Coping with Climate Change: Vulnerability, Adaptation and Resilience Among the Tawakha of Rural Honduras, post-Hurricane Mitch

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Draft: 9 February 2010

Keywords: vulnerability, resilience, disasters, governance, adaptive capacity, social-ecological systems

Words: 7,354

ABSTRACT

How will rural poor communities in the developing world cope with increased extreme weather events brought by climate change? Two distinct views hold currency in the literature and policy circles – that the resource-reliant poor are acutely vulnerable and communities need external assistance to prepare for such events; and that climate-related shocks can actually catalyze latent adaptive capacities of smallholders and local communities, offering a 'window of opportunity' for welfare-improving change. In this paper we examine these views through a longitudinal case study of vulnerability, adaptation and resilience of an indigenous community in eastern Honduras to devastating flooding in 1998 from Hurricane Mitch. Data were gathered between 1996-2002, i.e., prior-to and following the event, through repeated household surveys, in-depth interviews and focus groups. Results from this 'natural experiment' indicate that although the community was indeed highly vulnerable to the hurricane – in part due to prior development assistance – with the poorest households being hardest hit, the disaster enabled the poor to initiate a profound institutional change that led to a more equitable land distribution, slowed primary forest conversion, and positioned the community well to cope with comparable flooding ten years later. Specifically, our findings suggest that: (1) the fate of the 'poorest of the poor' is not sealed: in the face of covariate shock, poor households can break out of seemingly intractable 'poverty traps'; (2) rural communities have the potential to autonomously and effectively adapt their institutions in the face of climate-related shocks (not merely adjusting their activity or investment mixes) and to do so in ways that enhance the ecological sustainability of livelihood practices; (3) pre-disaster development assistance can increase communal vulnerability; and, (4) sources of pre-disaster vulnerability can also be sources of resilience and analysts can seriously misdiagnose development/adaptive needs if not recognized as such. Future interventions should foster spaces and capacities for endogenous change in local governance systems to enhance resilience to extreme climate-related events.

1. Introduction

Millions of resource-reliant communities worldwide are on the front lines of climate change, facing increasingly frequent and extreme weather events (Paavola & Adger, 2006; Adger & Brooks, 2003; Pelling, 2003). As these new conditions threaten to overwhelm the rural poor's standard adaptive mechanisms (Adger et al., 2003), how will they cope?

The past decade has seen a burst of scholarship on the issue. Many analysts emphasize the acute vulnerability of rural smallholders, particularly where the burden to adapt to climate change compounds the challenges of decades of trade liberalization, leaving them "doubly exposed" (Leichenko & O'Brien, 2008). Others warn that shocks ultimately serve to reinforce the pre-disaster status quo, maintaining if not intensifying pre-existing political-economic structures (Passerini, 2000). Within communities, climate shocks are also expected to intensify socioeconomic inequalities, deepening the destitution of the poorest (Zimmerman & Carter, 2003). The development community is therefore increasingly committed to help the rural poor to adapt to climate change (Huq, 2007; Pielke Jr. et al., 2007; Lemos et al., 2007), especially through projects that build adaptive capacities and flexible governance structures (Dore & Etkin, 2003; Allen, 2003).

Others offer different prescriptions, based on a more complex and possibly hopeful perspective. The 'resilience community' in particular is drawing attention to the potential for climatic and other forms of dramatic change to catalyze communities' latent adaptive capacities (Adger, 2003; Adger & Brooks, 2003; Adger et al., 2003; Nelson et al., 2007), and to stimulate systemic improvements (Adger et al., 2005; Torry, 1978; Folke, 2006). Similarly, disaster economists and others have explored the mechanisms through which external shocks might stimulate economic growth and/or positive social change at national, community, and household scales (Passerini, 2000; Bradshaw et al., 2002; Moser, 2007; Skidmore & Toya, 2002; Cuaresema et al., 2008). With respect to the role of development in helping to affect such outcomes, scholars are often skeptical of the need for standard interventions, pointing out how assistance before and after shocks can in fact exacerbate vulnerabilities (e.g., Oliver-Smith 1996).

Empirical exploration of these issues, however, is difficult. An ideal study would retrospectively assess a social-ecological system over a period of time punctuated by specific environmental change, after which latent adaptive capacities would be revealed (Lemos et al., 2007). Not surprisingly, such natural experiments are rare (Kates, 1987; Passerini, 2000). Particularly needed are detailed ethnographic accounts that extend scrutiny well into the reconstruction phase, and trace the role of development programs throughout (Oliver-Smith, 1996; Oliver-Smith & Hoffman, 1999; Hilhorst, 2004; Lemos et al., 2007). In this paper, we report on one such 'experiment.' We revisit a study that traced a rural Honduran community over a period (1994-2002+) that was punctuated by major devastation from Hurricane Mitch.

Hurricane Mitch struck Central America in late October, 1998. Unlike previous hurricanes, damage from Mitch was mainly due to torrential rains and mudslides. In mountainous Honduras (pop. 6.5 million), impact was nation-wide, with over 5,500 deaths and 8,000 missing persons; much of the country's transportation and communication infrastructure sustained heavy damage (Jansen, 2003). Honduras' acute vulnerability to the storm was widely seen as the result of a deeply flawed development trajectory, characterized by excessive reliance on export-oriented agriculture and entrenched socioeconomic inequalities that encouraged extensive deforestation and unplanned urban development (Boyer & Pell, 1999; Comfort et al., 1999; Bradshaw et al., 2002; Casolo, 2009). Not surprisingly, the urban poor and rural land-poor were particularly hard-hit. As Parks and Roberts (2006:343) concluded: "The story of Hurricane Mitch in Honduras serves as a parable about uneven vulnerability to global climate change."

Despite hopes to the contrary and US$2.75 billion in aid, subsequent relief and reconstruction only partially repaired the damage (see also Calderón, 2002). Ultimately, the pre-Mitch status-quo was reasserted, returning the country to its former level of poverty (Glantz & Jamieson, 2000; Casolo, 2009; Calderón, 2002; Jansen, 2003).[1] Honduras' experience of Mitch has since become a standard referent for ineffective response and missed opportunity in the face of catastrophic change (Paavola & Adger, 2006; e.g., Adger et al., 2005).

This general narrative of failed renewal obscures, however, a different Honduras. Relatively disenfranchised indigenous communities in eastern Honduras' Mosquitia region were no less

vulnerable to the storm; indeed, flooding there was catastrophic. But we focus here on a surprising scenario by which an indigenous community was ultimately able to use the 'window of opportunity' created by disaster to correct for a major cause of differential vulnerability and uneven well-being, and to increase intra-household and intergenerational equity and ecological sustainability in the process. Further, changes made following Mitch appear to have ratched-up the community's overall resilience to catastrophes, as when Tropical Depressions 16 and 43 hit in October 2008. Although their geomorphological impacts were reportedly similar to those of Mitch, their impact on regional livelihoods was relatively light (OCHA, 2009; E. Benitez, pers.comm. 8/26/09).

We also explore how external development interventions in the region before, during, and after Mitch contributed—positively or negatively—to this outcome. We argue that this case study offers generalizable lessons for policies regarding the resilience of rural communities, in part by challenging standard ways in which we think about how remote communities respond to massive and abrupt environmental change, and the ways in which they might be assisted.

2. Study Area

We focus on the social-ecological system of the indigenous village of Krausirpi and environs, located at 15^{o}N, 85^{o}W, some 400 km inland from Honduras' Caribbean coastline in the Mosquitia region of Honduras (Fig. 1). This is a region of lowland tropical forest where livelihoods and human-environment relationships, especially prior to Mitch, are well-studied (see, e.g., Herlihy, 1993; Godoy, 2001; House, 1997; McSweeney, 2000). The village is perched on a cutbank of mid Patuca River—the country's longest—and is backed by low hills drained by several streams, where manioc and upland rice are grown in swidden-fallow systems. In 1998, on the terraced meander opposite the community, beans and vegetables are grown seasonally in agroforestry systems that include cacao, peach palm, and other fruit and timber trees. Geologic and hydrologic heterogeneity create highly varied edaphic microenvironments throughout (House 2007).

