ARTICLE CASE

# Coping Strategies of Smallholder Farming Communities after the 2015 Nepal Earthquake: Insights into Post-Disaster Resilience and Social–Ecological Change

**KATHLEEN EPSTEIN[1], JESSICA DICARLO[2], ROBIN MARSH[3], ISHA RAY[4] AND INGER MÅREN[5]**

[1]Department of Earth Sciences, Montana State University, United States, [2]Department of Geography, University of Colorado, Boulder, United States, [3]Institute for the Study of Societal Issues, University of California, Berkeley, United States, [4]Energy & Resources Group, University of California, Berkeley, United States, [5]Department of Biology, University of Bergen, Norway
Email: kathleenepstein@montana.edu

ABSTRACT Environmental disasters, such as hurricanes, landslides, and earthquakes, are pervasive and disproportionately affect rural and poor populations. The concept of resilience is typically used in disaster scenarios to describe how a community or person is able to "bounce back" from a disaster event. At the same time, resilience theory also contends that disasters, or environmental shocks, can produce or initiate profound changes in social and ecological systems. This case uses a post-disaster resilience assessment to examine how the series of earthquakes that hit central Nepal in 2015 impacted farming communities. Mid-montane smallholder farming communities near the epicenters of the earthquakes were the most affected and the associated damages impeded traditional and subsistence agricultural practices. Our results show how some aspects of the Nepali farming social–ecological system (SES) bounced back more quickly than others and how farmers used various types of coping strategies, including the adoption of labor-saving cash crops as part of their post-disaster recovery. The increased interest in cash crops after the earthquake accelerates an ongoing transition toward more market activities in subsistence communities and illustrates the potential of environmental shocks to transform and change SESs.

## KEY MESSAGE

This case is an example of a participatory post-disaster resilience assessment. Readers of this case will gain an understanding of (1) the concept of social–ecological resilience in disaster scenarios, (2) the differentiated impacts of natural disasters on components of social–ecological systems, and (3) how recovery from disasters can produce and accelerate change in social–ecological systems.

## INTRODUCTION

Environmental disasters, such as hurricanes, landslides, and earthquakes, are pervasive and disproportionately affect rural and poor populations [1, 2]. Often these populations have long histories of interacting with disasters, and cope with and productively manage destruction and change by developing traditions, skills, and knowledge [3]. Understanding these adaptive capacities, strategies and coping mechanisms have become a key focus of disaster risk reduction (DRR). Here, DRR programs and assessments use the concept of *resilience,* or the ability to buffer change, as one way of understanding how communities cope with and recover from environmental shocks or disaster events [4].

This case examines post-disaster resilience among smallholder farming communities in Nepal that suffered devastating earthquakes in 2015. This case uses a social–ecological systems (SESs) framework, where human and natural systems are seen as fundamentally linked [5, 6]. Because smallholder farmers were among the hardest hit by the earthquakes, we developed an assessment of the social–ecological farming system to under-

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stand how various social and ecological components of the affected system, and communities within that system, are able to "bounce back" and adapt after disasters (Figure 1, Table 1).

## CASE EXAMINATION

### *Brief Review of SESs and Resilience*

Over the last several decades, the SES has become a well-known and widely used concept [7, 8]. An SES is defined as a set of dynamic and adaptive resources (cultural, socioeconomic, and natural) linked through relationships and feedbacks [8], but has also come to represent a turn in environmental problem-solving. Instead of operating within bounded disciplines, SES academics and practitioners attempt to consciously and conceptually integrate societal issues with ecological processes and, through this coupling, analyze more holistically the complex nature of human–environment relations [9].

The epistemological roots of SES are embedded in concepts of complex systems, dynamic change, and the now ubiquitous term, *resilience*. C.S. "Buzz" Holling is widely credited for introducing resilience and resilience thinking to ecology with his longitudinal study of budworm outbreaks in the spruce-fir forests of eastern Canada [10]. Observing the connections between budworm outbreak and forest growth were non-linear, Holling countered the long-standing succession and climax-oriented theories that posited that systems move steadily toward equilibrium. Instead, Holling argued that systems are dynamic, regularly enduring shocks and perturbations that can alter their fundamental state. From here, the term *resilience* came to mean the capacity of a system to absorb change by either persisting in its current regime or by moving into an alternate one [7, 8, 10]. Alongside broad interests in the science community to understand environmental change, the term resilience and idea of resiliency have diversified in meaning and application since Holling's early works. A summary of various definitions is presented by Aldunce et al [4].

