e.g., deviation from the mean in rainfall). In practice, however, such spatially rich data are rare – commons studies often rely on small-scale community surveys (Agrawal, 2001), and objective community shock data are rarely available.

[5] As an exception, the World Bank (1999) shows that past disaster experience positively influences marine ecological outcomes (based on subjective assessment) across community-based marine resource-management areas in five Pacific island states (including Fiji), though disaster is not the study's focus.

community-level analysis still does not dissect mechanisms underlying the causality; for example, disasters may damage habitats, thereby forcing people to alter their livelihood activities.

How the local political economy matters for community-based resource management depends on specific local institutions. In Fiji's customary marine resource management, building consensus among community members is a primary decision-making process (Veitayaki, 1998). Thus, the paper explores variations in household support for establishing MPA as a key determinant of the collective decision. I show that household disaster victimization increases the household's support. This disaster effect is identified only when the potential endogeneity of household-level housing damage is controlled for by using exogenous flood shock as an instrument.

I argue that the positive disaster effect on conservation is a result of disaster victims having a higher appreciation of local commons as safety nets than non-victims. This is because in the same area as my study area in Fiji, Takasaki (2011b) finds that households with housing not damaged by the cyclone intensify fishing to help other kin-group members with damaged housing; that is, the rural poor with limited coping capacity rely on local commons not only for self-insurance, as is commonly found in various locales (e.g., Jodha, 1986; Pattanayak and Sills, 2001; Takasaki et al., 2004; McSweeney, 2005), but also to augment mutual insurance even if resource use (fishing) is risky (Coomes et al., 2010).[6] I provide evidence that strong support for MPA among community members facilitates their consensual decision making for conservation, and then that community decision furthers overall support for conservation. As such, the inclusionary deliberation and decision making in community-based resource management can

[6] Based on a case study in Tonga, Bender et al. (2002) even argue that informal insurance arrangements per se can lead to sustainable marine resource use without management.

facilitate community adaptation to climate change through social learning from disaster experience, along the line of adaptive management (e.g., Holling, 1978; Walters, 1986; Lee, 1999; Plummer and Armitage, 2007).

The rest of the paper is organized as follows. Section 2 provides a description of the marine resource institution and management in Fiji. Section 3 describes the data, MPAs, and the disaster. Section 4 presents the econometric specification to identify the disaster effects on conservation and the estimation results, including evidence for social learning, followed by a robustness check in Section 5. The last section concludes.

2. Marine resource institution and management in Fiji

Each native Fijian belongs to a lineage of the *vanua-yavusa-mataqali-tokatoka* hierarchy: Vanua consists of several yavusa; yavusa consists of several mataqali; and mataqali consists of several tokatoka (Ravuvu, 1983). Roughly matching an old district (*tikina*) in the administrative unit, vanua ranges over several villages (*koro*); a village consists of one or a few yavusa, which includes several lower-order units, mataqali, and then tokatoka. Fijian customary law guarantees the collective ownership of land and marine resources. First, rural land is communally owned by mataqali (within a village) and is privately used, and by law it cannot be sold (communal land consists of about 83% of the country's total land). Second, the coastal zones across the country are demarcated into over 400 customary fishing grounds (*qoliqoli*) to which vanua or several yavusa (across several villages) hold customary rights to harvest marine resources; ownership of the foreshore rests with the state (Techera, 2008).

Ethnographic studies highlight Fijians' traditional marine resource-management practices, such as ritual protocols, taboos (e.g., no-take areas), seasonal bans, and their effective enforcement through social norms and sanctions (Siwatibau, 1984). The national government has been strengthening customary resource management by formalizing its arrangements and integrating them into the contemporary system; examples include registration of customary fishing grounds, boundary setting, licensing involving customary owners, and deterrence of poachers (Veitayaki, 1998).[7] As such, Fiji's contemporary marine resource management is built on its customary institution: "Community-based marine resource management is appropriate in Fiji because, in most communities, the rights of individuals within their collectively owned fishing area are related to group's consensual position. Management decisions and policies are based on *consensus*, which ensures the cooperation of everyone in the community" (Veitayaki, 1998, p51, emphasis added).

There has been an increasing interest across the country in the establishment of MPAs as a result of governments' extension work and nongovernmental (NGO) activities under Locally Managed Marine Area (LMMA) initiatives, which were officially launched in 2000 (Aalbersberg et al., 2005; Techera, 2008; Govan, 2009). By 2005, 177 villages in Fiji had established LMMAs, which cover 7,010km^2 with 440km^2 of MPAs (Locally-Managed Marine Area Network, 2006).[8] Establishing a village-level MPA involves consensual decisions among villagers in the village and among villages collectively owning the customary fishing ground. "The development of marine reserves and protected areas in Fiji could be easier, as the ownership of the customary fishing areas is already with the people who need only to agree as a group to have the

[7] By conducting economic experimental games among Colombian fishermen, Moreno-Sánchez and Maldonado (2010) show the dominance of co-management – like one in Fiji – among different management regimes of MPAs for resource sustainability.

[8] Although examining effects of resource management is not the focus of this paper, Lawson-Remer (2012) provides evidence that LMMAs improve household welfare.

arrangement formalized declaring a portion of their fishing grounds a marine reserve or protected area" (Veitayaki, 1998, p57).

3. Data, marine protected areas, and disaster

3.1. Data

In June-September 2005, I conducted a household survey among 906 households in 43 native Fijian villages in Cakaudrove Province in the northern region of the country.[9] There is a total of 32 qoliqoli in the province. In each of 16 districts in the province, villages were intentionally chosen to cover distinct environmental and economic conditions – 35 coastal and 8 inland villages. In each village, households were stratified by tokatoka and a combination of individual leadership status (e.g., kin leader, as defined below) and major asset holdings (e.g., shops) (all tokatoka were sampled); in each stratum, households were randomly sampled (50% of the population in each stratum, on average). The 43 villages in the sample cover 29 qoliqoli, 20 vanua, 53 yavusa, 146 mataqali, and 234 tokatoka;[10] some vanua and yavusa (and thus villages) own more than one qoliqoli.

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[9] The province, consisting of part of Vanua Levu, all of Taveuni, and other small islands, significantly lags behind the main island Viti Levu, where the state capital, two international airports, and most tourism businesses are situated. Fiji is divided almost evenly between native Fijians and Indo-Fijians. My study focuses on native Fijians who hold customary rights to harvest marine resources.