Fig. 1. Map showing the study community location within the Tawahka Asangni Biosphere Reserve (BTA) in eastern Honduras.

Krausirpi is the largest indigenous Tawahka village (pop. ~600 in 1998). Founded in the 1950s, the community is comprised of kin-based household clusters, in keeping with Tawahka's traditionally acephalous social structure (McSweeney, 2000). In 1998, households averaged almost 8 members (7.72; median=7), and about 17% were headed by single women. Due to very high rates of internal growth, the community's population expanded rapidly during the study period; in 1998, 75% of the population was under the age of 24—implying, *inter alia*, a heavy burden on working adults (McSweeney, 2002a). At that time, the village featured two churches, and elementary school, a government health clinic, and a few small stores. Residents traded labor, agricultural produce (especially rice, beans, and cacao), and forest products in markets up and down river; all transportation was by dugout canoe.

Tawahka territory is sandwiched between Miskito lands to the north and an expanding colonization frontier of Spanish-speaking *ladino* farmers to the south and south-west. *Ladino* colonization increasingly encroaches into the Tawahka Asangni Biosphere Reserve, or BTA (est. 1999), dramatically reducing Tawahka access to ancestral forests through forest conversion and related violence. The state forestry agency's enforcement of reserve boundaries has been rare. Forestry agents have been more likely to enforce rules on Tawahka, including prohibitions on timber harvests and land sales to outsiders (McSweeney, 2005).

Hurricane Mitch catalyzed or accelerated profound changes throughout the region—political, social, epidemiological, economic. For example, upriver from Krausirpi, where the Patuca river valley is more deeply incised into hilly terrain, two Tawahka communities (combined pop. ~200) were destroyed by the force of the flood. In the year or two following the storm, the more than a dozen deaths and innumerable physical and mental illnesses that hit the 1,200-strong Tawahka population were attributed to Mitch-created conditions of contaminated water, severely interrupted medical service provision, nutritional stress, heightened labor demands, and psychological depression and shock (Benítez, 1999; Cruz et al., 1999; De Vries, 2000; Honduras, 2003).[2]

In this study, however, we focus only on Krausirpi, and specifically on changes there in land use and ownership because: a) In Krausirpi, the floodwaters' impact on land-based assets was

particularly dramatic; b) smallholders' ability to weather shocks is strongly conditioned by land wealth (Prowse & Scott, 2008; Torry, 1978; Gitter & Barham, 2007); c) the author had particularly rich data on this community's agricultural dynamics due to 22 months of residence there prior to Mitch; and d) changes in the distribution of landesque capital offer a particularly parsimonious and meaningful means to address equity in process and outcome in the context of sudden environmental change (see also Fan, 2007; Casolo, 2009).

3. Methods

Fieldwork was conducted episodically over eight years, during which McSweeney spent a total of 30 months in the region. Data for the 1994-96 period were generated by McSweeney and three other researchers while employed by the Harvard Institute for International Development (Godoy, 2001). The remainder was conducted by McSweeney independently on separate trips in 1998 (prior to Mitch), 2001, and 2002. On each visit, data were derived through household surveys combined with in-depth interviews, focus groups, and participant observation. The number and composition of households surveyed during each trip varied. From the 87 total households in Krausirpi in 1998, 68 were interviewed in that year; 45 in 2001 (deliberately selected to span the spectrum of age and wealth based on 1998 data), and 70 in 2002. The final panel for all years, then, consists of 43 households, which in 2001 comprised 373 individuals, or 58% of the Krausirpi population and about a third (34%) of the total Tawahka population of the BTA. Since 2002, McSweeney has been in episodic communication with Tawahka leaders and Krausirpi residents via email and telephone, which has allowed discussion and qualitative corroboration of the processes described here. Data were analyzed using STATA 7.0 statistical program.

4. Results

A. Impacts of Mitch on Tawahka Agriculture

The Patuca River drains nearly 25,000 km^2, or 22% of the Honduran land surface (Canales, 1997). As Mitch delivered 1-2 ft of rain/day for three days to the already saturated and deforested basin, the upper river reaches saw waters rise ~15-25 m above usual high-water levels (NOAA, 2001; McSweeney, 2002b). At Krausirpi, where the channel widens, floodwaters lost

energy as they spread 2 km further into the floodplain than during any previous known seasonal flood. Along the river banks and first depositional terrace (formerly the most prized agricultural area), the floodwaters deposited a 0.5-5 m cap of sand and gravel (Cruz et al., 1999)

Agriculturally, the community proved highly vulnerable to the flood. 95% of cacao orchards (about 125 ha) were buried or washed away. Study households lost an average of 415 mature cacao trees (median: 250; n=44) and 4.8 ha of floodplain land, or about 45% of their total holdings (Table 1). The most optimistic assessments for the recovery of remnant floodplain soils suggested at a minimum five years to again support crops; all such lands were therefore widely considered 'lost' to agricultural production. Upland crops also suffered significantly from soil saturation and heightened rodent predation immediately after the storm (McSweeney, 2002b).

Table 1. Impacts of Hurricane Mitch on sample households in Krausirpi, showing the evolution of land wealth and distribution over the study period. Source: household surveys, 1998, 2001, 2002.

Over three days, then, the community effectively lost its most productive farmland. Economic impacts were immediate. Most noticeable was the total elimination of income from cacao sales, which had formerly contributed 38% of the community's combined cash income (McSweeney 2000), and had been particularly important as an unusually reliable, aseasonal source of steady cash.[3] Wind and rain impacted the 1998 rice harvest, which was ongoing when the storm hit. In Krausirpi, only 73% of households harvested any rice (compared to 97% in previous years); for those that did, yields were a third those of 1997. Bean harvests in early 1999 were negligible due to lack of seed and labor shortages related to shock and relief/reconstruction efforts. Hunger was reportedly acute in 2000, when food donations ceased and replanted banana, plantain, and manioc plots were not yet able to support sustained harvests (McSweeney, 2002b). Indeed, apart from donated food, Krausirpi received little reconstruction aid or recovery/reconstruction oversight relative to neighboring communities in the years following the storm, for a variety of reasons (many of them political) (Tinglas, 2000). Residents also reported a breakdown in mutual support networks, saying people had to "help themselves."[4]

Importantly, our analysis shows that agricultural losses were unevenly distributed within the community. When households were divided into terciles according to their total land wealth prior to Mitch, we found that while the formerly most land-rich tercile lost the most land to Mitch overall (8 ha; n=15), the formerly land-poor were arguably the most hard-hit, because they lost the largest *share* of their floodplain holdings (59%; n=14) (Table 1). Others have reported a similarly uneven impact from Mitch among smallholders elsewhere in Honduras (Morris et al., 2002; Mainville, 2003).

The immediate collective agricultural response to the devastation was a pulse in primary forest-clearing for the 1999 rice season. In that year, 66% of households cleared primary forest for rice—almost twice as many as had done so in 1994 or 1997 (see also Godoy et al., 1997).[5] Combined, study households cleared an unprecedented ~27 ha of primary forest in that year alone. Residents explained this extensification as a bid to carve out new upland fields to offset losses to floodplain holdings. This was noted with concern by conservation NGOs (Müller, 2000).

B. Origins of Vulnerability

Why was Krausirpi so ecologically, socially, and economically vulnerable to Mitch? In particular, why was such a large proportion of cash-based production spatially concentrated in the floodplain? Why were the land-poorest families most impacted? And why was unsustainable forest conversion the primary land-use response? Our research suggests that two processes were strongly influential.

Production Specialization

Like 'forest peasantries' worldwide, Tawahka traditionally pursued forms of strategic diversification—spatial, temporal, sectoral, psychological—to spread risk and maximize returns in a context of expected market, epidemiologic, and climatic uncertainty. For example, households farmed across multiple soil types and microclimatic environments. They also mixed multiple subsistence pursuits with market-oriented activities, both within and across sectors (McSweeney, 2004b; McSweeney, 2002c).

