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Risk management and coping strategies: climate change and agriculture in the Philippines

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We provide an initial framework to guide government priorities among programs seeking to reduce the natural-disaster vulnerability of Philippine farm households. The framework sheds light on the pros and cons of alternative policies to reduce household vulnerability, paying particular attention to the role of discounting. The limited coping tools available to low-income households strengthen the case for preventive polices that reduce the probability or the severity of damages. We argue, however, that the inability of poor households to cope with increased exposure to risks does not necessarily imply that social insurance programs should be expanded. Finally, inasmuch as disaster risk management policies at the national level typically lack coherent foundations, we suggest how the farm level risk management framework might be expanded to the national level.

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1. Introduction

Given the prominence of natural disasters, promoting public welfare requires sound risk management as well as appropriate economic policies. We provide a framework for government priorities to reduce the vulnerability of Philippine farm households. We begin with the likelihood that climate change will increase the probability of flooding in the Philippines, since rainfall is expected to both increase and be more concentrated (i.e., bring about more storms). Initial

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assessments also suggest that, despite greater mean rainfall, the dry season is likely to become drier.

Climate projections for the Philippines are similar to those for many other parts of the world (e.g., Lansigan, forthcoming; Wilson and Lasco, forthcoming). Using the Intergovernmental Panel on Climate Change for the A1B[2] scenario most relevant for the Philippines, Cinco et. al. [2013] project that the minimum and maximum temperatures will display increasing trends as 2050 approaches. According to this projection, the mean annual temperature is expected to increase by 1.9C to 2.2C by 2050, from the baseline temperatures of 25.5C to 27.6C in 1971-2000.[3]

The increasing mean and concentration of rainfall indicate that the wet seasons of June to August and September to November will become wetter in Luzon and Visayas. On the other hand, the increased rainfall concentration combined with increased temperatures is likely to increase moisture stress in the dry season.

One implication of these climatic changes is that the experience that farmers have heretofore gained about the frequency, duration, strength, and timing of rainfall is less reliable than before. This means that the subjective probability distributions implicit in farmer decision-making are becoming more dispersed and risk is increasing. The frequency of damaging storms may be expected to increase. There is also some evidence of greater frequency of droughts, albeit disputed [Cruz et al. 2007]. The bottom line is that the farmers' past experience becomes less useful as a guide to input decisions and risk management.

The risk-reducing actions available to farm households are limited and may entail reductions in expected profits that would not be rational to undertake (Roumasset [1976, 1979, 2015]; Walker and Jodha [1986]; Walker and Ryan [1990]; Duflo et al. [2008]). Accordingly, the increased risk induced by climate change may reduce farmers' welfare by requiring more costly measures to smooth consumption (e.g., removing children from school) and by increasing the intertemporal variability of consumption.

We want to provide a conceptual framework for understanding risk management and resilience at the household level. Towards this end, we use the Philippine Center for Economic Development Social Protection (PCED-SP) survey [Ravago et al. 2016] data to explain how Philippine farming households cope with natural disasters. At the national level, we ask, "How can public policy be designed to balance the available ex-ante and ex-post controls to maximize expected economic welfare, given the event distribution, with particular attention to disasters and climate change?" At the farm or micro-level, the question is, "How do farmers balance the available risk-reducing and coping instruments to

[2] IPCC's A1B scenario is a world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. It also entails balanced use of fossil and non-fossil energy sources, i.e., balanced across all sources.

[3] These baseline temperatures are the averages of the minimum and maximum temperatures over the indicated period.

maximize their well-being, given the event distribution, with particular attention to climate change and other adverse events?"

In the next section, we review the Philippines' vulnerability to climate change and natural disasters. We then turn to a conceptual framework for understanding resilience at the household level supported by survey evidence about coping strategies among farm households. The framework is then used to shed light on the pros and cons of alternative public policies for reducing household vulnerability.

2. Vulnerability in the Philippines and its effects on the agriculture sector

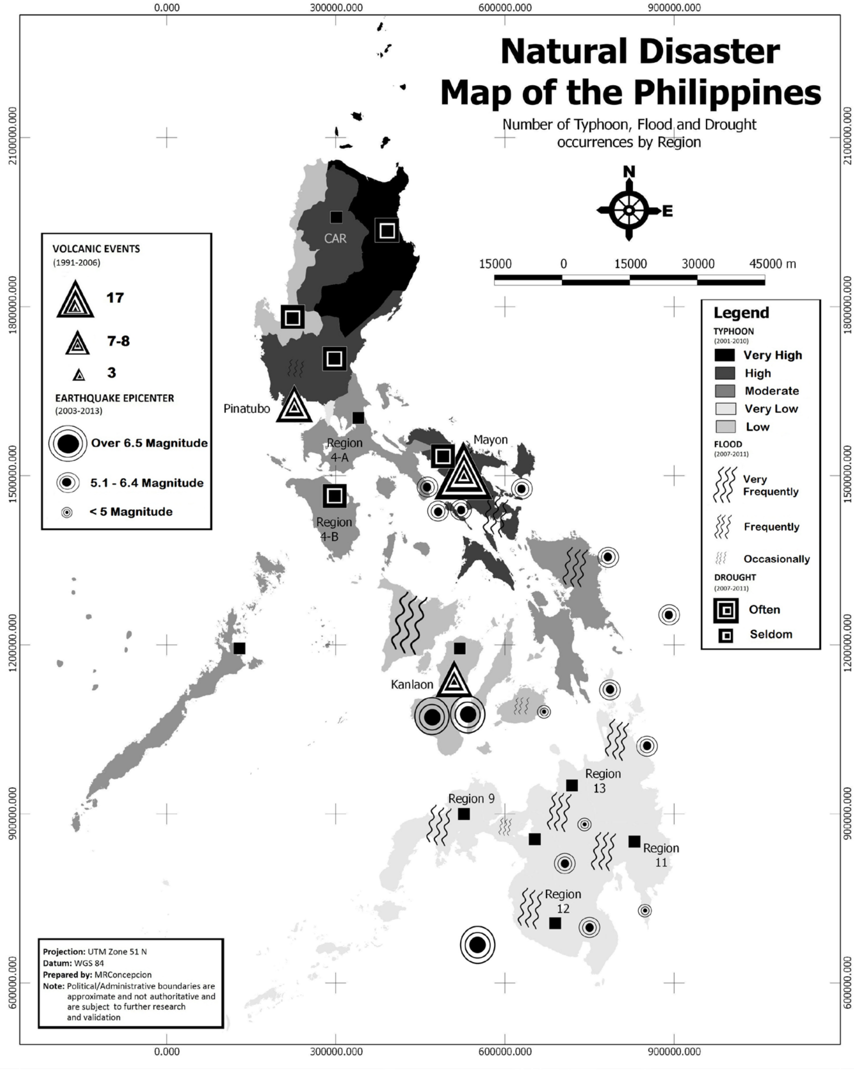
The geographical location of the Philippines exposes it to adverse natural events of extreme intensity. The warm waters of the Western Pacific, normally around 28 degrees, contribute to the formation of typhoons, 18 to 20 of which reach the Philippines each year on average.[4] Historically, Cagayan Valley (Region II), Central Luzon (Region III), and the Cordillera Administrative Region have been particularly vulnerable with about 7 to 9 typhoons crossing over each of these regions annually (Figure 1). Flooding occurs in a number of regions, with Western Visayas registering the highest incidence. Climate change appears to be moving the zone of greatest frequency and intensity southwards (Figure 1, PAGASA, Climate Data Section 2014).

The Philippines also lies within the Pacific Ring of Fire (also known as the circum-Pacific Belt) where most of the earth's volcanic eruptions and earthquakes occur [Sinvhal 2010]. Geophysical events, such as earthquakes and tsunamis, occur with regularity as a result. The Bicol Region, home of the active Mayon Volcano, experienced the greatest number of volcanic eruptions in 1991-2006. Earthquakes of high and moderate magnitude occur mostly in the Central Visayas and Bicol regions (Figure 1).

The Philippines ranks second in the risk index among the global hotspots of disaster risk behind Vanuatu [UNU-EHS World Risk Index 2014]. The same source defines "exposure" according to the population at risk and "vulnerability" to encompass "susceptibility," "coping," and "adaptation". Susceptibility is defined as the likelihood of being harmed if a natural hazard occurs. Coping refers to the ability of societies to lessen the adverse impacts of natural hazards. Adaptation is a long-term process that involves structural changes and strategies to better deal with the negative impacts of natural hazards. As the risk of natural hazards increases, exposure, vulnerability, and susceptibility increase as well.[5]

[4] Storms that develop over the northwestern Pacific Ocean are called typhoons. Those that originate in the South Pacific and over the Indian Ocean are called cyclones. The ones that form over the Eastern Pacific Ocean and the Atlantic Ocean are called hurricanes.

[5] Inasmuch as these definitions are somewhat vague, as are the official definitions adopted by the Philippine government, we suggest an alternative taxonomy in Section 4 that distinguishes between characteristics of vulnerability and the various levels of actions that can be taken to avoid it.