[10] An average village consists of 3.4 mataqali and 5.6 tokatoka, and on average, each mataqali and tokatoka consists of 14 and 8 households, respectively, in the population. Marriage across different kin groups in the village or different villages is common, and this paper focuses on the kin groups to which households currently belong.

Virtually all households in the sample employ traditional farming practices, using no mechanized equipment or animal traction to produce taro, cassava, coconut, and kava plants. Most households in coastal villages engage in subsistence fishing using lines and hooks, simple spear guns, or rudimentary nets, and more commercially oriented fishermen use boats and engines, along with more valuable nets. At the time of interviews, the mean monthly total income earned by sample households is F$1,582, or F$288 per capita (F$1 = US$.60); farming and fishing, respectively, account for 66% and 11% of income earned.

3.2. MPAs and marine resource management

Out of 35 coastal villages in the sample, 2 had established an MPA before the cyclone in January 2003 (detailed below). The analysis focuses on the remaining 33 coastal villages. At the time of interviews in 2005, 10 villages already had established MPAs, 1 was establishing an MPA, and 9 were considering establishing MPAs (henceforth I call these 20 villages *MPA villages*); the remaining 13 were not considering the establishment of MPA (henceforth *non-MPA villages*). Most MPA villages established or started to consider MPAs in 2004 or 2005, i.e., more than a year after the 2003 cyclone. The areas of MPAs established or being considered range in size from 1 to 20 acres (5.2 acres, on average).

The village survey conducted with village leaders asked why the village was active about establishing MPAs among the MPA villages (up to three reasons) and why it was not among non-MPA villages (up to three reasons) (see Table 1). The most common reason among non-MPA villages is limited villagers' interest (about 70%), and villagers' good understanding is a relatively common reason among MPA villages, reflecting the village's consensual decision-making process. The strength of leadership – at both the village and qoliqoli levels – is another important factor,[11] and declining marine resource stock is also a common concern. MPA villages more commonly participated in MPA workshops than non-MPA villages, though the difference is not statistically significant; only about one quarter of MPA villages received technical support.

Villages employ various resource-management practices: Almost all villages have bans on Sunday fishing and poison fishing; about 50% and 85% of villages restrict gill net and scuba diving, respectively, and there is no significant difference in these regulations between MPA and non-MPA villages. Although many of these regulations are set at the qoliqoli level, some of them are employed by individual villages. According to respondents' subjective assessments using a five-point-scale measure for enforcement of the regulations (1: not at all, 2: a little, 3: somewhat, 4: well, 5: very well), compliance with gill-net restriction was lower than that of other regulations, and compliance (for scuba diving, in particular) in MPA villages was higher than that in non-MPA villages. Overall, about three quarters of villages value overall management/conservation – at both the qoliqoli and village levels – somewhat or well, and about one quarter of villages, a little (according to respondents' subjective assessments using the same five-point-scale measure above); overall management/conservation is better in MPA villages than in non-MPA villages, indicating their positive correlation with involvement in MPA as a new conservation instrument.

3.3. Household support for MPAs

[11] Each vanua has a paramount chief, and some yavusa and mataqali, but not tokatoka, have sub-chiefs; there are also traditional leaders other than chiefs/sub-chiefs. Village chiefs can be served by chiefs, sub-chiefs, or non-chief leaders. Heads of qoliqoli are either vanua or yavusa chiefs. These hereditary traditional leaders play a major role in local governance within and across corresponding kin groups (Turner, 1992).

The household-level analysis is based on 632 households in the 33 villages that participated in fishing in the past one year at the time of interviews in 2005. The household survey, which was mostly conducted with household heads, asked how strongly the household supports MPA at the time of interviews in 2005, using the five-point-scale measure (1: not at all, 2: a little, 3: somewhat, 4: much, 5: very much); then, the survey asked the level of its support one year before, using the former measure as an anchor to facilitate retrospection (measurement errors in the latter measure are discussed later). The latter measure (henceforth *prior support for MPA*) corresponds to the timing when many MPA villages established or started to consider MPAs, thus capturing villagers' support for MPAs that determined their collective decision; in contrast, the former measure (henceforth *current support for MPA*) could be altered by the collective decision.

The results are shown in panel A of Table 2. Over three quarters of households show strong or very strong prior support for MPA (4th or 5th category). Current support becomes stronger than prior support: Over one half of households show very strong support; in particular, although the degree of support does not change among 83% of households, over 12% augment their support and less than 5% decrease theirs. Qualitatively the same results hold regarding whether or not the household supports MPAs very much (5th category) (panel B). These results provide evidence that the village's collective decision for MPAs positively alters household current support for MPA. Both prior and current support are stronger in MPA villages than non-MPA villages (the result for very strong current support is statistically weak) (see Table 3); that is, consistent with consensual decision making, the stronger villagers' prior support for MPA, the stronger is the community's involvement in MPA.

3.4. Disaster

On January 13, 2003, Cyclone Ami swept over the northern and eastern regions of the country; Ami was the only cyclone in the northern region from 1991 through 2005 (McKenzie et al., 2005). According to respondents' subjective assessments, over 60% of residents' dwellings – a main house and/or free-standing units, such as the kitchen, shower, and toilet (not all households have such units, as these facilities are often located inside the main house) – were damaged, and the mean value of total housing damage was about F$1,100 (Table 3); the cyclone caused no casualties, and permanent migration was virtually nonexistent after the disaster.

The provision of emergency relief (see Takasaki, 2011c for details) was followed by housing reconstruction programs. About one quarter of households received construction materials, and the mean amount received was about F$700; although almost the same proportions of households received aid more than a year before the interviews in 2005 and in the past one year, the average amount received in the former period was larger than that in the latter period. Although there was at least one disaster victim (with housing damage) in each village, there was no recipient of housing aid in a few villages. Although almost all aid recipients were disaster victims (i.e., virtually no leakage), about 40% of victims were recipients (i.e., large under-coverage), and aid was strongly targeted on housing damage value (Takasaki, 2011a). These descriptive statistics of damage/aid are very similar to those in the whole sample of 43 villages.

3.5. Disaster, fishing, and MPAs

Takasaki's study (2011b), which shows fishing intensification to help disaster victims as discussed above, captures fishing within a year after the 2003 cyclone based on his household survey conducted in 2003 in 9 coastal villages, 7 of which are part of my 43 sample villages; among his 9 villages, 2 villages, which do not overlap with my sample, and 1 overlapped village had established MPA before the cyclone; 4 other overlapped villages are MPA villages, and the remaining 2 are non-MPA villages. Thus, fishing served as local safety nets, especially in villages with strong involvement in MPAs.