By 1998, however, these forms of production diversification were being undermined. A decade of intense cacao promotion by a regional NGO had led to an unprecedented degree of spatial and economic concentration of production in cacao. For example, between 1994 and 1997, the share that cacao contributed to aggregate cash income more than doubled, from 15% to 38%; the number of households participating also grew during this time as some abandoned other sectors to focus on cacao. Further, even as cacao selling prices held constant, the average earnings from cacao per household increased 13-fold between 1994 and 1998 (McSweeney, 2000; McSweeney, 2002c).

On the one hand, this trend indicated success as envisioned by supportive multilateral agencies: a land-intensive, ecologically-friendly niche-market approach to raising income in an otherwise stagnant agricultural setting (see Clough et al. 2009). On the other hand, cacao benefits were unevenly distributed, creating and reinforcing land and income inequalities. Thus while the distribution of cash income in the community was relatively equitable (Gini coefficient = 0.33), incomes from the sale of agricultural crops—to which cacao contributed ~75%—were more skewed (GC=0.57; n=68). In addition, the fact that this specialized production was spatially concentrated on the banks of the country's longest river made the entire enterprise highly vulnerable to flooding.

Other specific development and conservation efforts also (indirectly) discouraged production diversification and increased reliance on cacao. For example, support for stock-raising—a highly mobile activity—was noticeably absent from all development programming targeting Tawahka during the 1990s, despite cattle's history in the region and demonstrated value as a productive asset and income source (Godoy et al., 1996). Further, increased state surveillance of Tawahka extractive activities contributed to the rising cost and risk of forest product extraction and sale (McSweeney, 2004a; McSweeney, 2005).

Land Concentration

In 1998, agricultural land in Krausirpi was held in usufruct. This meant that land in 'old-growth' forest was communally owned, with ownership conferred upon clearing of fields and the maintenance of fallows. While formerly effective, this traditional land-holding institution was

creating a highly uneven terrain of vulnerability by exacerbating land inequalities (see Table 2). This was the result of several inter-related processes: (a) the system favored households who had founded the community in the 1950s (see also Godoy et al., 1997); in contrast, newcomers and younger households found themselves holding small, widely scattered plots; (b) a vital mechanism by which young families might gain land in a usufruct system—i.e., land transfer due to gifting or inheritance—was curtailed by the community's rapid demographic expansion. Inheritance was rare given the very low mortality rates among adults, and with 15-year inter-generational periods and large families, parental interest in divesting land to grown children was low (McSweeney 2000); (c) while disadvantaged households could, in theory, accumulate land by hiring extra-household labor, this rarely occurred; instead, the land-poor often undermined their own land accumulation potential by selling their labor or by borrowing nearby land from their neighbors[6]; (d) the system contributed to the *perception* of land scarcity. Many young families despaired of ever owning more than scattered scraps of floodplain land and thus felt blocked from lucrative income streams from the floodplain (particularly cacao). The perceived availability of upland plots was little better. Although the community was surrounded by primary forest, residents often noted that they felt available land was impractically far. In response, young, labor-poor households began to shorten their fallow periods rather than clear new upland forest—a response that lessened yields and stalled further land accumulation. Others cleared more than they had seed to plant or labor to weed or harvest (see also Otsuka & Quisumbing, 2001). Both choices were ecologically problematic for the system as a whole.

Table 2. Selected household attributes for aggregate sample and disaggregated by terciles of initial 1998 land wealth.

As a result, the usufruct system was creating an increasingly skewed distribution of landholdings—a key indicator of socioeconomic vulnerability. In 1998, the most land-rich third of households owned 8 times more land than the poorest third, and 7 times more cacao trees (Table1). The most land-rich were also most likely to hold the "best" plots (a function of edaphic characteristics and proximity to the village by foot or canoe[7]). In contrast, the land poor held smaller, poorer quality, more discontiguous, scattered holdings.

Land inequality clearly contributed to the differential well-being experienced by families in Krausirpi prior to Mitch. For example, households with fewer floodplain holdings were less likely to be able to cover the costs of illness with agricultural income, instead turning to the more arduous harvest and sale of forest products. Relative land poverty was also associated with lessened ability to invest in children's education or to own cattle. In short, land wealth was closely correlated with the ability to weather idiosyncratic shock and to build a diversified asset portfolio (McSweeney, 2004a,b).

Land inequality was also taking a psycho-social toll on the entire community, particularly in the form of disputes about land borrowing and encroachment from neighboring parcels, internecine feuding, crop theft and spiteful crop destruction. These tensions were considered to be eroding communal networks of support, including traditions of meat and crop sharing and labor exchange, which impacted poor households particularly (McSweeney 2000).

C. Responses and Resilience

Prior to Mitch, then, a combination of production specialization and institutional inertia (leading to land concentration) were creating conditions of collective and individual vulnerability, as Mitch's impact revealed. Had analysis ended there, Krausirpi would have appeared little different from communities across Honduras. Four years after the storm, however, a very different and positive assessment was possible (see Table 1). Below, we describe these unexpected transformations in the agricultural system, then review how they occurred, and with what longer-term effects.

Land Reorganization

By 2002, the following changes in the agricultural system were particularly noticeable:

(a) Much more land came under ownership between 1998 and 2002 than during any comparable 4-year period—a net increase of 82%, or 26 ha per household, or 82%. Thus households not only recouped their Mitch-induced losses but added significantly more to their land portfolio.

(b) Land became more equitably distributed. In 1998, the most land-wealthy third of households owned 65% of all land, with the most land poor tercile holding just 8%. By 2001, the

formerly most land-poor's share doubled, to 16%, with the 'land-middle' and 'land-rich' holding 33% and 51%, respectively.

(c) Not surprisingly, households that owned the most land prior to Mitch had also gained the most land by 2002, increasing their holdings by an average of 33 ha by 2002. But their gains were almost matched by the formerly land-middle, who held 32 ha on average by 2002. Wholly unexpected, however, was that households in the bottom tercile of land wealth in 1998 posted the greatest *relative* gains: their holdings increased by 296% between 1998-2002, compared with 276% and 129% gains by the 'land-middle' and 'land-rich,' respectively.

(d) After the initial post-Mitch, pulse of extensification, clearance of primary forest declined noticeably (Fig. 2).

Fig. 2. Forest cleared for rice planting, by forest type.

As a result of these changes, many of the household-level factors that predicted land wealth were reversed (Table 3). In 1998, land was concentrated among community founders and middle-aged household heads. By 2002, those holding the most land (overall, and disaggregated by type) were more likely to be relative newcomers to the community, younger household heads, and those with less land in 1998. Further, the profile of a land-acquisitive household changed markedly. Households that had gained, by 2001, the most land *relative* to their pre-Mitch holdings were not only the originally land-poor, but were more likely to be younger, labor-poor households, newcomers to the community, and single women.

Table 3. Regression models predicting land ownership by type, for households before/after Hurricane Mitch.

Table 4. Tobit model predicting gains in land wealth by 2001 relative to total land held in 1998.

Agricultural Recovery

Concomitant with the change in landholding patterns was re-establishment of the subsistence base. For example, although *where* households cleared for rice immediately after Mitch (in March, 1999) differed from previous years, the *amount* cleared was comparable, and a year after the storm, rice yields were up to their pre-Mitch levels[8]. Bean yields—always more variable—on

the other hand, were way down—the result of bad weather in both 1999 and 2001, and due to the fact that farmers will still struggling to identify, within the new edaphic environment of the transformed floodplain and formerly untested streamcourses, the best sites for beans (McSweeney, 2004b). In the case of upland plots of manioc and banana/plantain, yields were considered largely recovered at the community level by 2002.

Agricultural experimentation also included efforts to re-establish cacao plantations along streamcourses and on the second and third terraces of the floodplain (previously rarely cultivated in cacao). By 2002, almost half of the 50 households sampled had established a cacao nursery and/or replanted on average, 130 cacao saplings.[9] Indeed, by 2001, respondents had ceased to use the pre-Mitch descriptors of land type as either in "floodplain" or "upland" because they had begun to plant in new places (e.g., along streamcourses in uplands) that confounded these earlier distinctions; landholdings were therefore not distinguished by location but by type of use (e.g., fallow, in current cultivation).

