The Gatekeeper Series produced by IIED's Sustainable Agriculture and Rural Livelihoods Programme aims to highlight key topics in the field of sustainable agriculture and resource management. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions for development that are particularly relevant for policymakers, researchers and planners. References are provided to important sources and background material. The Series is published three times a year – in April, August and December – and is supported by the Swedish International Development Cooperation Agency (Sida).

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Executive Summary

A study using a participatory action research approach and simple field techniques found significant differences in agroecological resistance between plots on 'conventional' and 'sustainable' farms in Central America after Hurricane Mitch. On average, 'agroecological' plots on sustainable farms had more topsoil, higher field moisture, more vegetation, less erosion and lower economic losses after the hurricane than control plots on conventional farms. The differences in favour of these agroecological plots tended to increase with increasing levels of storm intensity, increasing slope and years under agroecological practices, though the patterns of resistance suggested complex interactions and thresholds. For some indicators agroecological resistance collapsed under extreme stress.

With the help of 40 non-governmental organisations and 99 farmer-technician teams, 1,743 farmers measured key agroecological indicators on 1,804 plots paired under the same topographical conditions. These paired observations covered 360 communities of smallholders from southern Nicaragua to eastern Guatemala. The broad geographical coverage took into account the diversity of ecological conditions, a variety of practices common to sustainable agriculture in Central America, and moderate, high and extreme levels of hurricane impact. This coverage, and the massive mobilisation of farmer-technician field research teams, was made possible by the existence of a widespread smallholders' network for sustainable agriculture called *Movimiento Campesino a Campesino* (Farmer to Farmer Movement).

A model for measuring agroecological resistance is introduced, and it is suggested that comparatively higher levels of agroecological resistance are an indication of lower vulnerability and higher sustainability. However, the effectiveness of practices appears to be bounded by a combination of steep slopes, maintenance and design of soil conservation structures, and extremely high storm intensity.

Because the study was a large experiment in regional agro-environmental research, a number of methodological lessons were learned about the trade-off between participation and scientific rigour. While the ability to gather large amounts of data across wide areas had advantages, care must be taken to maintain the process of scientific inquiry among groups, rather than a simple focus on protocol.

After analysing the results from the study, agroecological and conventional farmers designed strategies for participatory, sustainable reconstruction and identified the factors driving and limiting the development of sustainable agriculture. They proposed policies for participatory sustainable reconstruction and sustainable agricultural development. Participants presented their findings in national meetings to representatives from government and international NGOs, and later distributed them publicly. However, although the study was influential in reconstruction activity in villages and programmes where MCAC is already present, it had negligible impact on national policies for reconstruction.

The paper concludes that while the *Movimiento Campesino a Campesino* has successfully advanced the technical and methodological aspects of sustainable agriculture, *a policy ceiling* is currently limiting the generalised spread of sustainable agriculture among smallholders in Central America.

MEASURING FARMERS' AGROECOLOGICAL RESISTANCE TO HURRICANE MITCH IN CENTRAL AMERICA

Eric Holt-Giménez

Introduction

The *Movimiento Campesino a Campesino* (MCAC) is a farmers' movement for sustainable agriculture that has spread steadily throughout villages in Mexico and Central America for the past 30 years. It is Central America's first movement 'from below' to be concerned with environment and development. MCAC's extensive, informal network of *campesino promotores* (peasant-extensionists)[1] has consistently reversed trends of declining agricultural productivity and environmental degradation on smallholder farms in hundreds of rural communities in Central America, often enhancing local control over broader development processes (Bunch, 1996; Guijt, 1998; Hocdé, 2000b; Holt-Giménez, 1989,1996; Ramos Sánchez, 1998). Nonetheless, farms using agroecologically-based methods of farming remain sustainable islands in a large, conventional sea. Probably less than half a percent of Central America's some 4 million campesinos practise what would be considered 'sustainable' agriculture.[2]

Farmer-led sustainable agricultural development approaches have been criticised in conventional development circles for not 'going to scale' (i.e. massive adoption), for their alleged weak economic viability, deficient science, and for the lack of evidence supporting claims of sustainability. These criticisms are not entirely misplaced. Analysing the economic viability of peasant farming styles with complex blends of pluriactive, risk-averse, subsistence and marketplace strategies is a daunting task, not easily undertaken by the NGOs and farmer organisations that have pioneered sustainable agriculture in Central America. Further, it is difficult to predict the overall sustainability of a given agroecosystem, and impossible to prove it beyond the 'test of time.' Are MCAC's farms sustainable? If so, why haven't the rest of Central America's farmers adopted these practices? Then again, if the problem is inferior science or poor economic viability, then why *do* some 15,000-20,000 *campesinos* practise some form of it? In short, what is driving, and what is limiting, the development of sustainable agriculture among the region's smallholders? This paper provides some answers to these questions.

Background and Framework

In October 1998, Hurricane Mitch slammed into Central America causing at least US$ 6.7 billion in damage to infrastructure and industry, an amount equal to approximately

1 In this paper I use the term campesino *interchangeably with "smallholder", "farmer" and "peasant."*
2 For example, Sustainable Agriculture and Rural Development (SARD), Sustainable Land Management (SLM), Low External Input Sustainable Agriculture (LEISA), etc.