If establishing/considering MPAs following the cyclone comes from an insurance motive augmented by the disaster experience, we would expect to see a positive correlation between disaster victimization and MPAs. There exists, however, no significant difference in household-level housing damage/aid between MPA and non-MPA villages (Table 3); this is so in terms of both the incidence of housing damage and damage value and both aid receipt and the amount received, regardless of the timing of receipt (flood measures also reported in Table 3 are discussed later).[12] The village means of the household-level damage measures – proportion of households with housing damaged and mean damage value – are qualitatively the same between MPA and non-MPA villages; when a dummy for MPA villages is regressed on those village-level damage variables without or with other controls, such as population size and market access (n=33), none of their estimated coefficients are statistically significant (results not shown). These descriptive and village-level regression analyses – along the same line as extant works on community-based resource management – do not control for village heterogeneity in factors determining the village's collective decision and vulnerability to disasters, which can be correlated with each other. Identifying the impacts of household housing damage on its support for MPAs within villages is the task carried out in the next two sections.

4. Empirical analysis

4.1. Econometric specification

[12] Comparing housing damage/aid between households who support MPA very much and others yields very similar results.

I start with the following ordered probit specification:

$$y_1^* = \alpha_1 + \beta_1 y_2 + \boldsymbol{\delta}_1 \boldsymbol{x} + \boldsymbol{V} + u_1, \tag{1}$$

where y_1^* is the latent indicator of household prior support for MPA; y_2 is the observed 0-1 indicator for household housing damage; $\boldsymbol{x}$ is a vector of exogenous household controls (defined below); $\boldsymbol{V}$ is a vector of village dummies; and u_1 is an error term that is assumed to be normally distributed. I consider disaster aid as an additional determinant in the next section. Village dummies fully control for village-level factors affecting household support for MPA, such as marine resource stock, local regulations, social norms, leadership, and heterogeneity in qoliqoli, as well as village-level covariate disaster shocks and aid supply. If household disaster victimization increases its prior support for MPA, $\beta_1 > 0$.

Social learning from disaster experience among community members suggests that the collective decision in MPA villages (i.e., establishing MPAs) increases non-victims' support for MPAs, and as a result, strong support for MPAs becomes more prevalent over time (as found in the descriptive statistics above). A simple way to test this is to estimate equation (1) for current support for MPAs: With augmented support among non-victims, the damage effect on current support should be smaller than that on prior support. Note that this altered equation (1) does not capture the effects of the collective decision, because it is controlled for by village dummies.

The identification assumption in equation (1) that household-level housing damage is uncorrelated with unobserved household heterogeneity determining its support for MPAs, such as preference for conservation, may not hold as follows. With village-level covariate shocks controlled for, whether or not housing is damaged in the village depends on its unobserved quality prior to the disaster, in particular, its durability against cyclone shocks (e.g., heavy wind, rain, flood), which is a function of cumulative investments in housing that the household had made, as well as its location in the village. If housing quality is positively (negatively) correlated with say, preference for conservation, i.e., households with housing less (more) vulnerable to cyclones tend to support MPA more, the estimated damage effect is biased downward (upward).

My empirical strategy is two-fold. First, since housing location is fixed with mataqali (a village subgroup owing land), it is effectively captured by mataqali fixed effects. Second, I endogenize household housing damage by using flood shock as an excluded identifying variable. The household survey asked the magnitude of flood, not damage caused by the flood, that the household experienced on its land based on a five-point scale (0: none, 1: small, 2: some, 3: large, 4: very large); over 40% of households in the sample had experienced a flood (Table 3), and there was at least one household with flood experience in each village. The identification assumption is that household flood shock affects its housing damage within mataqali and is uncorrelated with its unobserved heterogeneity in support for conservation. In particular, household housing investments correlated with its vulnerability to flood on its micro location, if any, are assumed to be uncorrelated with its unobserved heterogeneity.[13, 14]

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[13] If flood shock augments housing damage, and the damage effect on household support for MPA is positive, flood shock should increase the support. The descriptive statistics show mixed evidence: Floods are more common and larger in magnitude among disaster victims (with housing damage) than non-victims, as confirmed in the regression analyses below (descriptive results not shown), but also in non-MPA villages than MPA villages (Table 3). Without controlling for land conditions determining vulnerability to flood, however, the latter result is unlikely to reflect the true effect of flood; in particular, flood vulnerability may be negatively correlated with MPA for any reason. Indeed, once land conditions are controlled for, flood shock significantly increases household support for MPAs, as shown below.

The two-equation system is

$$y_1^* = \alpha_1 + \beta_1 y_2 + \boldsymbol{\delta}_1 \boldsymbol{x} + \boldsymbol{G} + u_1, \tag{2}$$

$$y_2^* = \alpha_2 + \gamma_2 w + \boldsymbol{\delta}_2 \boldsymbol{x} + \boldsymbol{G} + u_2, \tag{3}$$

where y_2^* is the latent indicator of y_2; w is flood shock; $\boldsymbol{G}$ is a vector of mataqali dummies; and u_1 and u_2 are error terms that are assumed to follow a bivariate normal distribution. The likelihood function is the product of the probability that support for MPAs lies in interval j (= 1, …, 5) and housing is damaged ($y_1 = j$, $y_2 = 1$) (y_1 is the observable indicator of y_1^*) and the probability that support for MPA lies in interval j and housing is not damaged ($y_1 = j$, $y_2 = 0$) across observations:

$$L = \prod_i \prod_j \left[P\left(c_j > y_{1i}^* > c_{j-1}, y_{2i}^* > 0\right)\right]^{Z_{ij}} \cdot \left[P\left(c_j > y_{1i}^* > c_{j-1}, y_{2i}^* < 0\right)\right]^{Z_{ij}}, \tag{4}$$

where i is observation (household); c_j and c_{j-1} are the cutpoints of interval j to be estimated; and $Z_{ij} = 1$ if y_{1i}^* falls in category j (these two probabilities are the same as equations 9 and 10 in Adams et al., 2003). Equations (2) and (3) are jointly estimated by a maximum likelihood estimator. The corresponding reduced-form equation is

$$y_1^* = \alpha_1 + \gamma_1 w + \boldsymbol{\delta}_1 \boldsymbol{x} + \boldsymbol{G} + u_1. \tag{5}$$

If β_1 is positive and statistically significant in the two-equation system maximum likelihood estimate, γ_1 should be positive and significant in the ordered probit estimate of equation (5).

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[14] Errors in retrospectively measured prior support can be significant, and if they are correlated with housing damage in equation (1), the order-probit estimates are biased. In my empirical strategy, measurement errors in prior support, if any, are assumed to be uncorrelated with household flood shock within mataqali.