Income (Re)diversification

Closely related to the re-establishment and re-organization of the agricultural system was the re-organization of cash income sources (Fig 3). The loss of cacao and restrictions on forest harvests underlay the dramatic declines in earnings from the sale of agricultural and forest products (with household participation rates in each declining by 15% and 10%, respectively). The relative importance of local wage earnings in agriculture remained high because despite relatively low returns, there was a marked increase in participation rates—from 11% to 25% of households. Earnings from livestock became more relatively important after Mitch as households looked to the sale of milk, eggs, and cheese to mitigate the lost income-smoothing effect of steady cacao sales.[10] A particularly dramatic increase was the share of earnings from local salaried/waged work due to new salaried positions with forestry service, NGOs, or other organizations involved in post-Mitch reconstruction or management of the BTA. Noteworthy too is the appearance of two new sectors, ("distant wage work" and "remittances"), reflecting the new strategy of sending a household member (usually a young man) to find work along the Honduran coast or in Honduran cities; such cyclical migration had formerly been rare (McSweeney, 2000).

Fig. 3. Share of aggregate cash income by sector, comparing 1998 and 2001, for same 44 households.

The new configuration of income sources, however, generated only half of the aggregate cash income earned by the same households in 1998 (Table 2). Interestingly, however, the formerly most land-poor households actually saw an *increase* in their average cash income between 1998 and 2001—in stark contrast to the more than five-fold decrease in earnings among the 'land-middle', and more than a 50% cash income drop among households in 1998's top land-wealth tercile (Table 2). This increase was influenced by the land-poor group's success in capturing waged/salaried positions with state and development organizations. Informants explained that the same attributes that predicted land poverty—youth (and with it, higher rates of education and Spanish fluency) and smaller families—were attractive to employers. As a result, this group's share of the cash income 'pie' rose from 18.2% in 1998 to 41.1% by 2001 (Table 2). Ironically, households in this group invested their earnings in land by hiring other households (particularly the formerly land-middle group) to clear new fields for them. These transfers account for the relative sectoral emphasis of 'land-middle' households on local wage work in agriculture—in fact, a low-return emphasis that helps to explain the sharp decline in mean incomes within this group by 2001.

D. Socioecological Improvement through Institutional Transformation

By 2002, then, there is considerable evidence to indicate that residents of Krausirpi had not simply 'gotten back on their feet' agriculturally and economically, but had actually *improved* their livelihood system in important ways, particularly in terms of social equity (i.e., lessening of asset wealth inequalities and income inequalities) and sustainability (lowered deforestation rates). To understand these positive and unusual outcomes requires closer scrutiny of the specific dynamics of land accumulation underlying it.

Land Accumulation Strategies Post-Mitch

The remarkable gains in land wealth by study households in the wake of Mitch were achieved through three processes:

a) Forest clearing: as noted above, households increased their landholdings by carving new fields out of primary forest, and did so at a particularly rapid rate in the year after Mitch.

While this path to land accumulation was hardly new, the post-Mitch economic landscape offered wage opportunities that allowed the formerly land-poor new access to this route. Young households with relatively well-educated heads—including single women—used their organizational salaries to pay others to make fields for them.

b) Accelerated inheritance: Mitch created the conditions for households to 'take stock' of their landholdings, and those to which they might be entitled as children or spouses of the deceased. In the years following Mitch, many respondents reported pursuing land claims or consolidating specific parcels, that they had formerly considered not worth claiming or maintaining. As a result, 12% of fallow land owned by sample households in 2002 had been 'inherited' since Mitch (mean: 2.9 ha).

c) By 'blazing' a plot of primary forest, thus effectively reserving it for future use. This land accumulation strategy—unlike those above—was wholly new; its emergence is detailed below.

The 'Blaze' System

Without doubt the most important factor shaping the community's emergent resilience was the institutional transformation that allowed a radical new form of land redistribution. Specifically: Fig. 4 shows the dramatic post-Mitch emergence of a new type of landholding: primary forest.[11] That is, by 2001, 64% of study households claimed to actually own forest that they had not yet cleared. This represented a radical departure from the usufruct system; these households effectively grafted elements of the *ladino* land-claiming system onto their own. Thus while 'blazing' a forest parcel secured households' transferable *use rights* to the land (as in the *ladino* system), the parcel's resources (fish, NTFPs, and game) retained communal rights of access (absent in the *ladino* system).[12] Further, involvement in the system remained predicated on community membership, with land sales to outsiders prohibited. These combined characteristics appear to mark this system as a local, regionally distinct innovation (cf. Hayes 2008).

Fig. 4. Composition of landholdings in Krausirpi over time.

By 2002, 41.4% of households aggregate landholdings were in primary forest (Table 2). Households that had been in the 1998 'land middle' terciles were particularly likely to be reliant

on the blaze system for accumulating land after Mitch—they held almost 50% of all their land in forest reserve by 2002. It appears to be no coincidence that these households also were those to earn the lowest income share (just 8%) by 2001: the same attributes that identify these households—middle-aged families with fewer dependents, older heads, and less land originally (see Table 3)—were those that made them both relatively disadvantaged in the post-Mitch wage market and simultaneously less able to pursue more labor or cost-intensive forms of land accumulation.

Benefits of New System

For adopters, the social and economic benefits of the new system were compelling. Labor efficiencies increased as travel times to even a distant parcel compared well against multiple visits to scattered fields. In fact, new footpaths improved access to once-remote uplands, and temporary shelters allowed people to stay in fields overnight. Further, labor effort was no longer wasted in speculative forest clearing; blazing itself demanded little effort. Social problems were lessened as farmers spaced themselves out over the landscape. Large plots also maximized the potential for risk to be spread over a range of agriculturally untested soils. Farmers experimented with rice, manioc, plantain, and bean varieties; evidence suggests that they did so with no measurable decline in initial yields, suggesting the upland's agricultural potential had been formerly underappreciated. Adopters also expressed relief at the relative ease with which the new system allowed them to 'set aside' land for their children. Finally, the new system yielded ecological benefits: as enrollment grew, clearing of primary forest for rice dropped (Fig 4).

Quiet Revolution

The agricultural shake-up enabled by the new landholding system represents an institutional phase shift—fundamentally transforming patterns of land ownership, management, and inheritance, with important ecological implications. Because *how* institutions change is critical to their long-term resilience (Hayes 2008), we review below how the new system came about.

Several factors may have emboldened young households to break old rules and experiment with a 'foreign' system. One was the semi-official imprimatur lent to the process by ICADE-led discussions of new forms of landholdings during zoning discussions for the BTA. Second, a

precedent had been set within the BTA: the 'blaze' system had been long used in one upriver Tawahka community in which male household heads were all *ladinos*. Finally, by destroying the community's best lands, Hurricane Mitch created the conditions for re-imagining agricultural possibilities—a perceptual 'window of opportunity' that was seized upon by those most constrained under the earlier system.

By just *how* did they pull it off? Most striking to us was the silent, almost "viral" way in which the new system spread, in a fundamentally bottom-up mode of quiet action. No leader emerged to champion the new system; no meetings were held to discuss it; by 2002, some interviewees even remained ignorant of its existence. Instead, the process spread from neighbor to neighbor, and involved individual negotiations regarding parcel boundaries. Generally, interviewees were unwilling to consider the new system revolutionary, but rather something that each decided to do. According to one adopter, "each person decided on their own." By 2009, all households had reportedly 'bought into' the system.