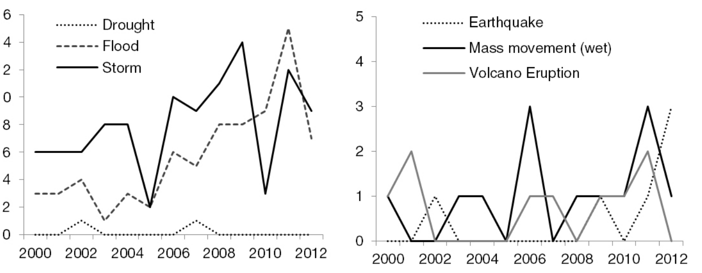


Source of data on typhoons: Philippine Atmospheric, Geophysical and Astronomical Services Administration, climate data section (August 2014)
Source of data on floods and droughts: Department of Agriculture, management information division (August 2014)
Source of data on volcanic events: Philippine Institute of Volcanology and Seismology, volcanology division (August 2014)
Source of data on earthquakes: Philippine Institute of Volcanology and Seismology, seismology division (August 2014)

FIGURE 1. The incidence of natural disasters

Naturally occurring events reach disaster status when they overwhelm local response capacity and cause great damage and human suffering. For a natural hazard to be considered as a disaster by the Centre for Research on the Epidemiology of Disasters[6], the following criteria must be satisfied: ten or more people killed; 100 or more people injured or suffered losses; a state of emergency declared; and a call for international assistance issued.

Figure 2 presents the year-on-year occurrence of selected natural disasters for the period 2000-2012. On the average, seven out of 20 storms that pass through the country annually reach disaster status. The figure suggests a slight upward trend, especially from 2005. The trend would be more pronounced with the inclusion of super typhoon Haiyan (local name: Yolanda) in November of 2013. Disastrous flooding shows an increasing trend over the same period. The data used here does not show any significant increase in droughts, however.



Source of basic data: Emergency Events Database, Centre for Research on the Epidemiology of Disasters

FIGURE 2. Frequency of natural disasters, Philippines

Figure 2 does not show a distinct trend in the incidence of geophysical events, including earthquakes and volcanic eruptions, that have reached disaster status. The slight upward trend since 2005 may be partly a consequence of that year being fortuitously sparse in terms of adverse events and partly because of increased exposure. Even if the incidence of adverse events does not increase, however, those that do occur may reach disaster status more frequently due to greater populations being exposed to harm. At high levels of per capita income, the reverse is likely, because vulnerability can be reduced by various avoidance measures. It is not far-fetched to hypothesize a disaster Kuznets curve, with

[6] The Centre for Research on the Epidemiology of Disasters maintains the Emergency Events Database, the largest database of natural disasters at the country level. The database can be accessed at http://www.emdat.be/country-profile .

disasters first increasing with per capita income (and population) declining. That is, at lower levels of income, the population effect dominates. At higher levels, the effect of greater spending on disaster avoidance becomes greater.

Studies have shown that natural disasters adversely impact different aspects of an economy, from long-run growth rates to natural-resource prices (Cavallo and Noy [2010]; Cavallo et al. [2010]; Skidmore and Toya [2002]; Prestemon and Holmes [2002]). Das [2003] examined both direct and indirect effects on the agricultural sector. Direct effects include the destruction of crops, farm buildings, installations, machinery, equipment, means of transport, stored commodities, cropland, irrigation works, and dams. Indirect effects include the loss of potential production due to increased costs or the decreased availability of some inputs and disruption of the marketing chain.

Agriculture contributes about 10 percent of the Philippines' total output and employs nearly one third of the total labor force [Ravago and Balisacan 2016]. The growth of the sector has been lackluster over the 2000-2010 period, a fact at least partly attributable to the vulnerability of the sector to weather-related shocks. Philippine agriculture has always been heavily affected by natural disasters. Table 1 presents the aggregate value of damage to agriculture commodities from typhoons, floods, and droughts. During the period 2000-2013, total damage amounted to ₱195 billion. The crops that were typically damaged were rice and corn, with a total aggregate damage of ₱86 billion and ₱29 billion, respectively. Fisheries products also recorded significant damages, with an aggregate value of ₱12 million for the same period. Annual value of damages hiked up from 2009-2013. Typhoons Ondoy (Ketsana) and Pepeng (Parma) hit several parts of Philippines in late September and early October 2009, which brought the total annual damage to agriculture to ₱29.5 billion. In 2012, Typhoon Pablo damaged the banana producing areas in the Southern part of the Philippines to the tune of ₱22.2 billion. Aggregate damages to irrigation and other agricultural facilities were estimated to be ₱8.9 billion and ₱15.7 billion, respectively (see Table 2).

TABLE 1. Total value of damage to agriculture due to typhoons, floods, and droughts in the Philippines, by commodity, 2000-2013 (₱ million)

Year	Rice	Corn	HVCC	Banana	Veg	Coconut	Sugarcane	Others	Fisheries	Livestock	Total
2000	1,595	58	352	-	91	47	41	95	358	8	2,644
2001	805	546	359	-	65	0	74	0	255	95	2,200
2002	548	330	115	-	12	0	-	-	127	16	1,150
2003	1,320	1,696	424	-	124	1	-	0	242	49	3,857
2004	1,698	1,436	1,155	-	738	439	-	159	1,906	44	7,576
2005	1,942	2,446	32	-	20	-	-	-	6	0	4,447
2006	3,401	1,179	3,178	-	233	1,115	-	602	1,081	223	11,012
2007	1,882	2,783	376	-	178	0	-	-	89	3	5,311
2008	5,015	1,806	2,283	-	-	1,133	36	12	3,152	246	13,683
2009	23,842	1,418	2,504	-	-	-	-	69	1,597	88	29,519
2010	15,559	8,486	1,108	-	-	-	-	-	303	28	25,484
2011	17,842	2,752	1,185	-	-	-	-	-	859	165	22,804
2012	3,878	1,719	2,036	22,232	-	1,122	-	20	723	369	32,099
2013	7,139	2,770	-	1,493	435	17,746	1,211	542	1,552	828	33,716
Total	86,468	29,426	15,109	23,725	1,895	21,604	1,362	1,500	12,250	2,162	195,501
Average	6,176	2,102	1,079	1,695	135	1,543	97	107	875	154	13,964

Source of data: Department of Agriculture, management information division (August 2014)
Notes: “Abaca, Tobacco, Cassava, Mango, Root Crops, Other Crops, and NFA” are consolidated under “Others”. Average for banana and other crops are based only on one or two years. HVCC is high value commercial crops

TABLE 2. Total value of damage to agricultural facilities and irrigation due to typhoons, floods and droughts in the Philippines, 2000-2013 (₱ million)

Year	Agricultural facilities, infrastructure, and equipment	Irrigation
2000	0.23	0.23
2001	880.21	880.21
2002	31.35	31.35
2003	11.66	11.66
2004	636.13	636.13
2005	-	-
2006	1,287.17	1,287.17
2007	2.62	2.25
2008	1,865.86	1,697.50
2009	190.01	
2010	167.92	1,279.99
2011	241.72	2,143.55
2012	82.72	1,735.98
2013	3,508.41	2,181.15
Total	8,905.99	15,747.56
Average	636.14	1,124.83

Source: Compiled by authors from Department of Agriculture, management information division (August 2014).

In 2013, the country experienced a typhoon which was the most destructive since the turn of the new millennium. Super typhoon Yolanda devastated Visayas and resulted in losses of ₱571 billion to the national economy. The damage to the agriculture sector was ₱62 billion (see Table 3).

TABLE 3. Total value of damage and loss to the economy by typhoon Yolanda

Sector	Damage and loss (P million)				
	Damage		Loss		Total
	Public	Private	Public	Private	
Infrastructure sectors	16,024.30	4,285.00	7,108.40	6,565.40	33,983.10
Electricity	5,329.30	1,500.00	4,575.20	4,126.40	15,530.90
Roads, bridges, flood control, and public buildings	4,255.20	-	322.90	-	4,578.10
Transport	6,010.80	216.00	24.30	-	6,251.10
Water and sanitation	429.00	2,569.00	2,186.00	2,439.00	7,623.00
Economic sectors	3,743.50	67,560.00	87.00	106,716.60	178,107.10
Agriculture	3,743.50	27,560.00	87.00	30,716.60	62,107.10
Industry, services	-	40,000.00	-	76,000.00	116,000.00
Social sectors	23,175.30	305,472.10	3,442.30	22,628.80	354,718.50
Education	17,953.50	3,726.20	1,303.90	916.30	23,899.90
Health	1,170.80	1,959.90	1,932.40	510.50	5,573.60
Housing	4,051.00	299,786.00	206.00	21,202.00	325,245.00
Cross-sectoral	4,000.00	-	300.00	-	4,300.00
Local government	4,000.00	-	300.00	-	4,300.00
Total (P million)	46,943.10	377,317.10	10,937.70	135,910.80	571,108.70
Total (US$ million)	1,063.60	8,549.20	247.80	3,079.40	12,940.00

Note: Data from some sectors are incomplete due to ongoing field assessments. These are indicated in the sectoral sub-sections.
Source: Reconstruction Assistance on Yolanda, National Economic and Development Authority [2013]

Israel and Briones [2012] estimated the consequences of typhoons, floods and droughts for agriculture using the Agricultural Multi-Market Model for Policy Evaluation. This model is an 18-sector partial equilibrium production model suitable for understanding the underlying economic fundamentals, in contrast to predicting market movements. The study illustrates how initial damages have substantial cascading effects on local production and consumption through prices, incomes, and marketing chains.