I consider two sets of household controls: The first set includes social status (a dummy for clan leader),[15] education (a dummy for secondary education of any adults), and demographic factors (household size, the proportion of children/elderly, age of household head); the second set adds asset holdings (fishing capital and land holdings) to the first set. Social status and adult education are fixed effects and demographic factors a year before and at the time of interviews, respectively, are used for prior and current support; current asset holdings are used for both, although distinct from land holdings, fishing capital may change significantly over the course of a year (information of fishing capital a year ago is lacking). Fishing capital can be endogenous, because it is correlated with unobserved household skills and preference for fishing, which determine its support for MPAs; MPAs may also influence household investment in fishing capital. With the lack of a valid identifying variable for fishing capital, I estimate models with and without fishing capital to see how different the remaining estimation results are.[16]

4.2. Estimation results

Estimation results are reported in Table 4 (results of household controls are discussed in the next section).[17] The ordered probit estimates of equation (2) – either without or with household controls – show that housing damage has no significant effects on prior or current

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[15] I call households with leaders with chief, sub-chiefs, or non-chief leader status, as defined above, clan leaders. In the sample, most clan leaders are sub-chiefs or non-chief leaders, as many chiefs, including qoliqoli heads, live in cities.

[16] Asset holdings and demographic factors capture household permanent income; controlling for income is feasible only for current support for MPAs (information of past income is lacking).

[17] Mataqali with no variation in support for MPAs across households are dropped because mataqali dummies perfectly predict the support.

household support for MPAs (panel A). (The results are very similar to each other without and with asset holdings as household controls, and only the former results are shown; the ordered probit estimates of equation 1 with village dummies are also very similar). In contrast, the two-equation maximum likelihood estimates show that the estimated coefficients of housing damage are positive at a 1% significance level for prior support, but not current support, across specifications (the estimated cross-equation correlations are about -.45 for prior support); flood shock – on a normalized five-point scale (with 1 = very large flood) – strongly determines housing damage (panel B), and the ordered probit reduced-form results of equation (5) consistently show that flood shock significantly increases prior support, but not current support (panel A).[18] Estimated marginal effects of housing damage on prior support at the means are positive only for very strong support (5th category) (the point estimates are about .22), and its negative marginal effects on the other four categories are relatively similar to each other; the results for current support are qualitatively the same with very limited statistical significance at conventional levels.

Housing damage is thus endogenous in equation (2); that assuming its exogeneity leads to strong downward bias in its estimated effects suggests a significant positive correlation of unobserved housing quality and household heterogeneity. The nonsignificant effects on the dummy for MPA villages of village-level housing damage (constructed from household-level damage measures) in the village-level regressions discussed above are consistent with the ordered-probit results and also biased for the same reason; the descriptive results in Table 3 do not reflect causality, either. Housing damage mostly affects whether or not the household shows

[18] The estimated cutpoints for prior support with household controls (column 2 of panel B), for example, are -2.4, -2.0, -.96, and .07.

very strong prior support; consistent with social learning from disaster experience, this damage effect diminishes following the collective decision made for MPAs.

5. Robustness check

The robustness check in this section focuses on the binary information about very strong household support for MPAs in the following linear probability model:

$$y_1 = \alpha_1 + \beta_1 y_2 + \boldsymbol{\delta}_1 \boldsymbol{x} + \boldsymbol{G} + u_1, \quad (6)$$

$$y_2 = \alpha_2 + \beta_2 w + \boldsymbol{\delta}_2 \boldsymbol{x} + \boldsymbol{G} + u_2, \quad (7)$$

where y_1 is redefined as an observable 0-1 indicator for very strong prior (or current) support; distributional assumptions for error terms are not made. The endogeneity of housing damage y_2 is controlled for by estimating equation (6) using a two-stage least squares (2SLS) estimator with the first-stage equation (7), where w is an excluded instrumental variable.

OLS and 2SLS estimation results, respectively, reported in Table 5 (where robust standard errors are shown) are qualitatively the same as the ordered probit and two-equation system maximum likelihood results in Table 4, suggesting that the latter results are not conditional on the specification assumptions (e.g., normality, homoscedasticity). Although OLS estimates of the damage effects are not statistically different from zero (panel A), the 2SLS estimates for prior support are over .30 at a 5% significance level, and those for current support are positive but much smaller with no statistical significance (panel B). The first-stage results are strong across specifications – a very large flood increases the probability that housing is damaged by over .40 (the F value of this excluded instrument is over 50). In the corresponding reduced-form models (equation 6 with y_2 replaced with w), the results for prior support, but not current support, are statistically significant – a very large flood increases the probability that the household supports MPAs very much, by about .13.

Estimated coefficients of household controls (corresponding to columns 2, 3, 7, and 8 of Table 5) are reported in Table 6, along with their descriptive statistics. The results are very similar between OLS and 2SLS estimates, buttressing the exogeneity of these controls; when asset holdings are added as additional controls, none of the remaining results change significantly, suggesting that the potential endogeneity of fishing capital is not a major concern for identifying the effects of housing damage.[19] The following statistically significant results are noted. First, households with more children (in proportion) are more likely to show very strong prior support for MPA, suggesting that parents prefer to protect marine resources for their children; that is, they have long-term perspectives on conservation. Along with the diminished damage effect over time, this pattern becomes weaker for current support, suggesting that through social learning, having long-term perspectives becomes more prevalent among households regardless of their demographic composition. Second, in contrast, clan leaders tend to show very strong current support, but not prior support, suggesting that although they are initially neutral about MPAs, they adjust their support to the collective decision. Although this does not tell anything about their leadership in the collective decision, which is controlled for by mataqali dummies, it provides evidence for social learning among local leaders, which could lead to more establishment and better management of MPAs in the future.

Next, I estimate the damage effect at the margin by redefining y_2 as housing damage value (log).[20] Estimation results reported in Table 7 are qualitatively the same as those for the

[19] Interpreting estimated coefficients of fishing capital, some of which are statistically significant, requires caution because of its potential endogeneity discussed above.

[20] Distinct from damage incidence, in which recall errors are minor, measurement errors in damage value can be significant, causing attenuation bias that also can be controlled for in the

damage dummy in Table 5 (the results without asset holdings as household controls are shown). On one hand, OLS estimates are statistically nonsignificant across specifications (panel A). On the other hand, according to the 2SLS estimates, a 10% increase in damage value augments the probability that the household shows very strong prior support for MPAs by about .005 at a 5% significance level; the estimated coefficients of damage value for current support are smaller with no statistical significance (panel B). Flood shock is a strong instrument (a very large flood increases housing damage value by about 300%), and the corresponding reduced-form results are consistent with the 2SLS results.