13% of Central America's GNP. Over 10,000 people died and 3 million were displaced or left homeless (CRIES, 1999; Ecocentral, 1998). Hitting the region just as most farmers were harvesting their basic grains, the hurricane's torrential rains destroyed natural vegetation and standing crops and washed millions of tons of topsoil from hillsides into rivers. Mudslides and floods destroyed rural bridges, roads, homes and buildings. Honduran agricultural losses were estimated at US$2 billion. In Nicaragua, small-scale farmers suffered the brunt of over US$76 million in damages. Five percent of the cultivated area in Guatemala was lost to the hurricane. Because the disaster disproportionately affected Central America's low income sectors, it was popularly known as 'El Huracán de Los Pobres', the Hurricane of the Poor.

Mitch's rains, the heaviest on record, dumped 20-50% of the average annual rainfall on parts of Central America in only five days. Most observers agreed that the unprecedented magnitude of the disaster in Central America was the consequence of decades of deforestation, unsustainable agricultural practices and other forms of environmental degradation that left the region exceptionally vulnerable to an erosive event. In this view, Central America's ecological vulnerability is the result of a development model that displaced poor farmers from bottom lands to fragile hillsides and the agricultural frontier, favoured extensive cattle ranching, and fostered a general overdependence on fertilisers and herbicides, leading to bare soils devoid of organic material.

While first reports regarding agricultural damage simply indicated that the levels of destruction were massive, subsequent on-site observations began to reveal a more differentiated pattern. Farms commonly referred to as 'sustainable' appeared to have suffered less damage than their 'conventional' neighbours (Bunch, 1998; Ernst, 1998; Schlather, 1999). These farms generally belonged to smallholders working within MCAC. The farming practices commonly encountered in MCAC included a wide range of soil conservation and agroecological management, tested and promoted by these smallholders for over 20 years (Annis, 1992; Bunch, 1995; Holt-Giménez, 1996; Selener *et al*., 1997). Such practices include structural, agronomic and agroforesty techniques (Table 1). Conventional smallholders in Central America commonly use a mix of traditional and 'semi-technified' practices that use external chemical inputs without the benefit of machinery or irrigation.

Obviously, there is some mix and overlap between these two categories, as some conventional farmers employ some agroecological techniques and vice-versa.[3] However, MCAC's farms are fairly distinguishable from their conventional neighbours throughout the Central American landscape. Therefore, while geographically fragmented, as a group their farms provide a unique opportunity to compare sustainable and conventional practices over a wide range of ecological conditions. The farmers, *promotores* and technicians in MCAC are experienced in on-farm, farmer-led experimentation, participatory technology development, and farmer-to-farmer training (Hocdé, 2000a; Holt-Giménez, 1997). This exten-

3 For example, some conventional farmers reduce slash and burn techniques, plant on the contour or rotate crops; some sustainable farmers apply some external inputs, rotate less, etc.

Table 1. Farming Practices

TYPE	PRACTICES				FUNCTION
MCAC PRACTICES					
Mechanical practices	Contour ploughing	Rock and vegetative contour bunds	Contour ditches	Terraces	Soil & water conservation/ management
Agronomic practices	Cover/inter/ relay cropping with grains and legumes	Intensive, in-row tillage	Compost, vermiculture, animal manure	Integrated Pest Management: traps, organic pesticides and repellents, beneficial insects	Fertility, soil building, weed and pest control, water conservation, soil protection
Agroforestry	Woodlots	Multistorey & alley cropping	Vegetative strips	Live fences	Fuel, fodder, timber, fruit, reduction of runoff, nutrient pumping/cycling, habitat for beneficial insects, shade
CONVENTIONAL PRACTICES					
Mechanical practices	Ploughing/ cultivating with (not against) the slope	Dibble-stick planting			Create seedbed, reduce labour input
Agronomic practices	External chemical inputs: (fertilisers, pesticides, herbicides)	Slash and burn			Supply nutrients, control weeds and pests

sive network of local expertise was the basis for the design and implementation of a three-month field study that used paired observations to compare agroecological resistance between sustainable and conventional farms in Guatemala, Honduras and Nicaragua.[4]

Sustainability, vulnerability and agroecological resistance

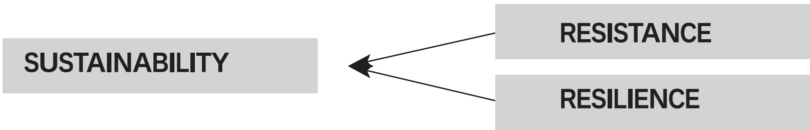
Hurricane Mitch, like all 'natural' disasters, was actually a combination of natural hazard and human *vulnerability* (Smith, 1996; Wilches-Chaux, 1994). Vulnerability is

4 The study was conceived by the author, with valuable contributions from Professors Jonathan Fox, David Goodman, Stephen Gliessman and Margaret Fitzsimmons of the University of California, Santa Cruz. Pascal Chaput of Nicaragua provided invaluable support in the design process and both administered the project and coordinated the fieldwork in Nicaragua. Gonzalo Rodríguez, Manuel Camposeco and Maritza Zuleta coordinated the fieldwork in Guatemala and Honduras. Anasonia Recinos Montes was the methodologist. Nicolás Arróliga of GeoDigital-Nicaragua designed the database. World Neighbors was the sponsoring agency for the study, and administered the project in Guatemala and Honduras.