3. Disaster management capacity in the Philippines

Given the history of natural disasters experienced in the Philippines, it is not surprising that disaster risk management in the country can be traced back to the 1930s during the Commonwealth Period. The principal office in-charge was the Civilian Emergency Administration, created by Executive Order (EO) 355. This office, through the National Emergency Commission, was mandated to formulate and execute policies and plans for the protection and welfare of the civilian population under extraordinary and emergency conditions. From thereon, other laws were passed creating—or renaming—the agency in-charge of disaster risk management. The National Disaster Coordinating Council (NDCC) was created by Presidential Decree 1566 in 1978 to coordinate and supervise disaster management in the country. It was composed of Secretaries of various national agencies and chaired by the Secretary of National Defense. In its three decades of existence, the NDCC shifted from reactive emergency management to more proactive and comprehensive disaster risk management. This resulted in disaster risk management being integrated into the country's development agenda.

In July 2009, the Congress passed Republic Act (RA) 9729, also known as the Climate Change Act [2009]. The objective is to mainstream climate change into the formulation of government policy by establishing a National Framework Strategy and Program on climate change. The same law created the Climate Change Commission (CCC) with the mandate of coordinating, monitoring and evaluating the programs and action plans of the government relating to climate change. The CCC is a national government agency attached to the Office of the President. Executive Order 888 was signed in 2010, adopting the Strategic National Action Plan (SNAP) on Disaster Risk Reduction (DRR) through 2019. SNAP is intended as a road map for sustaining disaster risk reduction initiatives in the country and promoting good practices of individuals, organizations, local government units and the private sector. The same executive order also institutionalizes DRR planning by all government agencies.

Shortly after the signing of Executive Order 888, NDCC was reconstituted into the National Disaster Risk Reduction and Management Council (NDRRMC) by the passage of RA 10121 [2010]. The law gives NDRRMC functions of policy-making, coordination, integration, supervision, monitoring and evaluation on matters related to disaster risk management. The secretary of national defense chairs the body, with the secretaries of interior and local government, social welfare and development, science and technology, and socio-economic planning serving as vice-chairs.

After the institutionalization of DRR and the creation of NDRRMC, Administrative Order No. 1 was issued directing local government units (LGUs) to adopt and use the DRR Guidelines. NDRRMC and the CCC coordinate their activities under a Memorandum of Understanding to harmonize local climate change action plans and local disaster risk reduction management plans by the

LGUs. The National Economics and Development Authority (NEDA) is tasked to conduct capacity-building activities that integrate DRR into planning of the local, regional, and national level government offices. Cognizant of geographical considerations, the government incorporated spatial considerations in the Midterm Update Philippine Development Plan 2011- 2016 [NEDA 2013]. The Midterm Update defined the geographic focus of government interventions based on the following: Category 1: the number or magnitude of poor households in the province; Category 2: the provincial poverty incidence, or the proportion of poor individuals to the provincial population; Category 3: the vulnerability of the province to natural disasters (floods and landslides, in particular). Table 4 lists the provinces in Category 3 many of which lie along the country's eastern seaboard facing the Pacific Ocean. When natural disasters hit these provinces, the marginally non-poor can easily slide into poverty.

Despite the history of disaster management in the country, the Philippines' ability to efficiently and systematically respond to disaster is concededly still a work in progress. Several constraints and issues hamper disaster risk management in the country [NDRRMC 2011]: 1) ineffective vertical and horizontal coordination among member agencies; 2) limited coverage by governmental and partner organizations due to resource constraints; 3) ineffective LGU capacities such as the lack of managerial and technical competencies; 4) limited funds, equipment and facilities for monitoring and early warning; 5) insufficient hazard and disaster risk data and information; 6) inadequate mainstreaming of disaster risk management in development planning and implementation; 7) poor enforcement of environmental management laws and other relevant regulations; and 8) inadequate socioeconomic and environmental management programs to reduce the vulnerability of marginalized communities.

TABLE 4. Philippine Development Plan midterm update Category 3, provinces exposed to multiple hazards

Region	Province
Region I: Ilocos	Ilocos Norte, Ilocos Sur
Cordillera Administrative Region	Abra, Benguet
Region II: Cagayan Valley	Cagayan, Quirino, Isabela, Nueva Vizcaya
Region III: Central Luzon	Zambales, Pampanga, Aurora
Region IV-A: CALABARZON	Cavite, Laguna, Rizal, Quezon
Region V: Bicol	Albay, Catanduanes
Region VI: Western Visayas	Antique,Iloilo
Region VII: Central Visayas	Bohol
Region VIII: Eastern Visayas	Eastern Samar, Leyte, Northern Samar, Southern Leyte
Region IX: Western Mindanao	Zamboanga del Sur, Zamboanga Sibugay
Region XIII: Caraga	Dinagat Islands, Agusan del Sur, Surigao del Norte, Surigao del Sur

Note: A number of these provinces are included in the Hazards Mapping and Assessment for Effective Community-Based Disaster Risk Management Project, NDCC 2006-2011.

The most severe test to data of the country's disaster management and response capacity was when super typhoon Yolanda hit the country in November 2013. Protocol called for post-disaster needs assessment before formulating a recovery plan. Given the extent of the damage (Table 3) and the size of the affected area, however, it was found that six months would have been required to complete a reconstruction and recovery plan if protocol were followed, resulting in unacceptable expense and impact on people's lives. As an expedient, the government through the NEDA, and with assistance from foreign partners, instead prepared an organized framework to restore the economic and social conditions in the affected areas to pre-Yolanda levels while strengthening their resilience to disaster [NEDA 2013].

Studies suggest a very high rate of return to investment in disaster preparedness. Kelman and Shreve [2013] find US$3 to US$30 worth of benefits (avoided damages) for every dollar of investment depending on the type of disaster or hazard. Improvements in the country's disaster preparedness are urgent, given the projected increased in both the occurrence and intensity of extreme natural events. But better national policies require a framework for natural disaster risk management at the national level as well as risk management at the farm level. We develop these in the following section, after which we provide empirical evidence based on a survey of farm households.

4. A framework for natural disaster risk management

Disaster risk management as espoused and practiced will often appear *ad hoc* and ambiguous especially from the viewpoint of the theory of decision making under uncertainty [Alexander 2013]. For example, some approaches to disaster risk management relate to reducing vulnerabilities without considering the full range of possible outcomes and their likelihoods. This can only lead to sub-optimal strategies inasmuch as the benefits of risk reduction must be weighed against the opportunity costs of strategies foregone. On the other hand, the standard theory of decision making under uncertainty typically relates to a single decision, given a distribution of outcomes for each value of the decision variable. In contrast, the objective of disaster management is to select a sequential portfolio of management strategies as illustrated in Figure 3.

We assume a probability distribution over the levels of an event, e.g., a typhoon, or an earthquake. The national policy problem is to select a strategy corresponding to actions taken at the levels represented by the ovals in Figure 3. The rectangles following each action represent distributions and/or summary statistics thereof.

To avoid the frequent confusion surrounding the definitions of terms, it is useful to note that "mitigation" and "coping" are verbal nouns referring to possible actions, while "risk", "vulnerability", and "resilience" are abstract nouns referring to characteristics of prior and posterior probability distributions. Whereas the official government definition lumps all mitigation actions together, Figure 4 distinguishes actions according to the stage at which they are taken. This should not be understood to mean that actions can be recursively determined. Instead, a complete risk management strategy determines actions simultaneously. For example, the extent of preventative zoning and the strictness of building codes depend on the distribution of event risks and the costs of subsequent coping and other possible actions.

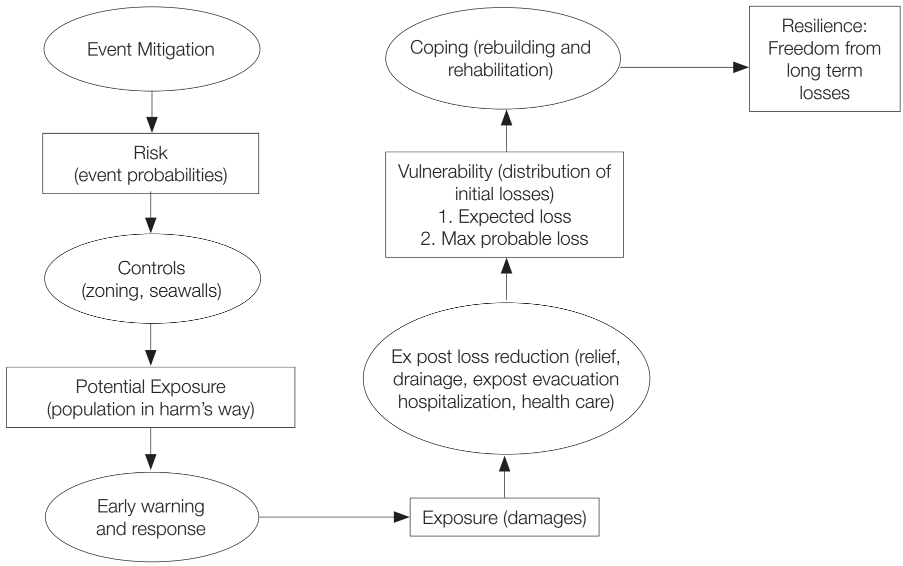


FIGURE 3. Natural disaster risk management

In what follows, we regard event mitigation as not possible or exogenous, an example being the mitigation of climate change for a small economy such as the Philippines. Event risks are thus exogenous probabilities that an event exceeds critical levels (e.g., rainfall, wind speed, Richter levels). Events of varying severity are often characterized, for example, as occurring once in ten years, once in 100 years, and so on. Given "controls" such as seawalls, building codes, zoning requirements, and the like, event risk can be translated into the distribution of potential exposure. This relates metrics of potential damages, e.g. fatalities, to various adverse states of the world and their probabilities. A summary statistic of potential exposure may then be the sum of the number of fatalities in each adverse state multiplied by their respective probabilities, i.e. expected loss. The decision maker then chooses some controls, for example early warning technology and protocols, such that the distribution of actual exposure is more favorable than that of potential exposure. Ex-post evasive action includes emergency dredging, repairs, and additional evacuation. Vulnerability refers to the distribution of initial losses. It is a "risk of loss" measured by probabilities that loss exceeds critical levels, expected loss, or loss at the lower end of the density function (e.g. the severity of a "100-year event"). Resilience is then defined to be "security," for example one minus the probability of sustaining losses greater than a particular threshold. The risk that losses above critical levels are sustained beyond particular lengths of time is therefore an integral of the joint frequency distribution of loss and time—above a particular loss and beyond a particular length of time. Coping is the intervening set of actions that reduces sustained losses, i.e. increases resilience, for example, actions that smooth consumption, e.g., borrowing, relief/rehabilitation.