It is possible to speculate on ways in which the system's ability to get 'off the ground' was in fact predicated on the low-key nature of its dissemination. For one, there is reason to believe that the quiet process minimized the potential for derailment by state representatives who might have erroneously interpreted the changes as land *privatization*, thus undermining support for the Tawahka's communal land claims. Further, the viral process allowed young families to establish stakes in the new system, minimizing potential distortion by community founders (cf. Passerini, 2000). It would be misleading to suggest, however, that the strategy was *deliberately* pursued for these reasons. Instead, the quiet process represented an endogenous form of institutional change entirely consistent with Tawahka governance norms and reflective of their traditionally diffuse power structure. To some degree, early adopters saw *no need* to seek communal consensus (or to necessarily 'stay under the radar'), since Tawahka norms have always been built through individual action that is subsequently sanctioned. In this case, communal approval was eventually signaled by the widespread adoption of the practice.

5. Discussion and Conclusions

In sum, then, we found that in one rural community in Honduras, unexpected institutional change in the wake of Mitch served—directly and indirectly—to ultimately enhance systemic resilience and improve livelihoods in important ways. The case raises questions about several emerging orthodoxies about rural peoples' response to climate change.

A. The fate of the poorest is not sealed

Most literature on the response of rural communities to aggregate shocks (climatological, economic, or other), predicts that pre-existing social differentiation is ultimately re-asserted, if not intensified, throughout the recovery and reconstruction process. To be sure, disasters can provide windows of opportunity. But empirical evidence overwhelmingly shows that it is the better-off who are most able to take advantage of those opportunities, thus reestablishing the status-quo and reinforcing social inequality in the aftermath of abrupt external change (Oliver-Smith, 1996; Passerini, 2000; Adger, 2003; Adger et al., 2003; Abel et al., 2006). Development economists have also show persuasively that both idiosyncratic and covariate shocks tend to deepen the poverty of the poorest (Zimmerman & Carter, 2003; Prowse & Scott, 2008). In Honduras, studies of smallholders' responses to Hurricane Mitch have found these predictions to be largely borne out (Casolo, 2009; Morris et al., 2002; Mainville, 2003).

This study suggests that alternative outcomes are possible. Unexpectedly, we found that the status quo was undermined, not reinforced, when Mitch provided the window of opportunity for the community to reorganize its subsistence base and effectively re-write its landholding rules. This allowed the land-poor (directly and indirectly) to escape the poverty traps that dampened their effective access to land and thus profoundly constrained their livelihood options. Particularly noteworthy is that single women were among those differentially enriched by this process (cf. Casolo 2009).

This hopeful process, however, only became apparent years into post-Mitch reconstruction. We suggest that similar surprises may emerge from greater analytical attention to long-term recovery trajectories following (climatic) disaster (see also Passerini 2000).

B. Adaptive dynamics of endogenous institutional change

The Tawahka of Krausirpi's ability to effect transformative institutional change in the wake of disaster exemplifies adaptive capacity. That is, the system demonstrated its ability to learn, innovate, and be flexible, with clear ecological benefits. Further, in social outcome, it exemplified the ultimate goal of good governance: social justice (Lebel et al., 2006).

This example, while small and one-off, nevertheless disrupts several emerging orthodoxies about the ability of rural communities to effect transformative institutional change. First, it is surprising that, in the wake of Mitch, the community engineered *any* persistent institutional change at all. Most studies suggest that rural peoples' adaptation to climate changes is manifest in household-level adjustments and innovations in their investments and their productive activities—not in their institutions (Heijmans, 2004; Adger & Brown, 2009; Paavola & Adger, 2006). In fact, much research predicts that meaningful structural change is unlikely in such settings, for various reasons (Passerini, 2000). In the rare post-disaster contexts in which rules *are* re-written, their effects tend to be short-lived (Oliver-Smith & Hoffman, 1999; Anderson & Woodrow, 1989). Several studies of post-Mitch reconstruction in Honduras have lent support to these findings (Jansen, 2003; Jeffrey, 2002; Casolo, 2009); this study therefore offers an important exception.

Second, development literatures suggest that vulnerable rural communities are unable to engineer transformative institutional change without external support and/or facilitation (REFS). Yet in Krausirpi, the new land-holding system emerged endogenously, requiring none of the external funding found to be important for institutional change in other indigenous communities (Abel et al., 2006; Hayes, 2008); nor was it stimulated or supported by any supra-local actors (or even local elites).

Finally, the means by which locals transformed their landholding structure seems unusual, particularly to the degree that it appeared as an 'emergent property' of the system, built through a silent, 'snow-ball'-like process of cumulative decision-making by individual households. Thus the change did not emerge, as elsewhere in post-Mitch Honduras, in the heated context of 'crisis politics' (Casolo, 2009; Jeffrey, 2002; Jansen, 2003). Nor did it require the transaction costs

typically associated with landesque rule-making (Hayes 2008; see also Passerini 2000). Nor did it rely on the specific forms of governance (e.g., deliberation, explicit consensus-building, and participation) that are typically promoted by governance-development programs (Lebel et al., 2006).

It is likely that this sequence of surprises is predicated in part on Krausirpi's indigenous character: residents know each other, most are related, and there is a long-term cultural commitment to place. Thus public social capital is relatively high, such that prior to Mitch there existed the basic elements (though fraying) of trust and mutual understanding essential for institutional flexibility in the face of environmental change (Adger, 2003; Lebel et al., 2006).

In this respect, the case lends much-needed empirical support to two related propositions regarding support for communities facing climate change. The first is that social capital can represent a community's most important adaptive resource. The second is that forms of effective governance, which arise from specific constellations of social capital, may be hard to anticipate or recognize—in effect, they are "shadow systems" (Pelling and High 2005).

In the case of Krausirpi, community members had the time and the institutional space to sort out and slowly enact a new post-disaster order. Perhaps not surprisingly, this favorable context was the unintentional result of the community's relative *neglect* by formal reconstruction efforts. A lesson here is that neither the nature of the systemic improvement that is required to help a community to prepare for climate change, nor the path to achieve it, may be apparent. Those seeking to foster improvements might best focus their attentions on ensuring a *favorable context for the emergence of endogenous solutions*, rather than on identifying or implementing particular ones (see also Folke 2006).

C. Sources of vulnerability as sources of resilience

In its capacity to self-organize and improve in response to disaster, the community of Krausirpi demonstrated its resilience to the shock of Hurricane Mitch (Adger et al., 2005; Pelling & High, 2005). In retrospect, it is possible to identify some of the adaptive capacities latent to the system

that were critical to that outcome (Table 5). For example, communal fatalism about the inevitability of (unpleasant) change stimulated a willingness to prepare for 'another Mitch'—indeed, the expectation of change is a critical element of successful adaptation (Adger & Brown, 2009). Similarly, the Tawahka's traditionally diffuse, acephalous governance structure accommodated the viral, bottom-up mode of institutional transformation.

Table 5. Community characteristics as sources of vulnerability and/or resilience.

Paradoxically, however, several of these 'sources of resilience' appeared, prior to Mitch, to be sources of vulnerability (Table 5). Some—such as the lack of leadership structure—were being deliberately targeted by development initiatives. That some system characteristics can be both sources of resilience *and* vulnerability, depending on context, presents obvious development challenges (Adger et al., 2005; Nelson et al., 2007; Folke, 2006). Often, the issue is discussed in terms of the 'either/or' trade-offs that must be made between investments in short-term vulnerability reduction versus investments in long-term resilience resources.

While more research is certainly required, we suggest that such programmatic trade-offs are avoidable. After all, among the range of latent resilience resources triggered by Mitch, some had also been instrumental in mitigating quotidian stressors prior to Mitch (e.g., capacity for social learning; see Table, above). In short, sources of vulnerability are not necessarily sources of resilience, nor vice-versa. To recognize system characteristics most likely to *promote* resilience and *lessen vulnerability* across various scales and schedules of change, analysts might shift their perspective from asking "what's wrong with this socio-ecological system?" to "what in this system is working well? And what appears to have been working well for a long time?" Asking such questions should ideally reveal system attributes that deserve support.