So far, I have not considered disaster aid as a potential determinant of household support for MPAs. As housing aid is positively correlated with housing damage (targeting), whether this omitted variable causes bias in the estimated damage effects depends on whether it influences household support. With a lack of valid instruments for housing aid, I estimate models with housing aid as an additional exogenous control to see whether the remaining estimation results change significantly. Adding the dummy for aid receipt – more than a year before the interviews in 2005 for prior support and by the time of interviews for current support – to the models with the damage dummy does not significantly alter the remaining results (columns 4, 5, 9, and 10 of Table 5), nor does adding the log amount of corresponding aid received to the models with the damage value significantly change the remaining results (columns 3 and 6 of Table 7); and, both aid receipt and amount are statistically nonsignficant across specifications. Hence, the potential bias caused by omitted disaster aid in the early analyses is unlikely to be significant.

2SLS estimation. Jointly estimating the ordered probit and tobit models for the altered equations (2) and (3) with the damage dummy replaced with damage value (which is 0 for non-victims) encounters convergence problems in the two-equation system maximum likelihood estimations.

6. Conclusion

Using original household survey data in Fiji on the establishment of community-based MPAs following a tropical cyclone, this paper empirically examined whether and how experiencing climate-related disasters can improve the rural poor's adaptation to climate change through community-based resource management. Controlling for the endogeneity of household-level housing damage revealed that household disaster victimization increases the household's support for establishing MPAs for future safety nets. Under Fijian traditional consensual institutions, social learning from disaster experience among community members facilitates their collective decision for conservation to enhance community resilience to climate shocks.

In Fiji, the disaster played a trigger role for systemic improvement (McSweeney and Coomes, 2011), together with external (government/NGO) efforts to promote MPAs integrated with customary resource institutions. Policy interventions in the form of community-based resource management should explore the potential of its inclusionary mechanisms for facilitating community adaptation to climate change through social learning (Tompkins and Adger, 2004). At the same time, more research is needed to examine how large and common such potential is across different local institutions (Agrawal, 2010). That treating disaster victimization exogenously failed to reveal the potential in Fiji exemplifies the critical importance of the identification of causality in natural resource management and conservation.

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References

Aalbersberg, B., A. Tawake, T. Parras, 2005. Village by village: recovering Fiji's coastal fisheries. In: United Nations Development Programme, United Nations Environmental Programme, The World Bank, World Resources Institute (Eds.), World Resources 2005 -- The wealth of the poor: managing ecosystems to fight poverty. World Resources Institute, Washington, D.C., pp. 144-151.

Adams, J. D., E. P. Chiang, J. L. Jensen, 2003. The influence of federal laboratory R&D on industrial research. Review of Economics and Statistics 85, 1003-1020.

Adger, W. N., T. P. Hughes, C. Folke, S. R. Carpenter, J. Rockstrom, 2005. Social-ecological resilience to coastal disasters. Science 309, 1036-1039.

Adger, W. N., S. Huq, K. Brown, D. Conway, M. Hulme, 2003. Adaptation to climage change in the developing world. Progress in Development Studies 3, 179-195.

Agrawal, A., 2001. Common property institutions and sustainable governance of resources. World Development 29, 1649-1672.

Agrawal, A., 2010. Local institutions and adaptation to climage change. In: R. Mearns, A. Norton (Eds.), Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World. World Bank, Washington, D.C., pp. 173-198.

Agrawal, A., 2011. A positive side of disaster. Nature 473, 291-292.

Agrawal, A., C. C. Gibson, 1999. Enchantment and disenchantment: the role of community in natural resource conservation. World Development 27, 629-649.

Baland, J.-M., J.-P. Platteau, 1996. Halting Degradation of Natural Resources: Is There a Role for Rural Communities? Clarendon Press, Oxford.

Bender, A., W. Kägi, E. Mohr, 2002. Informal insurance and sustainable management of common-pool marine resources in Ha'apai, Tonga. Economic Development and Cultural Change 50, 427-439.

Béné, C., 2003. When fishery rhymes with poverty: a first step beyond the old paradigm on poverty in small-scale fisheries. World Development 31, 949-975.

Campbell, J. R., 1984. Dealing with Disaster: Hurricane Response in Fiji. Pacific Islands Development Program, East-West Centre, Honolulu.

Coomes, O. T., Y. Takasaki, C. Abizaid, B. L. Barham, 2010. Floodplain fisheries as natural insurance for the rural poor in tropical forest environments: evidence from Amazonia. Fisheries Management and Ecology 17, 513-521.

Crawford, B., M. Kasmidi, F. Korompis, R. B. Pollnac, 2006. Factors influencing progress in establishing community-based marine protected areas in Indonesia. Coastal Management 34, 39-64.

Endfield, G. H., 2012. The resilience and adaptive capacity of social-environmental systems in colonial Mexico. Proceedings of the National Academy of Sciences of the United States of America 109, 3676-3681.

Eriksen, S. H., K. O'Brien, 2007. Vulnerability, poverty and the need for sustainable adaptation measures. Climate Policy 7, 337-352.

Ferraro, P. J., 2009. Counterfactual thinking and impact evaluation in environmental policy. New Directions for Evaluation 2009, 75-84.

Ferraro, P. J., S. K. Pattanayak, 2006. Money for nothing? A call for empirical evaluation of biodiversity conservation investments. PLoS Biology 4, 483-488.

Folke, C., 2006. Resilience: the emergence of a perspective for social-ecological systems analyses. Global Environmental Change 16, 253-267.

Gjertsen, H., 2005. Can habitat pretection lead to improvements in human well-being? Evidence from marine protected areas in the Philippines. World Development 33, 199-217.

Govan, H., 2009. Status and potential of locally-managed marine areas in the South Pacific: meeting nature conservation and sustainable livelihood targets through wide-spread implementation of LMMAs. Coral Reef Initiatives for the Pacific, New Caledonia.

Hallegatte, S., P. Dumas, 2009. Can natural disasters have positive consequences? Investigating the role of embodied technical change. Ecological Economics 68, 777-786.

Holling, C. S., 1978. Adaptive environmental assessment and management. John Wiley & Sons, New York.

Jodha, N. S., 1986. Common property resources and rural poor in dry region of India. Economic and Political Weekly 21, 1169-1181.