Choosing an optimal strategy then involves finding the least cost combination of strategies at each level of avoidance. The difficulty of optimization is due to the interdependence of the various levels of risk reduction. The extent of risk reduction at one level depends on how much risk has been reduced at prior levels. Optimal risk reduction at early levels also depends on the capacity to reduce risk at higher levels. In particular, the ability of governments or farm households to cope with risks depends on prior decisions. For example, drawing down savings as a way of coping with a disaster depends on savings behavior in previous periods. In this sense, optimal coping strategies involve prior planning as well as ex post actions.

A search algorithm is needed to solve for the least cost set of strategies for a single security system, e.g., by backwards induction. One could conceivably solve for optimal ex post coping for each of many vulnerability distributions and then go backwards, solving for ex post relief for various exposure distributions and so on. Given the huge number of potential strategies and the difficulty of establishing all the consequences, this task can become extremely complex, and we are unaware if even a hypothetical problem of this sort has ever been solved. This is presumably one reason why actual disaster risk management appears *ad hoc*. Nonetheless, it is useful to describe an idealized procedure before deciding what compromises are needed in practice.

At the farm level, disaster risk management can be collapsed into two sets of controls: those for reducing risks, and those for coping with risks (Figure 4). Risk reduction encompasses all aspects of farming technique. By their choice-of-technique, including capital formation and diversification, farmers are implicitly choosing a probability distribution of outcomes. Risk-reduction strategies consist of actions that reduce the extent of damages in bad times (e.g., choice of crop, variety, planting date, and pest control) and actions that reduce portfolio risk (e.g., crop and employment diversification and the use of multiple planting dates). These strategies can be reduced to a relationship between a "premium," i.e., the sacrifice in expected income and the amount by which risk is reduced (see numerical illustration in the next section).

We view the choice of coping strategy here as an ex ante decision involving precautionary mechanisms such as saving and insurance that can be used to smooth consumption in the face of adverse events. Saving includes the purchase of durables that can be resold if necessary. Insurance includes the cultivation of relationships or social capital that can be drawn upon in hard times [Walker and Jodha 1986]. Ex-post coping actions involve the execution of precautionary strategies, e.g., cashing in savings or insurance and borrowing from relatives and friends.

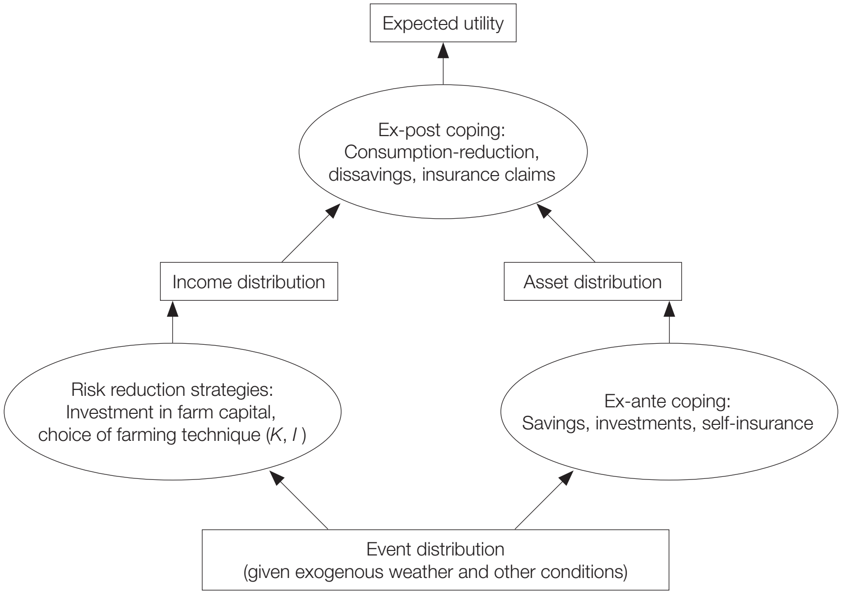


FIGURE 4. Farm-level risk management

5. Farm household risk management

The challenge lies in integrating risk management and coping strategies into a single decision-making framework. We consider a two-period model with a single stage of decisions, e.g. precaution without the *ex post* part of coping.[7] On-farm capital, K, is subject to damage with probability π. The production function in the undamaged state is AK^{α}. In the damaged state, production is θAK^{α}, $0 \leq \theta \leq 1$. At time 0, the household decides whether to augment its endowment, W, by borrowing B, and how to allocate its augmented endowment between farm capital (K), other investments (N), and initial period consumption (C_0). The budget constraint is $W_0 + B = C_0 + K + N$. We assume that borrowing rates are higher than lending/investment rates so that if $B > 0$, $N = 0$ and vice versa. The borrowing rate is denoted by r while the rate of return of other investments is given by ρ.

The household's problem is to maximize expected utility, V, i.e:

$$\max_{K,N,C_0} V = U(C_0) + \beta EU(C_1)$$

subject to the budget constraint: $C_0 + K + N = W_0 + B$

[7] *Ex post* coping could be included in a two-period model by allowing the farm household to sell undepreciated capital (at a discount) and/or to enjoy a terminal value of undepreciated capital that has not been sold. This would further complicate the analysis.

where β is the discount factor (inverse of one plus the discount rate).

Consumption in period 1, C_{1j}, is state-dependent, i.e.,

$$C_{11} = \theta AK^{\alpha} + (1+\rho)N - (1 + r)B$$

and

$$C_{12} = AK^{\alpha} + (1+\rho)N - (1 + r)B$$

where j =1,2 denote the bad and good states respectively.

Thus, the expected utility function, V, can be expanded as

$$V = U(W_0 + B - K - N) + \beta\pi U(\theta AK^{\alpha} + (1 + \rho)N - (1 + r)B) + \beta(1 - \pi)U(AK^{\alpha} + (1 + \rho)N - (1 + r)B)$$

A first-order condition for this problem is:

$$\frac{\partial U/\partial C_0}{\beta(\pi\theta\,\partial U/\partial C_{11} + (1 - \pi)\partial U/\partial C_{12})} = \alpha AK^{\alpha - 1}$$

The left-hand side, $U'(C_0)/\beta E[U'(C_1)]$, is the marginal rate of substitution between current and future consumption, where the latter is given in expectations form. The right-hand side is the marginal product of capital in the undamaged state, $\alpha AK^{\alpha - 1}$. This Ramsey-type equation governs optimal saving. As shown by Gollier [2013], the household discount rate is given by the marginal product of capital in the good state $\alpha AK^{\alpha - 1}$, adjusted downward for a term reflecting precaution. A household with greater impatience, i.e., with a lower discount factor, must have a lower marginal product of capital. This implies greater consumption and less capital formation, a potential factor that increases the difficulty of the poor in climbing out of poverty.

The second first-order condition is:

$$\alpha AK^{\alpha - 1} \frac{(\pi\theta\,\partial U/\partial C_{11} + (1 - \pi)\partial U/\partial C_{12})}{(\pi\,\partial U/\partial C_{1} + (1 - \pi)\partial U/\partial C_{12})} = 1 + \rho = MEI$$

This equation says that the optimal composition of farm and non-farm investments is determined by the condition that the expected-utility-weighted marginal product of farm capital K is equal to the marginal efficiency of non-farm investments.

Even this simplified framework is too complicated to yield unambiguous comparative statics regarding the increase of risk and risk aversion on saving and the composition of investments. For that we turn to a numerical analysis of an alternative model that includes the option to lower the variance of farm output at some sacrifice to mean output, analogous to purchasing insurance.

Our farm household now has three instruments to control current consumption (period 0) and consumption in each of two states at period 1. It can make on-farm investments (farm capital, K) and off-farm investments (N), and it can invest in "insurance" (I). I represents the envelope of various forms of diversification and self-insurance encompassing activities that lower the variability of household income at some cost, e.g., the application of pesticide. At time 0, the household decides on whether to augment its endowment, W, by borrowing, B, and how to allocate its augmented endowment to farm capital (K), insurance (I), other investments (N), and initial period consumption (C_0).

The budget constraint faced by the agent is:

$$W + B = C_0 + K + I + N \tag{1}$$

All other variables are as previously defined; in particular, the borrowing rate for capital is denoted by r; the return on off-farm investments is ρ.