D. Development efforts can increase rural vulnerabilities

As is more the norm than the exception (Leichenko & O'Brien, 2008; Eakin, 2006; Oliver-Smith, 1996), our study shows how economic development interventions prior to Hurricane Mitch ultimately increased the community's vulnerability to climatic shock. In particular, the promotion of cacao accelerated socio-economic stratification, focused income sources on a

single crop, and spatially concentrated production in a floodplain. We suggest that in future, income-generation programs in rural communities instead support multiple activities simultaneously—preferably those that contrast in their system requirements—i.e., in the timing of their labor demands, in their spatial requirements, or in the type of capitals they require (see also Eriksen & O'Brien, 2007). While such initiatives might initially increase project inefficiencies and costs, and may lower net income returns (Prowse & Scott, 2008), they will also enhance subsistence security and drastically lessen the chance that years of development effort be obliterated by a single catastrophic event.

Similarly problematic are the growing number of development efforts to build leadership capacity and rural governance structures (see, e.g., Pielke Jr. et al., 2007). In Krausirpi, considerable development effort was devoted to workshops and courses designed to 'capacitate' promising individuals in particular skills—in effect, to professionalize Tawahka and thus build the sort of internal governance capabilities seen to be lacking (e.g., leader-facilitated participatory decision-making). While this training did help to prepare Tawahka to work for regional NGOs and to find jobs beyond the BTA, our findings suggest the Krausirpi's ultimate resilience to Hurricane Mitch was in part predicated on a process of institutional change that relied on the incomplete incorporation of such exogenous models into local governance systems. The lesson here is that there is no ideal model of governance that will best help communities to cope with climate change (see also Bankoff, 2004).

Notably, however, the Krausirpi case indicates that employment opportunities with state and non-state development actors can be critical sources of cash in the initial phases of reconstruction. Thus while the specific development interventions may be misspecified, incomplete, or counterproductive, residents' earnings from involvement in such efforts can be important for supporting their self-defined projects.

Finally, this study also calls attention to the need for renewed attention to the role of land tenure security as a critical element of resilience. Especially for 'forest peasantries' and other smallholder societies living in settings where land remains relatively abundant (but contested), this case makes clear that secure access to land can be a vital communal safety net in the wake of

covariate, climate-induced shock. After all, the Tawahka's long-term political commitment to securing their homeland from outsider encroachment ensured that land was available in Krausirpi's hinterland to buffer the shock of Mitch. In effect, the forest provided a communal insurance policy against disaster (see also McSweeney 2004, 2005). We argue, therefore, that development efforts to build rural peoples' resilience to climate change must reach beyond standard income-generation and capacity-building and governance efforts, and must also include support for local peoples' self-defined and explicitly political struggles for land and resource access and, in the case of indigenous people, territorial autonomy and self-determination.

[1] Honduras today remains the second-poorest country in the hemisphere (after Haiti), and nascent improvements in human development appear to be unraveling in the wake of the June, 2009 coup.
[2] For example, in mid 2001, 58% of 50 households interviewed in Krausirpi reported a major illness of a household member since the hurricane hit, with time lost to illness averaging 3.3 months. The reported median cost of treatment was 2,000 Lempiras, or about 30% of households' average cash income in 1998 (prior to Mitch).

[4] These comments are corroborated by responses to hypothetical questions about sources of cash income in times of need. In 1998, before Mitch, 29% of households mentioned forms of social capital (e.g., loans from family, neighbors, shopkeepers) as a means to meet minor medical expenses. By 2001, only 7% did so.
[5] By 2001, sample households claimed an average of 2 ha more cultivated land over their 1998 holdings—suggesting that in total area in cultivation or fallowed, they more than recouped their Mitch-induced losses. Two caveats are warranted here, however. First, the 'new' lands were generally in upland, not in the floodplain. Second, in the wake of Mitch, households appeared to take more careful stock of their landholdings. They were therefore more likely to report parcels of land (particularly old fallows) that before Mitch they may have considered to have reverted to the communal land pool.
[6] Despite repeated inquiries, residents insisted that lands are truly borrowed, not 'rented,' in that no compensation of any kind was expected. Indeed, many respondents still found the idea of "charging" for seasonal use of a plot of land (e.g., through sharecropping or payments) laughable.
[7] Tawahka used no pack animals in this period and made little use of tumplines in transporting harvests.
[8] Based on household survey data on rice yield data for Krausirpi for selected years. In lb/0.25 ha, rice yields averaged 1120 (1994, n=32 households); 573 (1995; n=31); 931 (1997; n=42); 328 (1998; n=32—in that year, only 73.4% of households were able to harvest rice prior to the hurricane); 596 (1999; n=48), and 648 (2000; n=48).
[9] Faith in cacao as an important investment did not appear affected by experience of the hurricane. When household heads were asked what they would ideally like to leave their children as an inheritance, 9.7% of total responses were "cacao orchards." In 2001, despite the damages from Mitch, 10.2% were.
[10] Conditions for raising both chickens and cattle were much improved by the re-arrangement of the village that was catalyzed by Mitch. Most importantly, many residents cited fear of 'another Mitch' to leave their cramped houseyards and build new homes, encircled with wire, on the community periphery far from the riverbank. This effectively 'spread out' the community, facilitating care for (and minimizing disruptions from others') free-range livestock.
[11] I first noted families claiming primary forest in 1998, when a resident explained that he, along with about four other households, were inspired by the Tawahka Federation's calculations, during land legalization efforts, that every household had a right to 50 ha of land. At the time, the benefits of the blaze system were recognized; as this resident said "That way, the children's inheritance is there. Piece by piece [i.e., the usufruct system] is no good. Better to find a large personal plot" (IS, fieldnotes, 1998). Still, at that time, only an estimated 8% of households had claimed primary forest in this way.
[12] In a further 'unbundling' of property, the trees belonged to the state (under the rules of the Biosphere Reserve). *Any* Tawahka, therefore, could be fined for harvesting trees for timber or canoes on any given parcel. As of April 2009, this fine system was effectively enforced by a military post established in the village.

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Table 1. Impacts of Hurricane Mitch on sample households in Krausirpi

HOUSEHOLD MEANS	All house holds (n=43)	1998 Land Wealth Terciles: Land poor	Land middle	Land rich	anova P>F
n	43	15	13	15	
Landholdings prior to Mitch (1998)					
Total land held (ha) 1998	13.9	3.4	11.7	25.8	***
-in floodplain	6.0	1.3	4.7	11.7	***
-in upland	7.5	1.5	6.6	14.2	***
-in primary forest	0.2	0.1	0.4	0.0	
No. mature cacao trees owned	422.0	108.5	357.1	777.0	***
Tercile's share of total land 'pie', 1998		8.0	27.3	64.8	n.a.
Impacts of Mitch					
Average floodplain land lost to Mitch (ha)	4.8	1.8	4.4	8.0	***
Land lost to Mitch as share of all land held in 1998 (%)	45.0	58.8	40.9	35.5	
Adoption of 'blaze' system					
Share claiming primary forest, 2001 (%)	63.6	46.7	71.4	73.3	
Share claiming primary forest, 2002 (%)	53.9	18.2	71.4	64.3	
Share of primary forest in total land (1998)	1.2	3.8	3.4	0.0	
Share primary forest in total land (2001)	40.3	35.0	54.9	31.8	
Share primary forest in total land (2002)	41.4	22.3	49.1	38.0	
Landholdings, 2001					
Total land held (ha) 2001	25.3	11.7	25.3	40.0	***
-in fallow and cultivated	15.2	7.6	11.4	27.1	**
-in primary forest	10.2	4.1	13.9	12.7	
Share tercile owns of total land 'pie', 2001		16.1	32.5	51.4	n.a.
Net gain in landholdings 1998-2001 (ha)	11.4	8.3	13.6	14.2	
Percent gain from 1998 landholdings, 2001 (%)	82.0	244.	116.2	55.0	

	All house holds	1998 Land Wealth Terciles			
		1			
Landholdings, 2002					
Total land held (ha) 2002	40.8	13.5	44.0	59.0	**
-in fallow and cultivated	25.0	10.8	22.3	38.8	*
-in primary forest	16.9	3.0	21.6	22.4	*
Net gain in landholdings 1998-2002 (ha)	26.9	10.1	32.3	33.2	
Percent gain from 1998 landholdings, 2002 (%)	193.5	295.6	276.1	128.7	
No. cacao trees planted since Mitch (to 2002)	129.7	42.7	112.9	215.0	
Fallow lands inherited after Mitch (to 2002)	2.9	1.4	0.3	6.2	

P>F= *<0.1, **<0.01, ***<0.001 (oneway ANOVA)

Table 2. Selected household variables: aggregate mean and by 1998 land wealth.