Johannes, R. E., 1978. Traditional marine conservation methods in Oceania and their demise. Annual Review of Ecology and Systematics 9, 349-364.

Johannes, R. E., 2002. The renaissance of community-based marine resource management in Oceania. Annual Review of Ecology and Systematics 33, 317-340.

Lawson-Remer, T., 2012. Do stronger collective property rights improve household welfare? Evidence from a field study in Fiji. Working Paper, New School University.

Lee, K. N., 1999. Appraising Adaptive Management. Ecology and Society 3.

Locally-Managed Marine Area Network, 2006. LMMA Network 2005 Annual Report. LMMA Network.

McKenzie, E., B. Prasad, A. Kaloumaira, 2005. Economic impact of natural disasters on development in the Pacific: Volume 1 Research report. The University of the South Pacific, Suva.

McSweeney, K., 2005. Natural insurance, forest access, and compounded misfortune: Forest resources in smallholder coping strategies before and after Hurricane Mitch, northeastern Honduras. World Development 33, 1453-1471.

McSweeney, K., O. T. Coomes, 2011. Climate-related disaster opens a window of opportunity for rural poor in northeastern Honduras. Proceedings of the National Academy of Sciences of the United States of America 108, 5203-5208.

Moreno-Sánchez, R. d. P., J. H. Maldonado, 2010. Evaluating the role of co-management in improving governance of marine protected areas: an experimental approach in the Colombian Caribbean. Ecological Economics 69, 2557-2567.

Ostrom, E., 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge.

Otsuka, K., F. Place, 2001. Land Tenure and Natural Resource Management. The Johns Hopkins University Press, Baltimore and London.

Paavola, J., W. N. Adger, 2006. Fair adaptation to climate change. Ecological Economics 56, 594-609.

Pattanayak, S., E. Sills, 2001. Do tropical forests provide natural insurance? The microeconomics of non-timber forest product collection in the Brazilian Amazon. Land Economics 77, 595-612.

Pelling, M., 2003. Natural Disaster and Development in a Globalizing World. Routledge, London.

Pelling, M., C. High, 2005. Understanding adaptation: what can social capital offer assessments of adaptive capacity? Global Environmental Change 15, 308-319.

Pelling, M., J. I. Uitto, 2001. Small island developing states: natural disaster vulnerability and global change. Environmental Hazard 3, 49-62.

Plummer, R., D. Armitage, 2007. A resilience-based framework for evaluating adaptive co-management: linking ecology, economics and society in a complex world. Ecological Economics 61, 62-74.

Pollnac, R. B., B. R. Crawford, M. Gorospe, 2001. Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. Ocean and Coastal Management 44, 683-710.

Pomeroy, R. S., B. D. Ratner, S. J. Hall, J. Pimolijinda, V. Vivekanandan, 2006. Coping with disaster: rehabilitating coastal livelihoods and communities. Marine Policy 30, 786-793.

Ravuvu, A., 1983. Vaka I Taukei: The Fijian Way of Life. Institute of Pacific Studies, Suva.

Silva, P., 2006. Exploring the linkages between poverty, marine protected area management, and the use of destructive fishing gear in Tanzania. World Bank Policy Research Working Paper 3831, World Bank, Washington, DC.

Siwatibau, S., 1984. Traditional environmental practices in the South Pacific - A case study of Fiji. AMBIO 13, 365-368.

Skidmore, M., H. Toya, 2002. Do natural disasters promote long-run growth? Economic Inquiry 40, 664-87.

Smit, B., O. Pilifosova, 2001. Adaptation to climate change in the context of sustainable development and equity. In: J. J. McCarthy, O. Canziani, N. A. Leary, D. J. Dokken, K. S. White (Eds.), Climate change 2001: impacts, adaptation and vulnerability. Cambridge University Press, Cambridge, pp. 877-912.

Takasaki, Y., 2011a. Do local elites capture natural disaster reconstruction funds? Journal of Development Studies 47, 1281-1298.

Takasaki, Y., 2011b. Do the commons help augment mutual insurance among the poor? World Development 39, 429-438.

Takasaki, Y., 2011c. Targeting cyclone relief within the village: kinship, sharing, and capture. Economic Development and Cultural Change 59, 387-416.

Takasaki, Y., B. L. Barham, O. T. Coomes, 2004. Risk coping strategies in tropical forests: floods, illness, and resource extraction. Environmental and Development Economics 9, 203-224.

Techera, E., 2008. Customary law and community based conservation of marine areas in Fiji. In: R. C. Hillerband, R. Karlsson (Eds.), Beyond the Global Village: Environmental Challenges Inspirting Global Citizenship. Inte-Displinary Press, Oxford, pp. 107-121.

Tompkins, E. L., W. N. Adger, 2004. Does adaptive management of natural resources enhance resilience to climate change? Ecology and Society 9, 10.

Turner, J. W., 1992. Ritual, habitus, and hierarchy in Fiji. Ethnology 31, 291-302.

Veitayaki, J., 1998. Traditional and community-based marine resources management system in Fiji: an evolving integrated process. Coastal Management 26, 47-60.

Veitayaki, J., 2006. Caring for the environment and the mitigation of natural extreme events in Gau, Fiji Islands: a self-hep community initiative. Island Studies Journal 1, 239-252.

Wade, R., 1988. Village Republics: Economic Conditions for Collective Action in South India. Cambridge University Press, Cambridge.

Walters, C., 1986. Adaptive management of renewable resources. Macmillan, New York.

Westley, F., P. Olsson, C. Folke, T. Homer-Dixon, H. Vredenburg, D. Loorbach, J. Thampson, M. Nilsson, E. Lambin, J. Sendzimir, B. Banerjee, V. Galaz, S. van der Leeuw, 2011. Tipping toward sustainability: emergeing pathways of transformation. AMBIO 40, 762-780.

World Bank, 1999. Voices from the village: a comparative study of coastal management in the Pacific Islands. Pacific Islands Discussion Paper Series 9, World Bank, East Asia and Pacific Region, Papua New Gunea and Pacific Islands Country Management Unit, Washington, D.C.

Table 1. Marine protected areas and marine resource management in Fiji.