Output in period 2 is given by the stochastic production function $y = \theta A K^{\alpha}$, where θ takes the form $\theta = ½ \pm d/(1 + hI)$. Thus, "investments" in I reduce the variability of output y. The variable h reflects the "attractiveness" of insurance while the parameter d reflects how output will vary. For example, if $d = ½$ and $h = 2$, θ goes from ½ ± ½ to ½ ± ⅙ as I goes from 0 to 1. That is, θ becomes more tightly distributed around ½ as I increases.

Consumption in period 2 is state contingent; C_{11} denotes consumption in the bad state, and C_{12} denotes consumption in the good state.

$$C_{11} = AK^{\alpha}\,[½ - d/(1 + hI)] + [1 + \rho]N - [1 + r]B \tag{2}$$

$$C_{12} = AK^{\alpha}\,[½ + d/(1 + hI)] + [1 + \rho]N - [1 + r]B \tag{3}$$

The household's utility function in each period is of the constant relative risk aversion form: $U(C)=C^{(1-\eta)}/(1-\eta)$. The parameter η is equivalently the coefficient of relative risk aversion, the absolute value of the elasticity of marginal utility of consumption, and the preference for smoothing (inverse of the intertemporal elasticity of substitution).

The household's problem is to choose the level of K, I, and N to maximize its expected utility (V) subject to the budget constraint (1). That is, the agent's problem is:

$$\underset{K,I,N}{\text{Max}}\ V = U(C_0) + \beta \text{EU}(C_1) \tag{4}$$

where $EU(C_1) = \pi U(C_{11}) + (1 - \pi)U(C_{12})$ and π is the probability of a bad state subject to $W + B = C_0 + K + I + N$ and non-negativity conditions for consumption in any state.

We consider two coefficients of relative risk aversion, depending on whether the agent is risk neutral or risk averse. The corresponding two-period utility functions for these risk aversion coefficients are

$$\eta = 0 \Longrightarrow V = C_0 + \beta E(C_1)$$

$$\eta = 2 \Longrightarrow V = -1/C_0 - \beta E(1/C_1)$$

In what follows, we provide a numerical example to highlight some interesting cases where endowment falls (where agents have the option to borrow) and when the probability of a bad state changes. These are intended to illustrate the interaction of coping and risk taking and how these are affected by preferences and opportunities.

We first examine a high endowment scenario. The assumptions and parameters used follow:

- $W = 10$
- $\beta = 0.97$
- $A = 6$
- $\alpha = 2/3$
- $d = 0.5$ and $h = 2$. First period consumption is therefore:
- $C_{1i} = 6\ K^{2/3}\ (½ \pm 0.5/(1 + 2I)) + [1 + \rho]N$
- Rate of return on off-farm investment: $\rho = 0.4$.

We examine cases where the probability of a bad state is low, that is, $\pi = ⅓$ and the case where the probability increases to ½.

Table 5 shows the results for the high endowment scenario. For the risk-neutral case, current consumption (C_0) and consumption in the bad state (C_{11}) are very low. Without the need for smoothing, the household's best strategy is to put its eggs into the future good-state (C_{11}) basket. It does this by saving and investing in K and N.

As the preference for smoothing (η) increases, the sum of K, I, and N decreases in order to increase current consumption. Also, increasing the proportion of safe and risk-reducing assets (N and I), relative to K, increases bad-state consumption.

TABLE 5. High endowment scenario

Probability of a bad state	Risk neutral (η=0) Low (1/3)	Risk neutral (η=0) High (1/2)	Risk averse (η=2) Low (1/3)	Risk averse (η=2) High (1/2)
K	6.91	2.92	1.09	0.71
I	0.00	0.00	0.13	0.14
N	3.09	7.08	2.93	3.49
***K* / (*K*+*I*+*N*)**	0.69	0.29	0.26	0.16
***I* / (*K*+*I*+*N*)**	0.00	0.00	0.03	0.03
***N* / (*K*+*I*+*N*)**	0.41	0.71	0.71	0.80
C_0	Negligible	Negligible	5.84	5.65
C_{11}	4.33	9.92	4.78	5.42
C_{12}	26.09	22.16	9.79	9.15
Coefficient of variation (Consumption)	1.38	1.04	0.26	0.31
V	18.27	15.56	–0.30	–0.32

Source: Authors' calculations

As the probability of disaster increases, *K* becomes more vulnerable to damage so that agents increase the allocation of savings to the safe asset because of its higher expected rate of return. Agents with higher risk aversion increase proportion of their portfolios in *N* even more than risk-neutral agents in order to smooth consumption towards the bad state.

In short, without a preference for smoothing, the expected utility maximizing solution of the household is to invest heavily in high-payoff farm capital, which results in large consumption in the good state and low consumption in the current period and in the bad state. As risk or the preference for smoothing increases, the household adjusts its portfolio towards safer investments. An increased probability of disaster decreases current consumption, affording higher savings and an increased percentage of savings going to off-farm investments. The latter effect dominates the former such that investment in vulnerable capital decreases. Risk-reducing techniques represented by *I* again increase with risk but only slightly.

We now consider a low endowment scenario wherein our household can borrow to finance investment in farm capital and use risk-reducing techniques. As before, we disallow any strategy that risks negative consumption in the bad state. In effect, this augments the nature of risk aversion. Not only does the household hate to lose more than it likes to gain, according to the coefficient of risk aversion, but it is not allowed to violate a subsistence constraint.[8]

[8] Chetty and Looney [2006] suggest that households closer to subsistence are necessarily more risk averse. This is not true inasmuch as a consumption threshold may make households more desperate (Roumasset [1976]; Banerjee [2000]). To the extent that a subsistence constraint is important, it should be directly manifested in the model, not buried under the rug of risk aversion. This construct is also representative of an endogenous borrowing constraint; the lender does not lend an amount that risks a high probability of default.

With low endowments, agents have the option to borrow at a constant rate *r*, which is assumed to be higher than the rate of return for non-farm investments. Since the shadow price of loanable funds is *r* for this case, non-farm investment is zero. We assume that endowment is set to 1 and all other parameters are the same as in the previous scenario.

Table 6 presents the simulation results of the low endowment scenario. In the risk-neutral case, the agent borrows to finance the possibility of high consumption in the good state. However, risk-averse agents in this particular example do not borrow at all. These agents put almost half of their endowment into *K* and *I* and just over half for current consumption. This leaves future consumption in the bad state to be more than half of the amount as current consumption, with future consumption in the good state much higher. The composition of savings also changes in favor of risk reduction.

TABLE 6. Low endowment scenario

	Risk neutral (η=0)		Risk averse (η=2)	
Probability of a bad state	**Low (1/3)**	**High (1/2)**	**Low (1/3)**	**High (1/2)**
K	1.0000	1.0000	0.254	0.263
I	0.0000	0.0000	0.195	0.223
B	negligible[a]	negligible[a]	0.00	0.00
***K* / (*K*+*I*+*N*)**	1.0000	1.0000	0.57	0.54
***I* / (*K*+*I*+*N*)**	0.0000	0.0000	0.43	0.46
C_0	0.0001[a]	0.0001[a]	0.55	0.51
C_{11}	0.0000	0.0001	0.34	0.38
C_{12}	5.9999	5.9995	2.071	2.086
Coefficient of variation (Consumption)	1.73	1.73	0.96	0.95
V	4.0414	3.523	–3.09	–3.45

Source: Authors' calculations

[a] Although optimal borrowing in the risk-neutral case is very small, it is slightly greater in the high-probability case.

Increasing the probability of disaster has surprisingly little effect on household choice. On the one hand, the household is tempted to reduce investment in *K* in response to its increased vulnerability. On the other hand, the household needs *K* in order to provide for consumption in the future bad state. In our simulation, the latter effect outweighs the former and thus *K* increases slightly. As expected, the increased risk of disaster is reflected in lower expected utility for both the risk-neutral and risk-averse households.

Low-income households that are less patient, i.e., have lower discount factors, will consume more in the current period and allocate less to capital formation. This poses an additional barrier to climbing out of poverty.

In summary, we have shown that as the smoothing parameter η increases, high endowment agents will invest less in on-farm capital and more in off-farm capital to help smooth consumption between the good and bad states. The ability to undertake off-farm investments mitigates the need to employ risk-reducing measures on the farm. Low endowment households, on the other hand, borrow and invest in capital until its return in expected utility terms is equal to the cost of borrowing. They do not invest in off-farm investments, given the higher borrowing rate. Even risk-averse households do not avail themselves of off-farm investments because the expected marginal utility from capital is higher at low investment levels. Increased risk aversion does however result in higher levels of "insurance" as a device to smooth consumption between good and bad states.

In other words, there may be little that low-income households can do in response to increased vulnerability. This does not imply, though, as suggested by Chetty and Looney [2006], that there is a strong case for government-subsidized social insurance. Resources may actually be better spent on removing the underlying causes of poverty such as low agricultural productivity and transaction costs that tend to isolate disadvantaged areas.

Even the ex-ante risk management considered in this section involves non-trivial computations. A more complete model would allow for both *ex ante* and *ex post* coping strategies. This could be done in a three-period model, where the household makes consumption and investment decisions in both periods 0 and 1. If the adverse event occurs, the household engages in some belt-tightening by cutting back on consumption and investment, augments income by giving up some leisure, and borrows and/or sells durable assets. Alternatively, an augmented two-period model could be used, as suggested in footnote 7.