the level of difficulty to "*anticipate, cope with, resist, and recover from the impact of natural hazard*" (Blaikie, 1994), and can be expressed as an inverse function of the level of sustainability of a model or course of development (Cardenal, 1999; Wisner, 1993).

$$\text{NATURAL DISASTER} = \text{HAZARD} \times \frac{\text{VULNERABILITY}}{\text{SUSTAINABILITY}}$$

In this definition, sustainability is a function of resistance and resilience in response to disturbance and stress (Gliessman, 1998). Resistance is the ability of a system to resist the impact of a disturbance. Resilience is its ability to recover after the disturbance. Increasing the level of resistance or resilience to disturbance will raise the relative level of sustainability (and lower the relative level of vulnerability), mitigating the effects of natural disaster.



Using this model, trends towards or away from agroecological sustainability may be assessed by measuring trends in system resistance and/or resilience. In this study, farmers used paired observations to measure the relative differences in agroecological resistance between MCAC farms and their conventional neighbours.

Methodology

We decided to use participatory action research, PAR (de Wit and Gianotten, 1991; Fals-Borda and Rahman, 1991), to guide a research process based on farmers' objectives and their organisational and agroecological capabilities.

Organisation

In February 1999, three months after the hurricane, Guatemalan, Honduran and Nicaraguan Farmer Organisations (FOs) and NGOs working in sustainable agriculture were invited by researchers to national meetings to discuss the idea of a participatory study on the effects of Hurricane Mitch. There was high interest among these organisations; they were keen to evaluate their programmes, and wanted to influence the regional reconstruction process. It was felt that an objective study comparing sustainable and conventional farms would not only test assumptions about sustainability, but could contribute to the debate on participatory, sustainable reconstruction. By March, 40 FO/NGOs had joined the study (19 from Nicaragua, 11 from Honduras and 10 from Guatemala). Working under the Principal Investigator (PI) national research coordinators for each country and a methodologist were hired to facilitate training and documentation. It was hoped that field data from all three countries could be organised into a single regional database.

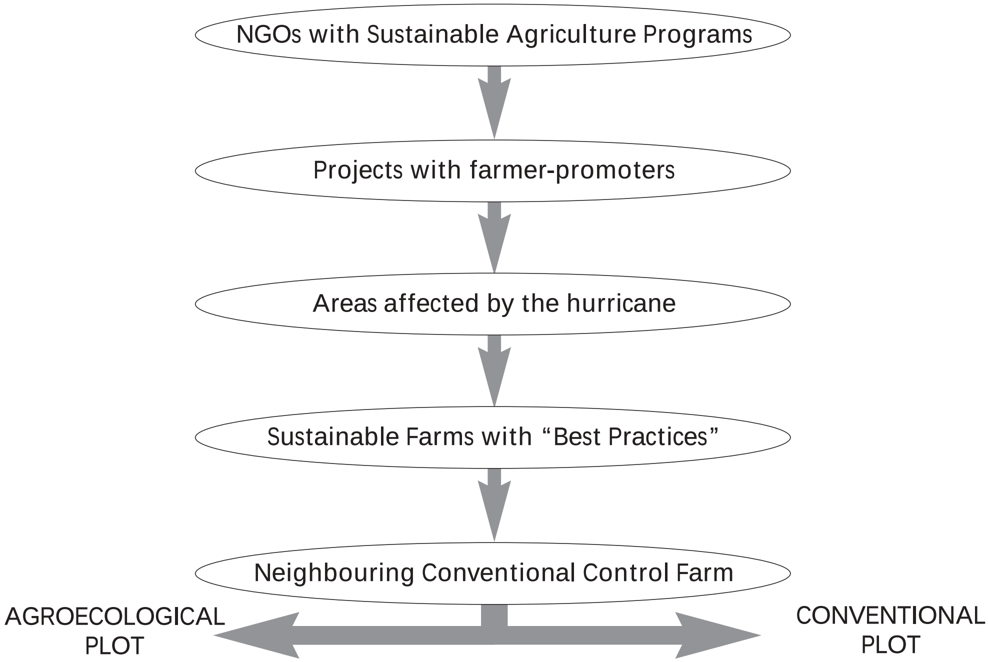
Methods

The study design rested on paired observations between sustainable farms and their conventional neighbours. In order to isolate practices as the independent variables, and selected agroecological indicators as dependent variables, paired farms were carefully chosen to be as similar as possible in their topography, slope, orientation and position in the watershed. Each pair needed to be either bordering each other or close nearby (100m). Small representative plots (~0.5ha) were selected on each farm for measurements.

Because of the geographic fragmentation and low incidence of sustainable farms in Central America, a random selection in areas affected by the hurricane would not have yielded sufficient numbers of sustainable farms (if any). Therefore, we used a purposive selection method (Figure 1).