HOUSEHOLD MEANS	All households (n=~43)	1998 Land Wealth Terciles: Land poor (n=15)	Land middle (n=13)	Land rich (n=15)	anova P>F
DEMOGRAPHIC VARIABLES, 1998					
Founder status (1-4) 1=founder; 4=stranger	2.6	3.0	2.9	1.9	**
Year of household formation	1981	1984	1980	1979	
Years lived in community	14.9	11.4	14.7	18.5	
Household size	7.8	6.7	8.1	8.6	
Age of household head in years	37.8	35.4	38.5	39.5	
Male workers (15-64 years)	1.6	1.5	1.8	1.7	
Female workers (15-64 years)	1.5	1.4	1.5	1.7	
Headed by single woman; 0=no;1=yes (%=1)	23.0	47.0	7.0	13.0	*
CASH INCOME GENERATION					
1998					
Total cash income (Lempiras)	14581.0	7941.0	9505.0	26297.0	**
Share (%) of cash income from:					
-sale of agricultural products (including cacao)	32.2	16.3	46.5	35.4	*
-livestock	2.9	1.4	6.2	1.1	
-business (self-employment)	11.0	7.7	8.5	17.4	
Share tercile earns of total cash income 'pie'		18.2	21.7	60.1	n.a.
2001					
Total cash income (Lempiras)	6969.3	8397.0	1754.0	10408.0	**
Share (%) of cash income from:					
-sale of agricultural products (including cacao)	0.0	0.7	0.2	4.9	
-wage work in agriculture (locally)	19.7	16.0	37.8	5.7	
-livestock	4.5	2.1	3.0	7.0	
-business (self-employment)	11.7	17.3	0.2	16.8	
-distant wage work (labor migration)	16.2	15.9	10.2	22.0	
-remittances	5.3	2.2	14.2	0.0	
Share tercile earns of total cash income 'pie'		41.1	8.0	50.9	

P>F= *<0.1, **<0.01, ***<0.001 (oneway ANOVA)

Table 3. Regression models predicting land ownership by type, for households before/after Hurricane Mitch.

	PRE-MITCH		POST-MITCH					
	Floodplain and fallow holdings, 1998		**Floodplain and fallow holdings, 2002**		**Primary forest claimed, 2002**		**ALL land held, 2002**	
	Rreg		Rreg		OLS		Rreg	
<u>Independent variables(1)</u>								
Founder (1-4) 1=founder; 4=stranger	-2.76	*	0.11	*	10.76	*	15.75	**
Year of household formation	37.47		-165.06	**	108.81		93.69	
(Year of household formation)^2	-0.01		0.04	**	-0.03		-0.02	
Age of household head (male or fem)	-1.13		8.32	**	-1.68	*	3.23	
(Age of hhld head) squared	0.01	*	-0.12	***			-0.07	
Male workers	4.33	**	4.47	*			5.12	
Number of dependents	-0.45		-0.97		-3.19	*	-3.92	
Headed by single woman (0/1)	-0.32		-25.28	**	-35.99	*	-65.55	**
No. cattle owned	0.31		1.91	*		*	3.16	*
Claimed primary forest (0/1)			-11.43	**			-7.81	
Cultivated land held	0.25	**	-0.14		-0.20		0.31	
Constant	19590.86		165196.6	**	-105221		-88310.83	
Observations	47		38		41		42	
Adjusted R2	0.56	** *	0.79	***	0.22	*	0.56	** *

(1) Household variables as of 1995 or 2001, lagging the dependent variable

* =<0.1; **=<0.01; ***=<0.001

Table 4. Tobit model predicting gains in land wealth by 2001, relative to total land held in 1998.

	Ratio of 2001:1998 land gained	
	Tobit	
Variable		
Years lived in Krs by 98	0.05	
(Years lived in Krs)^2	-0.001	
No. male workers 98	-1.83	***
No. dependents 98	0.63	*
No. adult brothers in village 98	-0.95	***
Headed by single woman	3.92	**
Share inc earned from agro (%)	0.08	***
Total land held in vega 98 (ha)	-0.45	***
(Total land held in vega)^2	0.01	***
No. peach palms owned 1998	-0.12	***
Claimed prim. forest by 01 (0/1)	5.36	***
Constant	-0.43	
No. observations	35	
No. obs<=0	9	
No. obs>0	26	
Pseudo R2	0.32	***

Table 5. A sample of community characteristics (A) in terms of their perceived contribution to individual and communal vulnerabilities prior to Mitch (B), and in terms of their role in the institutional changes that enhanced resilience after Mitch (C).

	A	B	C	D
		PRE-MITCH	**POST-MITCH**	
	System Characteristic	**Source of Vulnerability?**	**Source of Resilience?**	**Implied trade-off?**
A	Residents' shared belief in inevitability of (unpleasant) transformative events	Yes. 'Fatalism' seen as a barrier to collective action for positive change.	Yes: Belief in "another Mitch" helped motivate change.	YES
B	Capacity for social learning; willingness to experiment with external ideas, practices	No. Central to Tawahka cultural survival against assimilative pressures.	Yes: facilitated adaptation of 'foreign' landholding system; encouraged agricultural experimentation.	NO
C	Diffuse decision-making structure; no tradition of leadership	Yes: cited as barrier to collective action required to address problems.	Yes: bottom-up, viral nature of transformation was particularly effective; emboldened individual action: "Every family thinks for themselves."	YES
D	Indigenous commitment to a future in place	No. Drives political initiatives to secure ancestral lands; enhances livelihood security.	Yes: new landholding system relied on community's access to surrounding forest.	NO
E	History of collective and individual production specialization (sectoral, temporal, spatial)	Yes: creates production inefficiencies; patchwork nature of land ownership leads to social problems.	Yes: facilitated embrace of unknown internal agricultural 'frontier'; increased flexibility to changed production options.	YES

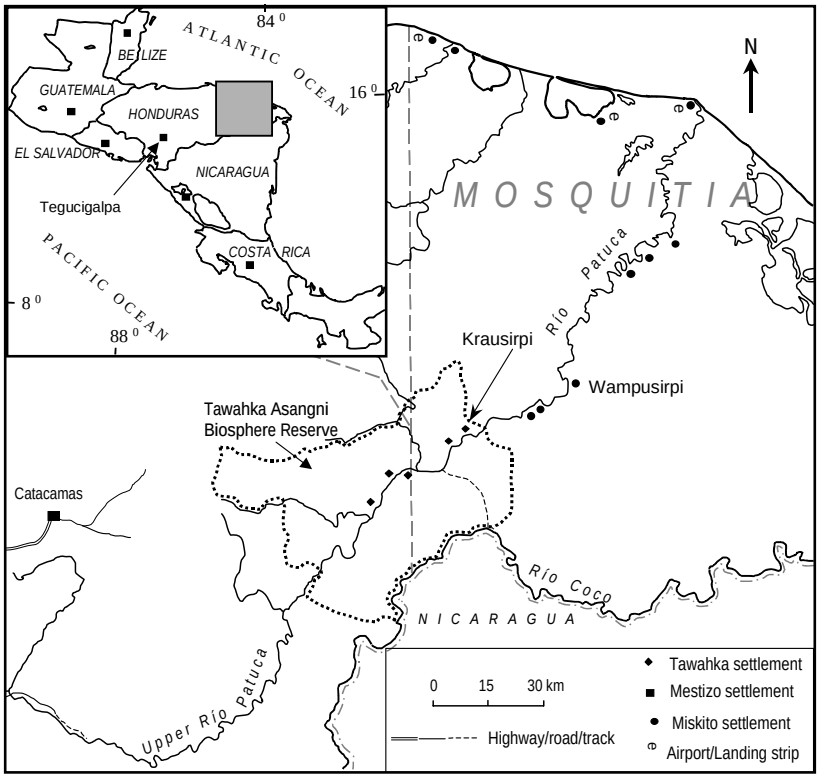

Fig. 1. Map showing the study community within the Tawahka Asangni Biosphere Reserve (BTA) in eastern Honduras. (Source: author).