6. Farm-level risk management: empirical evidence

We use farm household data from the baseline survey of the PCED-SP survey conducted in May-June 2014 [Ravago et al. 2016]. The purpose of the PCED-SP survey is to investigate the full spectrum of shocks and to examine how these households cope with shocks. The survey covered 32 types of shocks, defined as adverse events that reduce welfare, including health and economic shocks and shocks caused by naturally occurring events. The survey collected information on the demographic characteristics, income and expenditures, assets and housing characteristics, vulnerability to shocks, and the coping mechanisms the household employed, and participation in and utilization of social protection programs by the sample households. The survey used a multi-stage cluster sampling design with a nationally representative sample of 3,100 households that were randomly drawn from 57 out of the 80 provinces of the Philippines. The 57 provinces were chosen such that both high- and low-risk areas (in terms of weather conditions, population density, and security issues) were represented. The sample includes at least one province per region.

6.1. Stylized facts

Table 7 shows the economic profile of household respondents. Out of 3,100 households surveyed, 834 farm households were identified. A farm or agricultural household is defined to be any of the following: owner/non-owner of the land who is responsible for making day-to-day decisions in operating the holding, including the management and supervision of hired labor; owner/non-owner of the land who works on the land alone or with members of the household; owner of the land who does not work on the land but employs others to do so; self-employed working in a farm; employer in own family-operated farm receiving or not receiving cash or share of farm output; entrepreneur engaged in crop farming or gardening and livestock and poultry raising. About 31 percent of farm households sampled are in the poorest quintile.

TABLE 7. Economic profile of household respondents

	Count	Average	Number of farm households	Percentage of farm households
1 - Poorest	620	10,079	190	31
2	620	18,191	173	28
3	620	26,385	174	28
4	620	38,888	148	24
5 - Richest	620	75,756	149	24
Total	3,100	33,860	834	

Note: Constructed based on average per capita expenditure

Natural events of extreme intensity are classified as follows: frequently occurring natural events, where the reference period of recall is January 2009 up to the time of the survey; and less frequently occurring events, where the reference period is from 1980. Frequently occurring natural events of extreme intensity include damaging winds and rain, flooding, landslides, drought, extreme heat, big waves (including tsunami and storm surge), biological hazards, and crop losses from pests and diseases. Earthquakes and volcanic eruptions are classified as less frequently occurring natural events. The nature of the coping mechanisms used for frequently versus less frequently occurring events differs markedly, as do policy actions. Charveriat [2000] noted that public investments in preparedness for the more frequent events are typically undertaken because the realization of benefits accrues while those in power are still serving their time. In this paper, we focus primarily on the shocks arising from frequently occurring natural events and investigate the household coping mechanisms used.

Table 8 shows the incidence of shocks experienced by agricultural households from the seven identified frequently occurring natural events. Out of the 834 farm households, 779 households reported having experienced at least one of the seven frequently occurring natural events since January 2009. Among farm households, 355 households or 43 percent reported to have experienced strong winds and rain; 200 or 24 percent experienced flooding. The respondents were also asked to rank according severity (from 1 as most severe) the shocks that they have experienced. The ranking is relative to the 32 shocks identified in the PCED-SP survey. Of the 779 households reporting that they have experienced the named events, 445 households experienced these at "most severe" levels. Among the 355 farm households that experienced strong winds and rain, 233 or 66 percent rank this shock as the most severe. Among the 200 farm households reported having experienced flooding due to continuous rain and storms, 58 percent rank this shock as the most severe. For the 128 farm households that experienced drought, 44 percent rank it as the most severe. The last column of Table 8 shows that cumulative number of households who ranked the respective natural events in their top 5 most severe shocks. Out of the 834 farm household samples, 523 identified the seven shocks arising from frequently occurring natural events in their top 5 most severe shocks experienced from 2009-2013.

After the respondents reported and identified each shock, the survey explored losses and damages, investment and consumption adjustment, coping measures, and assistance sought from public and private institutions related to each shock. Table 9 shows the number of households that lost some of their assets from shocks and incurred medical and other recovery-oriented expenses. Damages of crops, livestock, and farming equipment were also reported (Table 10). Of the 355 farm households that experienced strong winds and rains, 67 percent lost all or part of their crops, 6 percent lost livestock, and 2 percent lost farming equipment. Of the 200 farm households that experienced flooding, 61 percent lost their crops, 8 percent lost livestock, and 1 percent lost farming equipment.

TABLE 8. Incidence and severity of shocks experienced by agricultural households

Type of shock (frequently occurring natural events)	Number of households experiencing specified shock	Number of households ranking shock as "most severe"	Number of households ranking shock among "top-five most severe"
Strong winds and rain	355	233	268
	(100)	(66)	(75)
Flooding due to continuous rain, storms, and so on	200	116	137
	(100)	(58)	(69)
Landslides/mudslides	10	4	4
	(100)	(40)	(40)
Drought	128	56	68
	(100)	(44)	(53)
Extreme heat	32	4	11
	(100)	(13)	(34)
Big waves (tsunamis and storm surges)	5	3	3
	(100)	(60)	(60)
Pest infestations and crop diseases	49	29	32
	(100)	(59)	(65)
Total	779	445	523

Source: Authors' calculations from PCED-SP survey data
Note: Figures in parenthesis indicate the share of households reporting a result among the total number experiencing the shock.

TABLE 9. Results of the shocks from frequently occurring natural events

Type of shock (frequently occurring natural events)	Loss/ destruction of assets	Unplanned medical expenses	Other expenses	No impact
Strong winds and rain	135	17	32	180
	(38)	(5)	(9)	(51)
Flooding due to continuous rain, storms, and so on	67	13	18	106
	(34)	(7)	(9)	(53)
Landslides/mudslides	3	0	2	5
	(30)	0	(20)	(50)
Drought	29	3	7	89
	(23)	(2)	(5)	(70)
Extreme heat	6	3	2	21
	(19)	(9)	(6)	(66)
Tsunamis and storm surges	2	0	0	3
	(40)	0	0	(60)
Pest infestations and crop diseases	18	0	6	26
	(37)	0	(12)	(53)

Source: Authors' calculations from PCED-SP survey data
Note: Figures in parenthesis indicate the share of households reporting a result among the total number experiencing the shock. See Column 1 of Table 8 for the total number of households experiencing each shock.

TABLE 10. Damages experienced by the farm households

Type of shock (frequently occurring natural events)	Crop loss	Livestock loss	Loss of farming equipment	No loss
Strong winds and rain	238	20	7	106
	(67)	(6)	(2)	(30)
Flooding due to continuous rain, storms, etc.	122	16	2	68
	(61)	(8)	(1)	(34)
Landslides/mudslides	9	0	0	1
	(90)	(0)	(0)	(10)
Drought	88	5	0	38
	(69)	(4)	(0)	(30)
Extreme heat	17	0	0	15
	(53)	(0)	(0)	(47)
Tsunamis and storm surges	1	0	0	4
	(20)	(0)	(0)	(80)
Pest infestations and crop diseases	46	0	0	3
	(94)	(0)	(0)	(6)

Source: Authors' calculations from PCED-SP survey data
Note: Figures in parenthesis indicate the share of households reporting a result among the total number experiencing the shock. See Column 1 of Table 8 for the total number of households experiencing each shock.

Respondents were also asked about the effect of particular shocks on household well-being. Among these, strong winds and rain and flooding affected the greatest number of farm households, with more than 50 percent of those experiencing shocks reporting that their family's well-being was greatly affected (Table 11).

Respondents were then asked whether their households have recovered from the negative consequences of the shocks. The respondents were asked to rate the extent of their recovery based on the following scale: (a) not at all; (b) not much; (c) much; and (d) yes, completely. Table 12 shows that about 20 to 50 percent of the farm households reported that they have fully recovered from the shock at the time of the survey. The others are still in various stages of recovery.

TABLE 11. Effect of shocks on the family's well-being

Type of shock (frequently occurring natural events)	No impact	Some impact	Much impact	Extreme impact	Total
Strong winds and rain	41	133	116	65	355
	(12)	(37)	(33)	(18)	(100)
Flooding due to continuous rain, storms, etc.	18	60	74	48	200
	(9)	(30)	(37)	(24)	(100)
Landslides/mudslides	2	1	5	2	10
	(20)	(10)	(50)	(20)	(100)
Drought	29	48	37	14	128
	(23)	(38)	(29)	(11)	(100)
Extreme heat	2	14	13	3	32
	(6)	(44)	(41)	(9)	(100)
Tsunamis and storm surges	1	2	1	1	5
	(20)	(40)	(20)	(20)	(100)
Pest infestations and crop diseases	2	13	21	13	49
	(4)	(27)	(43)	(27)	(100)

Source: Authors' calculations from PCED-SP survey data
Note: Figures in parentheses indicate the share of households in each category.

TABLE 12. Perception of recovery from shocks

Type of shock (frequently occurring natural events)	No recovery	Partial or full recovery			Total
		Little recovery	Significant recovery	Complete recovery	
Strong winds and rain	72	97	69	117	355
	(20)	(27)	(19)	(33)	(100)
Flooding due to continuous rain, storms, etc.	41	40	52	67	200
	(21)	(20)	(26)	(34)	(100)
Landslides/mudslides	2	1	2	5	10
	(20)	(10)	(20)	(50)	(100)
Drought	44	27	15	42	128
	(34)	(21)	(12)	(33)	(100)
Extreme heat	5	8	4	15	32
	(16)	(25)	(13)	(47)	(100)
Tsunamis and storm surges	1	2	1	1	5
	(20)	(40)	(20)	(20)	(100)
Pest infestations and crop diseases	8	5	17	19	49
	(16)	(10)	(35)	(39)	(100)

Source: Authors' calculations from PCED-SP survey data
Note: Figures in parentheses indicate the share of households in each category.