SAMPLING SELECTION

Figure 1. Site Selection Process



We selected indicators to measure the hydrological and erosive aspects of hurricane impact: e.g., topsoil depth, depth to humidity, percent vegetation, landslides, rill erosion and gully erosion. Economic losses from crop damage were estimated and inventories of farm practices were recorded. The methods of observation and measurement employed in the study were a hybrid of simple field techniques commonly used by the promotores of MCAC (Holt-Giménez, 1995), and field methods for agroecological assessment used to teach basic agroecology (Gliessman, 1999).

Because the study wanted to isolate the effects of the hurricane, fieldwork was conducted between the end of April and early June, before the onset of the spring rains. Because it would have affected topsoil and moisture measurements, farms that had already begun to prepare fields for planting did not enter into the study. Since most paired observations took place well before farmers began preparing their fields, almost all of the selected farms were able to participate in the study.

Training and quality control

Because of the strong presence of MCAC in Nicaragua, these FO/NGOs organised very quickly for the study, allowing this country to be used as the test site for training and field procedures. Researchers worked with Nicaraguan FO/NGO technicians to develop a single set of field methods and a simple field manual. Each technician selected two *promotores* to form a three-person field research team. Each NGO organised one to five farmer-technician teams. Once field methods and instruments were developed and field-tested, national coordinators held training workshops in all three countries to prepare the teams. Over 100 farmer-technician teams were trained over a three-week period in one-day workshops conducted on farms in potential research areas.

The methodological challenge was to sufficiently train a large number of research teams to take consistent, unbiased measurements and observations in highly variable ecological conditions. The importance of precision and unbiased observation was a central theme in team training. To control observational error between teams, technicians were all trained by the same researchers using the same methodology and field manual. To eliminate measurement errors between pairs of farms observed by the same team, each farmer-promoter was trained to make a specific set of measurements and observations. Within each team the same person always made the same measurements. Slope measurements were repeated four times per plot, soil depth, moisture and erosion measurements three times.[5] As a field check, both farmer-owners (sustainable and conventional) accompanied the research team during the data collection on both farms. Farmers signed off on the field sheet to indicate that in their view, observations and measurements had been done in an unbiased manner (otherwise, the paired observations were either thrown out or done again). Teams carried out 10-20 paired observations, usually one pair a day.

Results

Because the number of paired sites was large (nearly 1,000), and because these observations covered areas of moderate, high, and extreme storm intensity from southern Nicaragua to eastern Guatemala, the body of observations provides a good overview of smallholder practices, ecological conditions, and storm effects in Central America.

5 For a detailed explanation of methods, manual and field instruments see Pascal Chaput, Informe Nacional, Nicaragua, World Neighbors, 1999.

Comparisons between paired sites shows a consistent pattern of significant differences favouring agroecological (sustainable) over conventional plots. Despite high ecological variability between paired sites, agroecological plots in all three countries had more topsoil (Figure 2) more field moisture (Figure 3), and more vegetation (Figure 4).

Figure 2: Topsoil

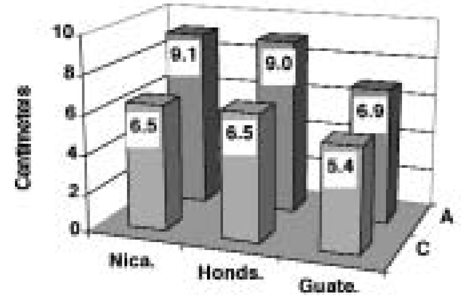


Figure 3: Depth to Humidity

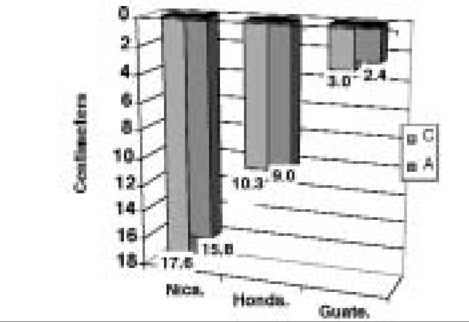
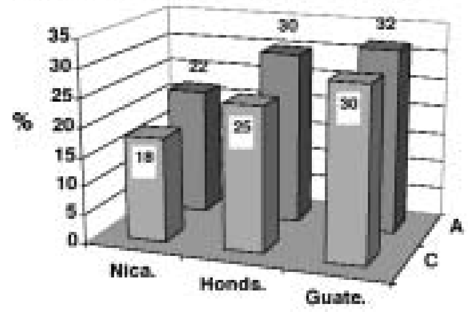


Figure 4: Percent Vegetative Cover



Key:
A = Agroecological plots
C = Conventional plots

Topsoil, Depth to Humidity and Vegetation

On average, agroecological plots had 30-40% more topsoil than conventional plots. While differences of two centimetres may seem small, they are equivalent to 200 m^3/ha of topsoil and an approximate erosion rate of 100 tons/ha/yr. (Toness *et al.*,1998).[6]

The indicator used to compare levels of field moisture did not establish field moisture *per se*, but compared the depth to observable moisture from the dry soil surface. The assumption was that moist soil found closest to the surface indicated greater levels of field moisture. On average, farmers had to dig 3%-10% less on agroecological plots than on conventional plots to reach moisture.