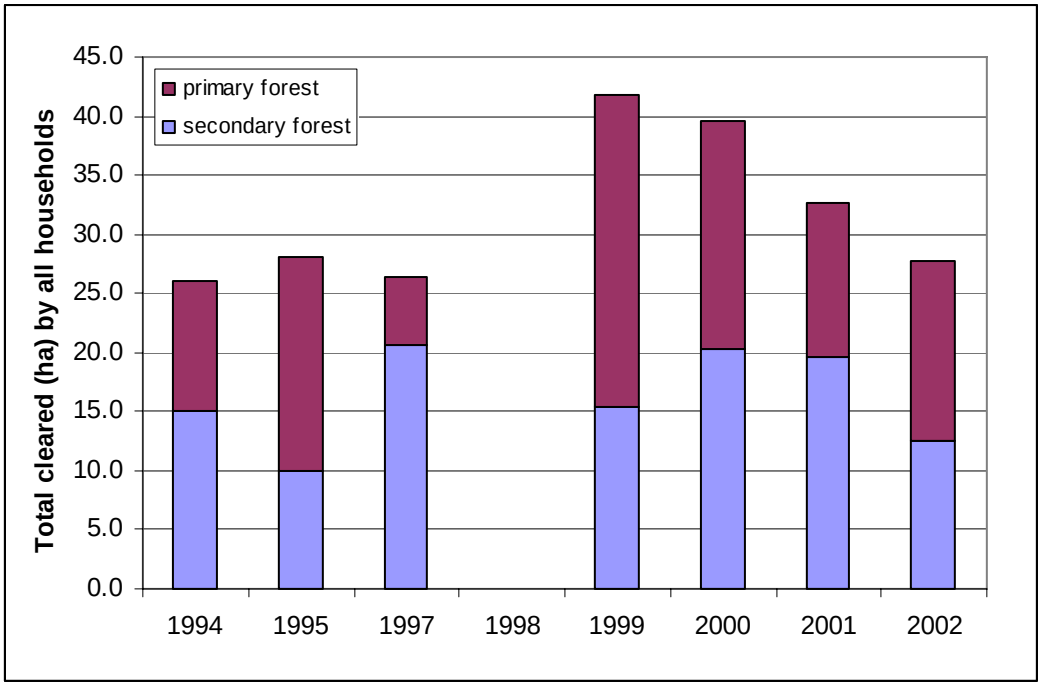

Fig 2. Forest cleared for rice planting, by forest type, by same households (n=~35) in Krausirpi.

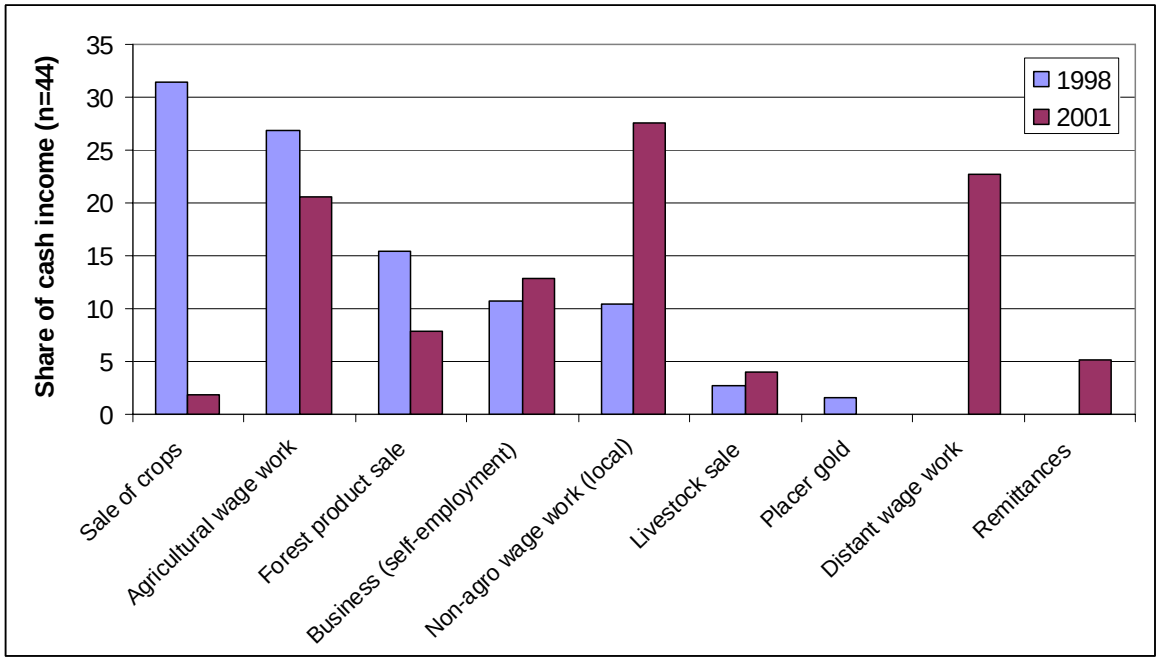

Fig. 3. Share of total market income by sector (%), comparing 1998 with 2001 (before and after Hurricane Mitch), for same 44 households.

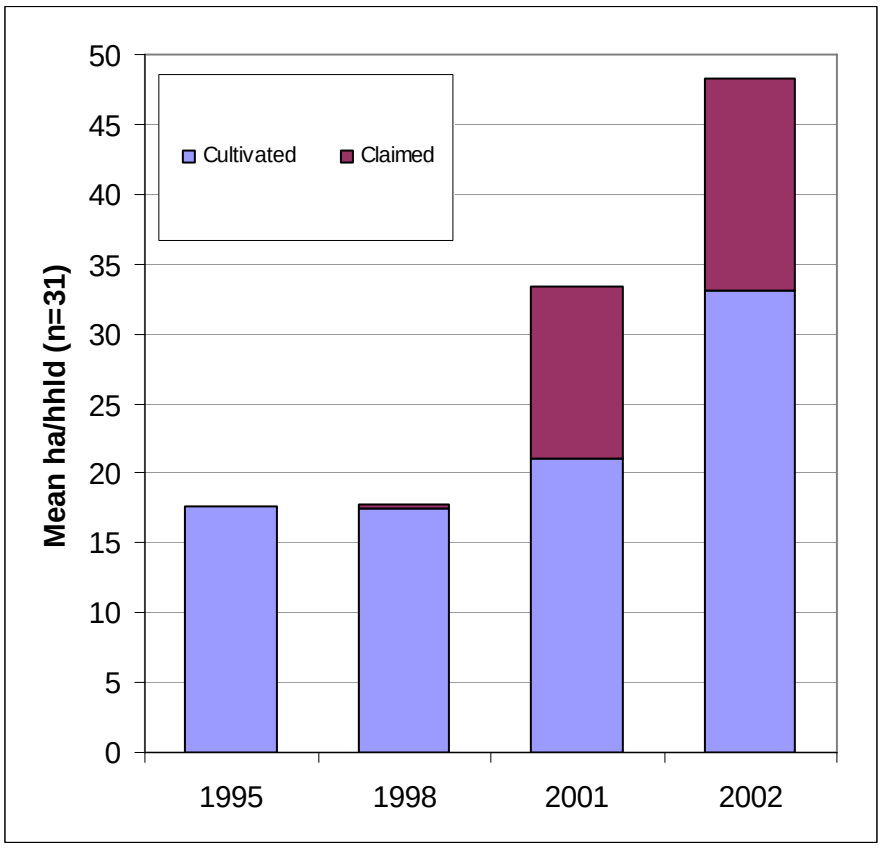

Fig 4. Composition of landholdings in Krausirpi over time. “Cultivated” includes fallows and plots in agroforestry.