Recovery in the context of the PCED-SP survey is understood in terms of the households' financial well-being. The respondent is asked how much money would have to be given to them in order to return to their family's previous well-being. Table 13 presents the households who ranked the shocks 1-5 according to severity and their perceived monetary value needed for recovery. Those who chose options (b), (c), and (d) across all shocks in Table 12 are grouped together under "Partial/Full Recovery" in Table 13. Expectedly, the amount required by those who did not experienced any recovery is higher at a median of ₱15,000 than those who have experienced partial or full recovery at a median of ₱10,000.

We now examine the various coping strategies employed by the farm households in order to deal with shocks. The survey asked the households their coping strategies according to the type of frequently occurring natural events. Table 14 presents the incidence of farm households resorting to financial coping strategies such as borrowing, drawing on savings, selling farm goods and equipment, and other financial coping strategies, including selling household assets, harvesting early, delaying investments, and mortgaging and pawning goods and assets. Across all shocks, farm households mostly depend on loans and drawing on their savings in order to cope with shocks.

TABLE 13. Average amount for recovery versus type of recovery

Type of recovery	Number of households	Mean value (₱)	Median value (₱)	Standard deviation	Coefficient of variation	Minimum (₱)	Maximum (₱)
No recovery	119	21,563	15,000	24,121	1.12	500	150,000
Partial or full recovery	403	22,778	10,000	30,280	1.33	1	200,000
Total	522	22,501	10,000	28,974	1.29	1	200,000

Source: Authors' calculations from PCED-SP survey data

About 8 percent of households that experienced the various shocks from the frequently occurring natural events reported selling goods, including crops that they might have otherwise consumed. About one-third of those households that experienced shocks have reduced their consumption to cope with shocks. Many of these households have requested assistance from the government, from individuals or groups, and from non-government organizations.

TABLE 14. Financial coping activities of the farm households

Financial coping mechanism	Number of households that adopted mechanism	Number of households that did not adopt mechanism	Total
Took out a loan	88	435	523
	(17)	(83)	(100)
Used cash savings	171	352	523
	(33)	(67)	(100)
Sold farm goods and equipment	42	481	523
	(8)	(92)	(100)
Other	40	483	523
	(8)	(92)	(100)
None	231	292	523
	(44)	(56)	(100)

Source: Authors' calculations from PCED-SP survey data
Note: "Other" includes borrowing from friends or family, pawning items, and so on.

Table 15 shows coping strategies available to the farm households and perceptions of the relative importance of these strategies. Respondents indicated that spending cash savings, reducing consumption, and borrowing from others were the most important coping strategies. Among the 523 farm households who have identified shocks from frequently occurring natural events in their top 5 most severe shocks, 30 percent said that spending cash savings is the most important coping strategy, 18 percent specified the reduction of consumption, and 14 percent indicated borrowing from others.

TABLE 15. Most important coping strategies

Most important coping strategy	Frequency (number)	Share (%)
Borrowing from others	74	14
Using cash savings	156	30
Delaying investment	2	0
Selling assets	12	2
Selling harvest/products	16	3
Pawning property	1	0
Stopping school/changing schools	3	1
Reducing consumption	92	18
Temporarily migrating	3	1
Receiving help from a politician	1	0
Taking on extra work	3	1
Asking relatives for help	1	0
None	159	30
Total	523	100

Source: Authors' calculations from PCED-SP survey data

Many respondents took precautionary measures at the start of planting season to lower the risk of loss. These measures included adjusting or delaying planting time, adjusting the choice of crop variety, increasing the use of fertilizer, building better farm infrastructure, building dikes for better water flow, and cleaning streams and canals of sediments and other impediments to flow. The survey shows that farm households invest in risk management measures when they are the primary beneficiaries. Adjusting planting time and choosing crop variety are the most common measures. However, as with other public goods, households seldom invest in cleaning canals and building dikes inasmuch as the whole community benefits from these activities. This is where local governments can fill in the gap.

Table 16A shows the incidence of households who took risk management measures by economic profile. About 77 percent of the 523 respondents who experienced shocks actually took these measures. Of these, relatively more were from the upper 60 percent segment of the sample. This is to be expected given the exercises in section 5. Poorer households have less ability to access the instruments of risk management in the face of shocks. Datt and Hoogeveen [2003] also found that poor Philippine households have limited ability to cushion consumption against shocks, relative to the non-poor.

TABLE 16A. Adoption of risk management measures, by economic profile

Economic profile	Number of households that adopted measure	Number of households that did not adopt measure	Total
Lower 40 percent	156	39	195
	(80)	(20)	(100)
Upper 60 percent	249	79	328
	(76)	(24)	(100)
Total	405	118	523
	(77)	(23)	(100)

Notes:
Pearson chi2(1) = 1.1682
Pr = 0.280
Source: Authors' calculations from PCED-SP survey data

We also examined whether prior experience of a shock would prompt the households to take ex-ante measures to cope with shocks and to manage risk. Table 16B shows that out of those who experienced a similar shock before, 77 percent took long-term risk management precautionary measures. Prior experience may also influence household responses when there is already an imminent natural event.

TABLE 16B. Incidence of taking risk management measures

Experienced shock before	Took risk management measures		
	No	Yes	Total
No	53	171	224
	(24)	(76)	(100)
Yes	65	234	299
	(23)	(77)	(100)
Total	118	405	523
	(23)	(77)	(100)

Notes:
Pearson chi2(1) = 0.2706
Pr = 0.603
Source: Authors' calculations from PCED-SP survey data

These responses include those precautionary measures typically taken right after receiving warning, such as securing the dwelling with ropes, stockpiling food and other essentials, moving to evacuation areas, going to the houses of relatives and friends, and moving productive assets to safer places. Table 16C (lower panel) shows that of those who had prior experience, only 10 percent took some form of these immediate precautionary measures after receiving warning.

TABLE 16C. Incidence of taking risk management and ex-ante coping measures

Experienced shock before	Took both risk management and ex-ante coping measures after receiving warning		
	No	**Yes**	**Total**
No	207	17	224
	(92)	(8)	(100)
Yes	271	28	299
	(90)	(10)	(100)
Total	478	45	523
	(91)	(9)	(100)

Notes:
Pearson chi2(1) = 0.5132
Pr = 0.474
Source: Authors' calculations from PCED-SP survey data

A primary motivation for undertaking precautionary measures is the risk of losing crops and other farm assets. Consistent with the risk management measures of adjusting planting time and choosing crop variety, Table 17 shows that about two-thirds of the farm households that experienced the shocks are worried about losing their crops.

In summary, floods and strong winds and rain are the most commonly experienced shocks that result in damages to assets and crops. About half of the farm households experiencing these events recover to some extent and are able to smooth consumption by using savings, obtaining loans, or selling farm goods and equipment.

6.2. Estimation

Given the stylized facts above, we investigate the factors that determine the partial or full recovery of farm households. We use a logit model[9] to estimate the probability of partial to full recovery of the households, where partial or full recovery is coded as 1. The number of sample considered in the model (n=523) are the farm households who rank the shocks arising from frequently occurring natural events as their top 1-5 most severe shocks (ranking is relative to 32 shocks identified in the PCED-SP survey). The model in Table 18A presents the full range of the farm household's financial and non-financial coping mechanisms. The precautionary measures that have been described primarily involve risk management. Ex-post coping measures in this analysis include spending cash savings and availing of loans, as discussed in the previous section. Depletion of non-cash savings is also included, e.g., selling crops and farm equipment, as well

[9] The empirical exercise follows the model in Ravago and Mapa [2014].

TABLE 17. Damages that concern farm households

Shock	Crop loss	Livestock loss	Loss of farming equipment	No loss
Strong winds and rain	258	29	15	82
	(73)	(8)	(4)	(23)
Flood due to continuous rain, storms, etc.	135	29	8	47
	(68)	(15)	(4)	(24)
Landslide/mudslide	10	1	0	0
	(100)	(10)	(0)	(0)
Drought	96	11	2	26
	(75)	(9)	(2)	(20)
Extreme heat	21	4	0	9
	(66)	(13)	(0)	(28)
Tsunamis and storm surges	2	0	0	3
	(40)	(0)	(0)	(60)
Pest infestation, crop diseases	47	2	0	2
	(96)	(4)	(0)	(4)

Note: Figures in parenthesis are percentages of the number of households reporting to total number that have experienced each shock. The total number of households that experienced each shock are found in Column 1 of Table 8.
Source: Authors' calculations from PCED-SP survey data

as the reduction of expenses on education, utilities and recreation, and stopping schooling altogether. Other forms of coping with shocks include migration and seeking assistance from the government and private groups. The model includes initial conditions of the households, such as educational attainment, age, gender of the household head, and whether the household is a beneficiary of the government's conditional cash transfer program. To account for behavioral effects, conditional cash transfer is also interacted with the two prominent coping mechanisms: spending cash savings and selling farm goods. A dummy for prior experience of the same shock is added to test if learning from past experience affects recovery. A dummy for Region 8 is also included given that super tyhoon Yolanda, the most recent natural event of extreme magnitude, severely hit the region. The model also includes a dummy for the farm households that rank the shock arising from these natural events as the most severe. These are the 445 farm households presented in Table 8 (column 2).