The measure of vegetation (both crops and natural) was considered both an indication of storm impact and a general indication of on-farm regenerative ecological processes.

6 Differences encountered in topsoil are an especially important finding because they suggest that the regional estimates of erosion damage from Hurricane Mitch based on satellite imagery (that only detected landslides and large areas of bare subsoil) were probably much too low. Ironically, peasants working with shovels and tape measures detected laminar soil erosion satellites missed…

Agroecological plots had approximately one-fifth more vegetative cover than conventional plots.

Erosion: Landslides, Rill and Gullies

While topsoil and depth to humidity were measured on all farms, severe erosion was found less often. Low incidences of severe erosion (on both agroecological and conventional farms) in Guatemala precluded meaningful comparisons. In the case of Honduras, inconsistency of field measurements and data entry errors on the field sheet and the database unfortunately led to the elimination of this data.[7] Nicaragua, the country with the highest number of paired observations, provides the best, statistically significant set of findings (Figure 5; Holt-Giménez, in press).

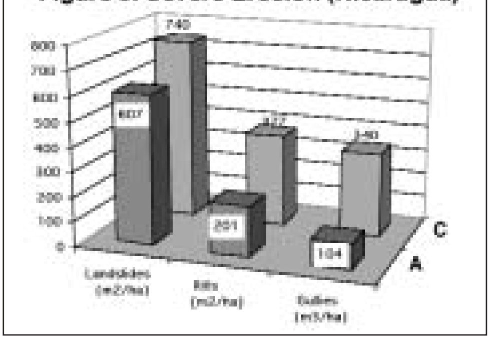


Figure 5. Severe Erosion (Nicaragua)

On average, agroecological plots lost 18% less arable land to landslides than conventional plots and had a 49% lower incidence of landslides. Agroecological plots averaged 47% less rill erosion than conventional plots. The frequency of rill erosion among agroecological farms was 58% lower than on conventional farms. Eighty percent of conventional plots were found to have up to 78.1m^2/ha more rill erosion than agroecological plots.

Agroecological plots averaged 69% less gully erosion compared to conventional farms. Gullies occurred 63% less on agroecological plots. Eighty percent of conventional plots had at least 20 m^3/ha more volume of land loss to gully erosion than did agroecological plots.

Net Profit/Loss

Average *profits* (measured directly after the hurricane) from agroecological farms were roughly equal to average *losses* from conventional farms (+$17.18 versus –$18.54). While agroecological farms averaged 193% higher farm incomes, median values of agroecological and conventional farms were similar (-$54.72 versus -$55.79), indicating that overall, farmers from both sectors probably suffered equally from the hurricane in economic terms. However the difference between mean and median was much greater in the case of agroecological farms, reflecting (relatively) high profits on some of these farms.

Agroecological Practices

The results of a multivariate analysis of co-variance using 19 different agroecological

7 The trends in soil erosion for Honduras and Guatemala, while not statistically significant, followed the same patterns favouring agroecological farms. World Neighbors put considerable effort into cleaning this data, see "Lessons from the Field" *in World Neighbors (2000).*

practices and storm intensity yielded highly significant overall effects on topsoil though not for any other indicators. Rock bunds, green manure, crop rotation and the incorporation of stubble all demonstrated strong effects on differences in topsoil depth between agroecological and conventional plots.

Trends in Agroecological Resistance

The Nicaraguan data allowed for further analyses and the detection of important trends in agroecological resistance among MCAC farms.

Old agroecological farms (10 years and older) had two and three times larger differences in topsoil, soil moisture and percent vegetation with their conventional neighbours than did young agroecological farms (1-2 years) with theirs, indicating that resistance increased over time for these indicators. However, differences in severe erosion rose in favour of mature agroecological farms (3-5 years old), then dropped for old farms, indicating a drop in agroecological resistance. This may be because farmers on older farms with established terraces tend to abandon the use of conservation ditches.

Differences in severe erosion tended to rise with increasing storm intensity, indicating increasing agroecological resistance with increasing levels of rainfall disturbance. However, on 30%-50% slopes, the differences in severe erosion between agroecological and conventional farms tended to fall, indicating the need to deal more effectively with heavy runoff on steep hillsides, and/or a ‘threshold’ for the effectiveness of these practices.

Agroecological farms on very steep slopes and those under extreme storm intensity lost their profit advantage in relation to conventional farms. This loss of relative economic resistance under a combination of extreme stress and disturbance (slope and rainfall) suggests physical limits to the economic viability of present agroecological practices. Newly established agroecological farms (1-2 years) also had no profit advantage over their conventional neighbours, suggesting that farmers are economically vulnerable early in the transition from conventional to agroecological practices.

Feedback Phase: Reconstruction Policy from the Grassroots

We used several post-fieldwork steps to share and enrich the study’s findings:

- Initial ‘feedback’ phase: research organisers shared preliminary findings with NGOs/FOs, farmer-technician research teams, local authorities and other local NGOs.

- Grassroots phase: farmer-technician teams shared the study with villagers in the communities where the research had been carried out.

- National presentation phase: researchers, promotores and technicians presented findings in a seminar for a broad audience of national and international NGOs, government officials, university researchers and the national press.