	All villages for analysis on MPA	MPA villages	Non-MPA villages	Difference	Standard error of difference
MPAs:					
Reasons for establishing/considering MPAs among MPA villages (0/1)					
Strong village leadership		0.50			
Declined marine resource stock		0.40			
Villagers' good understanding		0.20			
Qoliqoli head's strong support		0.20			
Reasons for not considering MPAs among non-MPA villages (0/1)					
Limited villagers' interests			0.69		
Qoliqoli head's limited support			0.23		
Not good access to sea			0.23		
Lack of technical support			0.15		
Workshop attendance (0/1)	0.28	0.35	0.17	0.18	0.17
Technical support received by MPA villages (0/1)		0.26			
Marine resource management:					
Restricted fishing practices (0/1)					
Gill net	0.48 (0.51)	0.40 (0.50)	0.62 (0.51)	-0.22	0.18
Scuba diving	0.85 (0.36)	0.85 (0.37)	0.85 (0.38)	0.00	0.13
Enforcement of restrictions among villages with restrictions (1: not at all, …, 5: very well)					
Gill net	2.94 (1.06)	3.25 (1.16)	2.63 (0.92)	0.63	0.52
Scuba diving	3.43 (1.00)	3.71 (0.92)	3.00 (1.00)	0.71 *	0.37
Overall management and conservation (1: not at all, …, 5: very well)					
Qoliqoli	3.36 (0.86)	3.60 (0.75)	3.00 (0.91)	0.60 **	0.29
Village	3.36 (0.86)	3.60 (0.75)	3.00 (0.91)	0.60 **	0.29
No. observations	33	20	13		

Note: Standard deviations are shown in parentheses. *10% significance, **5% significance, ***1% significance.

Table 2. Household support for marine protected areas.

A. Five-point scale - percentages (n=632)

		Current support					
		Not at all	A little	Somewhat	Much	Very much	Total
Prior support	Not at all (1)	2.2	1.0	0.0	0.0	0.0	3.2
	A little (2)	0.0	2.4	0.5	0.2	0.2	3.2
	Somewhat (3)	0.2	0.8	11.7	3.5	1.0	17.1
	Much (4)	0.0	0.6	1.7	22.8	6.5	31.7
	Very much (5)	0.0	0.0	0.0	1.3	43.7	44.9
	Total	2.4	4.8	13.9	27.7	51.3	100.0

B. Very strong support (0/1) - percentages (n=632)

		Current support		
		No	Yes	Total
Prior support	No	47.5	7.6	55.1
	Yes	1.3	43.7	44.9
	Total	48.7	51.3	100.0

Table 3. Marine protected areas and disaster.

	All villages in whole sample	All villages for analysis on MPA	MPA villages	Non-MPA villages	Difference	Standard error of difference
Support for MPAs:						
Prior support (1: not at all, …, 5: very much)		4.12 (1.01)	4.30 (0.85)	3.87 (1.15)	0.43 **	0.20
Current support (1: not at all, …, 5: very much)		4.21 (1.01)	4.39 (0.80)	3.95 (1.19)	0.45 **	0.20
Very strong prior support (0/1)		0.45 (0.50)	0.51 (0.50)	0.36 (0.48)	0.15	0.09
Very strong current support (0/1)		0.51 (0.50)	0.56 (0.50)	0.45 (0.50)	0.11	0.09
Disaster damage and aid:						
Housing damage (0/1)	0.62 (0.49)	0.63 (0.48)	0.61 (0.49)	0.66 (0.47)	-0.05	0.07
Housing damage value (F$)	1071 (2136)	1126 (2181)	926 (1908)	1405 (2490)	-480	291
Aid receipt more than a year before (0/1)	0.12 (0.32)	0.13 (0.34)	0.12 (0.32)	0.16 (0.37)	-0.04	0.06
Aid receipt in the past one year (0/1)	0.13 (0.33)	0.13 (0.34)	0.11 (0.31)	0.16 (0.37)	-0.06	0.05
Aid received more than a year before (F$)	450 (1663)	516 (1762)	425 (1652)	643 (1901)	-218	255
Aid received in the past one year (F$)	235 (1168)	244 (1185)	156 (933)	367 (1459)	-211	174
Flood (0/1)	0.44 (0.50)	0.43 (0.50)	0.35 (0.48)	0.55 (0.50)	-0.21 *	0.11
Flood magnitude (0: none, …., 4: very large)	1.23 (1.56)	1.16 (1.49)	0.86 (1.32)	1.59 (1.62)	-0.73 **	0.32
No. observations	906	632	368	264		

Notes: Standard deviations are shown in parentheses. Standard errors of differences are clustered by village. *10% significance, **5% significance, ***1% significance.

Table 4. Damage effects on household support for marine protected areas (five-point scale).

	Prior support (n=588)		Current support (n=564)	
Household controls	No	Yes	No	Yes
	(1)	(2)	(3)	(4)
A. Ordered probit				
Support for MPAs (1-5) (Equation 2):				
Housing damage (0/1)	0.022	0.021	0.050	0.064
	(0.119)	(0.119)	(0.123)	(0.123)
Log likelihood	-631.5	-628.6	-600.8	-597.6
Support for MPAs (1-5) (Equation 5):				
Flood shock (0-1)	0.496 ***	0.535 ***	0.249	0.266
	(0.164)	(0.165)	(0.164)	(0.164)
Log likelihood	-626.9	-623.3	-599.7	-596.4
B. Two-equation maximum likelihood				
Support for MPAs (1-5) (Equation 2):				
Housing damage (0/1)	0.691 ***	0.712 ***	0.519	0.518
	(0.262)	(0.251)	(0.332)	(0.325)
Housing damage (0/1) (Equation 3):				
Flood shock (0-1)	1.685 ***	1.736 ***	1.668 ***	1.717 ***
	(0.241)	(0.245)	(0.244)	(0.248)
Cross-equation correlation	-0.441	-0.459	-0.311	-0.304
	(0.154)	(0.147)	(0.204)	(0.201)
Log likelihood	-887.3	-880.0	-850.3	-843.6
Marginal effects of housing damage on each category at means:				
Not all (1)	-0.045 **	-0.047 **	-0.028	-0.027
	(0.023)	(0.022)	(0.021)	(0.020)
A little (2)	-0.030 **	-0.031 **	-0.031	-0.031
	(0.014)	(0.013)	(0.021)	(0.021)
Somewhat (3)	-0.098 ***	-0.100 ***	-0.067	-0.067 *
	(0.035)	(0.033)	(0.041)	(0.041)
Much (4)	-0.042 ***	-0.043 ***	-0.039 *	-0.039 *
	(0.014)	(0.014)	(0.023)	(0.023)
Very much (5)	0.215 ***	0.221 ***	0.165	0.164
	(0.080)	(0.076)	(0.104)	(0.102)

Notes: Standard errors are shown in parentheses. Household controls are clan leader (0/1), adult secondary education (0/1), household size (0/1), proportion of children (age 0-14), and proportion of elderly (age 66 or above). Other controls not shown here are mataqali dummies and constant. *10% significance, **5% significance, ***1% significance.