The results of the logit models (full and reduced models) are presented in Tables 18A and 18B. The full model in Table 18A and the reduced model in Table 18B have likelihood ratios (chi-square statistics) between 44.35 and 41.83, with p-values between 0.0001 and 0.0021. The p-values indicate very low probabilities that the independent variables of each model, taken together, have no effect on the dependent variable. In the full model (Table 18A), the coefficient for spending cash savings is significantly positive (within the 95 percent confidence interval). This is also true for the dummy variable for Region 8 and the educational variables.

Even though expenditures on education and discretionary consumption were not significant explanators of recovery, reduced educational expenditures may well reduce families' prospects for escaping poverty. Chetty and Looney [2007] examine the effect of household unemployment shocks on distributions of food consumption and education-expenditure growth rates for Indonesia. They show that the negative skewness of these distributions magnifies by two to three times the fall in mean levels. Consumption and education expenditures in the top decile grow at the same rate as before the shock. But the bottom 40-50 percent of households suffer lower growth rates with most of these experience declines. As households cut back on education spending and other investments, their prospects for eventually climbing out of poverty diminish.

TABLE 18A. What factors influence recovery (full model)

Dependent variable: Household has partially/completely recovered			
Explanatory variables	**Coefficient**	**Robust standard error**	**p-value**
HH took precautionary measures	0.04	0.28	0.84
Loan	0.02	0.31	0.91
Spent cash savings	0.81	0.29	0.01*
Sold farm goods and equipment	0.87	0.66	0.18
Reduced consumption (education, utilities, and recreation)	0.03	0.27	0.92
Moved to another area	-0.09	0.78	0.89
Received assistance (government and private)	-0.08	0.28	0.85
HH head is elementary graduate	0.39	0.34	0.22
HH head is high school undergraduate	1.02	0.39	0.01*
HH head is high school graduate	0.57	0.33	0.09*
HH head is college undergraduate	0.85	0.40	0.03*
HH head is college graduate	0.97	0.54	0.08*
Age of HH head	-0.01	0.01	0.24
Sex of HH head (female = 1)	0.70	0.43	0.10*
HH has other sources of income	0.33	0.33	0.28
Conditional cash transfer household	0.06	0.30	0.87
HH experienced similar shock before	-0.01	0.24	0.16
Interaction: Spent cash savings and conditional cash transfer HH	0.10	0.68	0.84
Interaction: HH sold goods and conditional cash transfer HH	0.19	1.27	0.85
Region 8 =1	-0.64	0.24	0.01*
HH ranked shock as most severe = 1	-0.53	0.35	0.13
Constant	1.39	0.64	0.01*

Number of Obs. = 523; log pseudolikelihood = -255.78045; Wald chi2 = 46.51 (p-value= 0.0011); McFadden R-squared = 0.0880; the significant variables (95 percent confidence interval) are indicated with *.

TABLE 18B. What factors influence recovery (reduced model)

Dependent variable: household has partially/completely recovered				
Explanatory variables	**Coefficient**	**Robust standard error**	**p-value**	**Marginal effects**
Spent cash savings	0.86	0.26	0.00*	0.13
Sold farm goods and equipment	0.93	0.58	0.11*	0.12
HH head is elementary graduate	0.40	0.33	0.22	0.06
HH head is high school undergraduate	1.03	0.39	0.01*	0.14
HH head is high school graduate	0.59	0.32	0.07*	0.09
HH head is college undergraduate	0.86	0.40	0.03*	0.12
HH head is college graduate	1.00	0.53	0.06*	0.13
Age of HH head	-0.01	0.01	0.36	0.00
Sex of HH head (female = 1)	0.73	0.43	0.09*	0.10
Conditional cash transfer household	0.11	0.26	0.68	0.02
Region 8 HH = 1	-0.67	0.23	0.01*	-0.12
HH ranked shock as most severe	-0.52	0.34	0.13	-0.08
Constant	1.36	0.61	0.03	

Number of Obs. = 523; Log pseudolikelihood = -257.38184; Wald chi^2 = 41.83 (p-value= 0.0001); McFadden R-square = 0.0823

Table 18B presents the results of Reduced Model 2, showing the marginal effects of different variables on the probability of recovery. The result shows that the most prominent coping activity for farm households is drawing down cash savings and selling farm goods and equipment. The coefficients of these two variables are positive for the 95 percent confidence interval. For households that utilized cash savings, the probability of partial to full recovery increases by about 13 percentage points (marginal effect) relative to households without savings, controlling for other factors. For households who sold their farm goods to cope with shocks, the probability of partial to full recovery increases by about 12 percentage points relative to households who did not sell goods, again controlling for other factors. As expected, the dummy variable for Region 8 has a negative sign. The farm households are most likely reporting super typhoon Yolanda as the most recent shock that they have experienced. For farm households who are in Region 8, the probability of partial to full recovery decreases by about 8 percentage points.

The results also show that education substantially increases the probability of recovery. If the household head had one or more years of high school, the probability of partial to full recovery increases by 14 percentage points. If s/the household head graduated high school, it increases by 9 percentage points. If the household head had college education but did not graduate, the probability of partial to full recovery increases by 12 percentage points. For college graduates the probability increases by 13 percentage points.

The gender of the household head also influences recovery as the result in Table 18B shows. For female-headed households, the probability of partial to full recovery increases by about 10 percentage points relative to male-headed households.

7. Discussion

Resilience in the face of natural disasters can be enhanced by government actions at four stages: interdiction, evacuation, relief, and rehabilitation. While there are government programs at all of these levels, there has been no concerted effort to compare the incremental cost-effectiveness of these programs and to thereby direct additional spending where it will do the most good.[10] This paper has provided an initial framework for determining priorities in the four interdependent stages.

We also provide a conceptual framework for understanding resilience at the household level and evidence from the PCED-SP survey about coping strategies of farm households. The common strategy of regarding the problem of farm household decision-making as a matter of static choice based on exogenous risk preferences is clearly inadequate. Households must decide on the expenditure shares of consumption, on-farm investment, and precautionary capital based on the likelihoods of adverse shocks and preferences for consumption smoothing. These can only be understood through the lens of multi-period modeling, not with single-period risk assessment and contrived risk preferences.

As either the preference for smoothing or the probability of disaster increases, wealthier households tend to substitute less-vulnerable off-farm capital for farm capital and to increase risk-reducing investments to avoid dramatic decreases in consumption when a negative event occurs. Poorer households only slightly increase risk-reducing investments and are left with considerable risk exposure. They are unable to borrow for off-farm investments and decrease their already negligible investments in on-farm capital. Given the severe limits on risk-reducing investments, there may be little that low-income households can do in response to increased vulnerability from climate change.

The survey evidence provides examples of the coping mechanisms employed by farm households, including borrowing, dissaving (reducing stocks of liquid and illiquid assets), harvesting early, increasing marketed surplus, and seeking assistance from individuals, groups, the government, and nongovernment organizations. Using cash savings, reducing consumption, and borrowing were the most important and most-frequently employed strategies. Farm households that had recently experienced shocks also took risk-reducing measures at the start of planting season, especially adjusting planting time and choosing a different

[10] Noel de Dios has colorfully referred to this syndrome as "rope-a-dope" policy formulation, choosing policies that give the appearance that government is addressing needs.

crop variety. Households seldom reported investing in risk-reducing public goods, however, such as cleaning streams and canals and building dikes. As expected, poor farm households report the least use of borrowing, asset reduction, and on farm risk-reduction.

The fact that low-income households are largely unable to cope with shocks does not, however, provide a strong case for government-subsidized social insurance. Crop insurance, for example, tends to be over-subsidized already (Wright [2014] and Wright [2015]). Risk management interventions are more appropriately directed toward the sources of risk aversion. A primary reason why farmers dislike losing more than they like gaining (i.e. are risk averse) is transaction costs [Roumasset 1979 and 2015]. Buying prices are higher than selling prices because of transportation, communication, and the costs of contracting. Borrowing costs are typically higher than the returns to saving for the same reasons. Government policies that decrease unit transaction costs (such as the cost of transporting one kilogram of produce one kilometer) thus decrease the costs of risk. Insofar as climate change increases the costs of risk, it also increases the benefits of transportation and communications infrastructure. Countries can ameliorate scarcity across locations through better infrastructure, thereby moderating the consequences of adverse events. Similarly, policies that improve the rule of law in commercial transactions (such as enforcing standards and measures) decrease the costs of risk. These transaction-cost-reducing reforms are win-win. They increase mean consumption while simultaneously lowering risks. In contrast, reducing expenditures on cost-reducing infrastructure in order to subsidize social insurance is likely to be lose-lose by lowering permanent incomes and artificially increasing risk aversion, leaving farm households more vulnerable even with the limited benefits that the insurance provides.

To the extent that climate change increases exposure to risks, it increases the costs of agricultural policies that increase transaction costs. For example, the policies of the National Food Authority both increase consumer prices and displace private investments in transportation and storage that would decrease the associated transaction costs [Roumasset 2000]. Similarly, land reform policies have increased transaction costs, most notably in the agricultural land market, to the point that legal transactions are uncommon [Sicat 2014]. Like the Hippocratic Oath, the first priority for better risk management in the face of climate change should be to stop making matters worse. ■

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