• Extended, public phase: made study's findings available to the development community in Central America through articles, websites, and electronic mailings.

• Follow-up phase one year later: a one-day workshop in Nicaragua allowed study participants to assess the study's impact on their reconstruction efforts.

Initial feedback phase

The first feedback phase, conducted in all three countries, consisted of some 20 workshops with agroecological and conventional farmers, farmer-technician teams, NGO/FOs, and key actors from local communities (eg., mayors, other NGO representatives, etc.). Farmers (men and women) were encouraged to bring their spouses. The objectives of these workshops were to share the results from the fieldwork, elicit experiences of the disaster and post-disaster, and build a vision with specific proposals for reconstruction.

Findings were presented as national, local and team averages, allowing participants to compare the field results from their own village-level measurements with those of the region, with other regions and with national averages. Farmers noted that MCAC's farms scored consistently higher than conventional neighbours in measures of agroecological resistance and that differences in agroecological resistance rose and fell depending on stress and disturbance. They discussed the influence practices and maintenance may have had on these results. Overall, farmers felt that the study proved the superior resistance and sustainability of MCAC's practices for *campesino* farmers, but felt that their practices could be improved.

In an effort to explore the determinants of farmer-led, sustainable agriculture, participants were asked why MCAC farmers had adopted agroecological practices and why conventional neighbours had not. Farmers responded that adoption and non-adoption depended on the factors in Table 2.

The consultation with farmers and community members indicated that in general, the development of sustainable agriculture was directly related to the failures of conventional agriculture on the one hand, and to on-ground successes of MCAC, and institutional support of NGOs on the other. While it was not possible to ascertain the exact reach of MCAC, it was clear that the movement used NGO programmes to expand into new areas and to maintain and deepen its presence in farming communities. NGOs provided a supportive vehicle and 'policy context' for MCAC, by providing transportation and financial support for farmer-to-farmer visits and workshops, support for *campesino* experimentation, access to new information, knowledge, seeds and technology, and in some cases, credit for sustainable practices and access to organic and international markets. While MCAC's blend of innovation and solidarity were key to the spread of farmer-led sustainable agriculture, adoption did not happen in a vacuum.

Though the agroecological and economic breakdown of conventional agriculture (agronomic involution, disappearance of subsidies, poor extension, etc) made farmers more

Table 2. Factors for Adoption or Non-adoption of Sustainable Practices

ADOPTION	NON-ADOPTION
Need to maximise production on small parcels of land Need to reclaim ecologically degraded land to increase production Debt avoidance (difficulty in paying off credit for agrochemicals) Need to lower costs Desire to reduce vulnerability to recurrent drought and floods Desire for greater autonomy (from banks and government conventional agriculture schemes) Concern for family health (avoid pesticide poisoning; desire for diverse, balanced diet) Access to MCAC training and farmer to farmer exchanges Technical assistance from NGO technicians (farmer-led experiments, advice, agronomic knowledge) Incentives (credit, market for organic products, tools, information)	Rented or sharecropped land (farmers are unwilling to invest in medium to long term improvements) Lack of time/family labour (labour-intensive soil & water conservation costs too high, especially for single women) Lack of knowledge (of SARD/SLM principles, practices and management) Too much land (farmers can rotate plots when degradation becomes a problem) Chemical subsidies (ecological degradation processes are masked by application of cheap fertilisers, pesticides and herbicides) Lack of environmental awareness (some farmers simply to do not 'care' about the environment) Tradition (resistance to change, unwillingness to risk new methods)

receptive to alternative approaches, without access to the human resources in MCAC and to the informational and logistical resources of the NGOs, these farmers might just as easily turn away from farming altogether. Given a favourable policy environment (albeit at the micro-level), *campesinos* had proven themselves capable of developing a form of agriculture that was more sustainable than the conventional agriculture supported by both government agricultural policies and mainstream international/national agricultural research. Farmers pointed out that the criticism levelled at MCAC (primarily from conventional agriculture adherents) regarding its inability to 'scale up' sustainable agriculture obviated the fact that to replace traditional agriculture, conventional agriculture itself had relied on extensive support from mainstream agricultural research, cheap credit and favourable price and market policies.

Participants split into groups to share experiences of the hurricane. During discussion, they suggested strategies for mitigation, assigning different participatory roles to different actors (Table 3). Participants split into groups again, this time to formulate their vision for sustainable reconstruction. The MCAC reconstruction strategy followed certain priorities and time frames (Table 4).