Table 5. Damage effects on very strong household support for marine protected areas.

	Very strong prior support (0/1) (n=538)					Very strong current support (0/1) (n=532)				
Household controls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Asset holdings controlled	No	No	Yes	No	Yes	No	No	Yes	No	Yes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. OLS										
Housing damage (0/1)	-0.001	-0.003	0.000	-0.011	-0.010	-0.007	0.002	0.004	-0.002	-0.002
	(0.049)	(0.050)	(0.050)	(0.053)	(0.053)	(0.051)	(0.051)	(0.052)	(0.057)	(0.057)
Aid receipt (0/1)				0.038	0.047				0.009	0.017
				(0.075)	(0.074)				(0.063)	(0.063)
R squared	0.182	0.195	0.204	0.195	0.205	0.181	0.193	0.197	0.193	0.197
B. 2SLS										
Housing damage (0/1)	0.303 **	0.324 **	0.315 **	0.367 **	0.352 **	0.140	0.162	0.162	0.195	0.191
	(0.154)	(0.153)	(0.149)	(0.178)	(0.174)	(0.150)	(0.148)	(0.148)	(0.179)	(0.178)
Aid receipt (0/1)				-0.112	-0.097				-0.079	-0.070
				(0.097)	(0.095)				(0.095)	(0.094)
First stage:										
Flood shock (0-1)	0.433 ***	0.435 ***	0.437 ***	0.380 ***	0.380 ***	0.422 ***	0.424 ***	0.424 ***	0.353 ***	0.353 ***
	(0.058)	(0.059)	(0.060)	(0.058)	(0.058)	(0.056)	(0.057)	(0.057)	(0.053)	(0.053)
Reduced form:										
Flood shock (0-1)	0.131 *	0.141 **	0.137 **	0.139 **	0.134 **	0.059	0.069	0.069	0.069	0.067
	(0.069)	(0.068)	(0.067)	(0.069)	(0.068)	(0.068)	(0.067)	(0.067)	(0.068)	(0.068)

Notes: Robust standard errors are shown in parentheses. Household controls are clan leader (0/1), adult secondary education (0/1), household size (0/1), proportion of children (age 0-14), and proportion of elderly (age 66 or above). Asset holdings are log of fishing capital (F$) and log of land ($m^2$). Other controls not shown here are mataqali dummies and constant. *10% significance, **5% significance, ***1% significance.

Table 6. Controls unreported in Table 5.

	Very strong prior support (0/1)				Very strong current support (0/1)				Means
	Panel A (OLS)		Panel B (2SLS)		Panel A (OLS)		Panel B (2SLS)		(Standard
	(2)	(3)	(2)	(3)	(7)	(8)	(7)	(8)	deviations)
Clan leader (0/1)	0.092	0.097	0.115	0.120	0.194 **	0.202 ***	0.208 ***	0.217 ***	0.09
	(0.080)	(0.080)	(0.076)	(0.075)	(0.078)	(0.078)	(0.074)	(0.073)	(0.29)
Secondary education	0.018	0.021	0.047	0.049	-0.002	-0.002	0.012	0.012	0.83
of adults (0/1)	(0.061)	(0.061)	(0.059)	(0.059)	(0.066)	(0.066)	(0.061)	(0.061)	(0.38)
Household size	-0.007	-0.009	-0.007	-0.010	-0.005	-0.006	-0.006	-0.007	5.7
	(0.010)	(0.010)	(0.009)	(0.009)	(0.011)	(0.011)	(0.010)	(0.010)	(2.7)
Proportion of children	0.262 **	0.261 **	0.245 **	0.244 **	0.116	0.109	0.122	0.114	0.33
(age 0-19)	(0.118)	(0.119)	(0.114)	(0.113)	(0.125)	(0.126)	(0.117)	(0.117)	(0.23)
Proportion of elderly	0.189	0.167	0.164	0.140	-0.160	-0.183	-0.168	-0.192	0.08
(age 66 or above)	(0.151)	(0.152)	(0.143)	(0.142)	(0.133)	(0.133)	(0.123)	(0.123)	(0.19)
Age of household	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	51.2
head	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(14.4)
Log of fishing capital		0.018 **		0.018 **		0.007		0.008	392.8
(F$)		(0.009)		(0.009)		(0.009)		(0.008)	(2634.6)
Log of land (m^2)		-0.013		-0.014		-0.013		-0.014	3.0
		(0.010)		(0.009)		(0.011)		(0.010)	(5.4)

Notes: Panels and columns match those in Table 5. Robust standard errors are shown in parentheses below estimated coefficients. Means of household size, proportion of children and elderly, and age of household head are at the time of interviews; means of fishing capital (F$) and land (acres) are shown; standard deviations are in parentheses below means. *10% significance, **5% significance, ***1% significance.

Table 7. Effects of damage value on very strong household support for marine protected areas.

	Very strong prior support (0/1)			Very strong current support (0/1)		
Household controls	No	Yes	Yes	No	Yes	Yes
	(1)	(2)	(3)	(4)	(5)	(6)
A. OLS						
Log of housing damage value (F$)	0.005	0.005	0.003	0.005	0.005	0.007
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.009)
Log of aid received (F$)			0.004			-0.001
			(0.010)			(0.009)
R squared	0.367	0.375	0.466	0.181	0.194	0.191
No. observations	538	538	532	532	532	526
B. 2SLS						
Log of housing damage value (F$)	0.042 **	0.045 **	0.057 **	0.019	0.022	0.032
	(0.021)	(0.021)	(0.026)	(0.020)	(0.020)	(0.025)
Log of aid received (F$)			-0.023			-0.015
			(0.016)			(0.016)
No. observations	538	538	532	532	532	526
First stage:						
Flood shock (0-1)	3.137 ***	3.171 ***	2.622 ***	3.137 ***	3.168 ***	2.565 ***
	(0.416)	(0.420)	(0.400)	(0.399)	(0.406)	(0.359)
Reduced form:						
Flood shock (0-1)	0.131 *	0.141 **	0.148 **	0.059	0.069	0.081
	(0.069)	(0.068)	(0.070)	(0.068)	(0.067)	(0.069)

Notes: Robust standard errors are shown in parentheses. Household controls are clan leader (0/1), adult secondary education (0/1), household size (0/1), proportion of children (age 0-14), and proportion of elderly (age 66 or above). Other controls not shown here are mataqali dummies and constant. *10% significance, **5% significance, ***1% significance.