National Presentations

At the national presentations of the study in Nicaragua, Honduras and Guatemala, participants presented findings to national media, government, international NGOs,

Table 3. Campesino Strategy for Participatory Agricultural Reconstruction

Main Problems	Solutions	Actors and responsibilities		
		Government	NGOs	Community
Land poor; insecure ownership Absence of credit and market policies favorable to sustainable agriculture, organic agriculture, conservation Outside organisations overlap in communities Lack of socio-environmental conscience Tradition	Agroecologically-based land reform Organised actions coordinated to promote policies favourable to sust.ag. Permanent work to raise agroecological consciousness and practices in *campesino* communities	Define and direct pro-sust.ag. reconstruction/reform policies Facilitate preferential credit for agroecological farming Finance certification procedures for organic farmers and open markets for organic and sustainable labelled products Support agroecological research Legalise campesino lands Donate land to *campesinos*	Coordinate their actions with the different institutions that work at the community level Publicise the results of the Mitch Study Formalise the study's institutional coordination for permanent, farmer-to-farmer research and training network	Reinforce local organisation and work to raise awareness at the *campesino* family level Carry out farmer research, field experiments and training Reconstruct and construct soil and water conservation structures Implement agroecological practices Convert to organic farming

Table 4. Campesino Vision for a Sustainable Future

SHORT TERM (3 years) LONG TERM (ten years)	Homes, wells, fences are rebuilt
Soil and water conservation structures have been repaired and new land brought under conservation The majority of families in the community are organised in support of sustainable agriculture The diversified "patio economy" is consolidated as stable source of family income Organisations (NGOs, Municipalities) are able to coordinate on participatory, local development efforts	The entire community farms agroecologically and conserves local natural resources in a coordinated way Production is highly diversified Roads have been improved, at least 80-90% of the population has access to basic resources (water, electricity, education, health) Producers are organised for the efficient marketing of agricultural surplus

and programme coordinators and project personnel from local NGOs. Participants also made the following policy recommendations for participatory, sustainable, agricultural reconstruction:

- Credit: preferential, low-interest production credit tailored for organic and agroecologically-grown crops; medium-term credit to finance labour costs of soil conservation structures, especially for single women

- Incentives: certification for sustainably farmed products; target/guaranteed price for sustainably farmed products; economic subsidies for soil reclamation and restoration

- Rights to property: government-financed title procedures for both private and communal forms of ownership

- Maintenance of watersheds: $C0^2$ capture, conservation of topsoil, conservation of biological diversity

- Penalties for environmental externalities: deforestation; water pollution; erosion

- Research and training: Farmer-Researcher network for agroecological research; agroecological research in environmental services and externalities; support of farmer-to-farmer exchanges, experimentation and training.

Public/Follow up

A preliminary report of the study and a CD-ROM of the interactive database of results were distributed among participants. Findings and a summary were posted on a website (agroecology.org). A follow-up inquiry done one year later with study participants in Nicaragua (Holt-Giménez, forthcoming) revealed the study to be an effective educational tool to promote sustainable agriculture. With the help of their agroecological neighbours, approximately half of the conventional farmers who had participated in the study went on to implement agroecological practices. Technicians from one NGO adapted the study to include more agroecological measurements and went on to apply it over a broader area. Some NGOs used the study to attract funding for sustainable reconstruction activities, and to influence local reconstruction projects. By working with the World Food Program, one NGO increased its coverage by 200%. Other NGOs incorporated the study as a permanent part of project monitoring.

Discussion

Campesinos farming in areas where Hurricane Mitch rained hardest claimed that the storm unleashed "*ten winters*" of rain on their fields in a week. The differences observed between sustainable and conventional farms, they reasoned, were an indication of what might be expected over the next decade. Though erosion processes cannot be extrapolated in such a linear fashion (the impact of Mitch's intensive rains was undoubtedly more severe than 10 winters of normal weathering), the study provided farmers and researchers with a compelling picture of agroecological trends and tendencies among and between sustainable and conventional farming styles in Central America.

By providing quantifiable evidence of higher agroecological resistance on sustainable farms, the findings validate many years of hard work by farmers in the *Movimiento Campesino a Campesino*, identify key factors driving and limiting sustainable agriculture in Central America, and generate an important list of policy options for 'scaling up'.

Specifically, the study uncovered problems and possible thresholds to present practices:

- The drop in resistance to severe erosion over time and on very steep slopes indicates that MCAC farmers need to renovate, modify, and maintain conservation structures to deal with excess runoff from extreme rainfall events (e.g., reverse-slope bench terraces, sloped toe drains, etc.).

- The collapse of economic resistance on very steep slopes and at high storm intensity suggests that some conditions are simply too extreme to farm successfully using current agroecological practices. Sustainable agriculture needs to address issues of ecologically-based land reform and policies for appropriate land use on hillsides, particularly in upper-watershed areas (e.g., payment for soil and water conservation, reforestation, maintenance of biodiversity, etc.).

- Lower economic resistance in the early years of establishing agroecological practices suggests that farmers are making the transition to sustainable agriculture precisely when their farms are most vulnerable, i.e. after the 'diminishing returns' agroecological involution has already begun. This points to the need both to provide incentives for transition *before* farms become so vulnerable, and for initial subsidies or backstopping during the transition period.

Researchers also encountered several methodological advantages and disadvantages to carrying out extensive, participatory research. The difficulty of balancing scientific validity with the complexity of sharing methods with farmers can lead to tradeoffs between the scientific rigour needed to ensure confidence and validity, and the methodological simplicity needed to ensure quality participation by farmers (Poudel *et al.*, 2000). This problem was overcome by taking a few key, 'simple' measurements on many farms (hundreds), rather many complex measurements on relatively few farms (dozens).

However, in this study, good fieldwork depended much more upon field experience than formal training. *Promotores* with years of experience digging soil profiles in farmer-to-farmer workshops were much more consistent in their measurements than young professionals with limited field experience.

The breakdown of protocol in Honduras points to the difficulty of mechanically replicating the methods of participatory research. Nicaraguan technicians and *promotores* had the opportunity to define the problem, formulate hypotheses, design procedures and test field instruments. They designed the study based on *their* levels of organisation and expertise. Because of time constraints, the P.I. was forced to extend the study's *methods* from Nicaragua to Honduras and Guatemala without accurately replicating the research *process* (that would have adjusted for different levels of organisation and expertise). This soon created severe procedural difficulties that compromised training, monitoring and data processing.

Nevertheless, the study's results in Nicaragua were highly significant statistically because of the very large sample size, made possible through the participatory approach and MCAC's extensive network of promotores. The fact that such a large amount of data was collected in such a short period of time suggests tremendous potential for farmer-led agro-environmental research. Organising future studies as research processes within pre-defined agroecological domains could help overcome the logistical problems of a participatory approach, reduce noise from ecological variability, and increase the statistical power of the data collected.

The study was highly valued as an interactive, cooperative learning experience and considered mutually beneficial by researchers, technicians, promotores and farmers. It benefited the participating NGOs by providing them with an indication of the agroecological impact of their work. Projects not only have a solid baseline for future agroecological impact monitoring, they can potentially compare their progress with others, and together could make important regional and national recommendations.

The fact that NGOs and farmers were able to coordinate on a national level to both monitor their own projects and carry out simple but relevant research, opens up important opportunities for coordinated, decentralised approaches to sustainable agricultural research. Follow up studies of this nature could increase both farmers' technical capacity, and the scope for scientists' research. Given the complex, diverse and ecosystem-specific nature of sustainable agricultural development, further broad-based participatory work in the area of agroecological vulnerability could offer new ways of researching agro-environmental problems. Once agroecological domains and indicators are chosen and field methods are mastered, the model for agroecological resistance could be re-applied to address agroecological resilience as well. New indicators for low-intensity and local, recurrent disasters such as drought, pest outbreaks and even market crashes could be developed to further measure resistance and resilience.

Participatory Action Research: Limits to Action?

The motive for this exercise in PAR was to enable MCAC to influence agricultural reconstruction. Certainly, the study's findings and farmers' vision/policy recommendations demonstrate a strong desire and capability for participatory, sustainable reconstruction. How participants actually used the study is revealing of the opportunities and limitations, not just of PAR, but of the state of sustainable agricultural development. On one hand, farmers, *promotores*, technicians and NGOs each undertook different 'actions' within their respective areas of influence to advance their own sets of social and institutional goals. This is very encouraging because it demonstrates the potential for multiple returns to participatory action research. On the other hand, despite the informal MCAC network, (and despite other more formal NGO networks in Honduras and Nicaragua), after the national presentations, NGOs made no further attempts to coordinate their activities. Neither did NGOs lobby for or otherwise address the study's policy suggestions. This was despite the fact that after the hurricane, NGO networks to influence national and regional reconstruction had emerged in both Honduras and Nicaragua.

The action taken and not taken by participants reflects their level of agency in sustainable agricultural development, and helps explain why sustainable agriculture remains 'bounded' within small-scale, local-level projects. Though MCAC and NGO/FOs have successfully developed a far-flung network for developing and sharing technological and methodological innovations, this has not translated into strategies, programmes or coordinated actions to address the structural constraints on sustainable agriculture such as national research programmes, or pricing, market, and credit policies. In fact, awareness of policy as a factor in sustainable agricultural development is low among most NGO/FOs. These agencies focus on implementing local-level projects rather than policy. Research and policy-oriented NGOs, operating internationally or in urban centres, are sympathetic and equipped to lobby at the international level (UN fora, World Bank, Consultative Groups, etc.), but have limited ability to create political will among decision-makers within national governments. Farmers' organisations in Central America often have NGO-sponsored projects for sustainable agriculture, but tend to focus their lobbying efforts on gaining better policies for conventional, not sustainable agriculture. Finally, MCAC, while made up of hundreds of highly capable *promotores* and farmer-innovators, is politically speaking, leaderless. This state of affairs has created a *policy ceiling* to the development of sustainable agriculture, making it the exception, rather than the rule. The inability of NGO/FOs and study participants to take coordinated action within the policy arena of agricultural reconstruction, is a result of the difficulty that national agencies working in sustainable agricultural development have to address policy at all.

Measuring Farmer's Agroecological Resistance to Hurricane Mitch found the obstacles to sustainable agricultural development within the socioeconomic and environmental vulnerabilities laid bare by the hurricane. Improving farmer's agroecological resistance and resilience, making them less vulnerable and more sustainable, has as much to do with overcoming structural constraints as it does with participatory technology development, farmer to farmer extension, or farmer-led research. On an optimistic note, this study provides the first level of policy change: validated results of the benefits of sustainable practices and evidence of a widespread group with a demonstrated interest in and capability for advancing sustainable agriculture. The *Movimiento Campesino a Campesino* and the NGO/FOs have proven their effectiveness in developing the technical and methodological aspects of sustainable agriculture. Can they rise to the challenge of addressing the structural constraints?

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