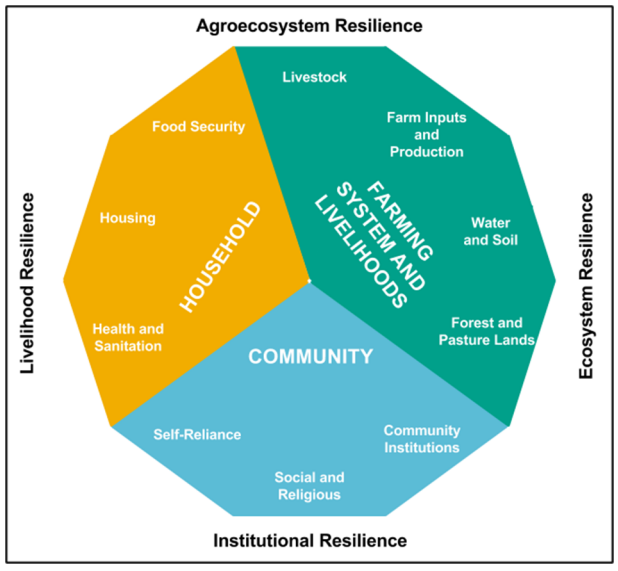


**FIGURE 1.** Schematic of resilience assessment used in interviews to track how aspects of the social–ecological system were able to "bounce back." We developed this assessment by drawing from existing resilience frameworks (Cutter et al. 2008; Buck & Bailey 2014) and adapting metrics to the Nepali mountain farming context.

### *Post-Disaster Resilience*

Post-disaster resilience describes how shocks impact both human and ecological communities and how deftly they can recover, or transform [6, 11, 12]. Studies of post-disaster resilience often emphasize the ability of communities to bounce back, which can include both the speed of recovery and the process of recovery itself (Figure 2) [4, 13]. Post-disaster resilience draws heavily from the field of community psychology [11, 12], as well as the perspectives on hazards and disasters pioneered by geographer Gilbert White. Connecting the social and ecological aspects of environmental crises like floods, White noted how more vulnerable communities could be affected more intensely by disasters [14]. This focus on reducing risk in vulnerable populations has led more recently to the integration of resilience into DRR and disaster management protocols [15]. For example, resilience is a key aspect of the Sendai Framework for Disaster Risk Reduction 2015–2030, supported by the United Nation's (UN) Office for Disaster Risk Reduction and developed by UN member states and non-governmental organizations (NGOs) [16]. Development agencies and organizations (e.g., the Rockefeller Foundation) as well as researchers have used the concept of resilience as a framework for reducing vulnerability and as a metaphor for sustainability. Such programs and research agendas often focus on identifying resilience-enhancing characteristics such as a community's capacity for planning [11], diversification within agricultural systems [17], or the presence of robust community institutions and social capital networks [18].

**TABLE 1.** List of categories, indicators, and metrics within the adaptation and recovery assessment used to track resilience following natural disasters for small-farm households (n = 79).

| Category | Indicator | Metrics (self-reported) |
|---|---|---|
| Farming Systems and Livelihoods | Farm inputs and production | Food crop productivity |
| | | Cash crop productivity |
| | | Overall crop quality |
| | | Diversity of crops produced |
| | | Seed storage system |
| | | Contributions of off-farm income |
| | Water and soil | Erosion on farm |
| | | Access to irrigation water |
| | | Irrigation system |
| | Forest and pasture lands | Access to forest resources |
| | | Access to grazing lands |
| | Livestock | Status of livestock |
| | | Farm structures/animal sheds |
| | | Use of livestock |
| Community | Community institutions | Access to local schools |
| | | Access to local health facilities |
| | | Participation in community groups |
| | Social and religious | Participation in festivals |
| | | Ability to engage with social networks |
| | Self-reliance | Capacity to help with rebuilding |
| | | Reliance on NGO aid |
| | | Reliance on local institutions |
| Household | Housing | Access to safe housing |
| | | Access to comfortable housing |
| | Food security | Ability of farm to provide food |
| | | Frequency of not having enough to eat |
| | Health and sanitation | Access to drinking water |
| | | Access to clean toilets |
| | | Access to water for hygiene/cleanliness |
| | | General physical health |

Indicators are derived from the literature and adapted to the Nepali context. We recorded participants' self-assessment of whether they were doing better, worse, or about the same on each of these metrics at 0 to 6 months after the earthquakes and 1 year after the earthquakes, compared to before the earthquakes. The aim in using this three-point scale is to track the direction of change in each resilience category, not the magnitude of change.

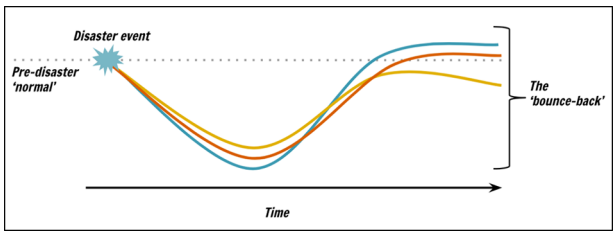


**FIGURE 2.** Post-disaster resilience is a way of understanding how communities cope with and recover from (environmental) shocks. Diagram adapted for assessment purposes from resilienturbanism.org.

### *The 2015 Earthquakes in Nepal*

In the spring of 2015, a series of earthquakes hit central Nepal. The first massive shock, a magnitude 7.8 event, struck on April 25th and was followed by a series of significant aftershocks. Another large earthquake, magnitude 7.3, struck on May 12th. As a result of these events, 9,000 people died, 23,000 people were injured, and 600,000 people lost their homes. The financial cost of associated damages amounted to almost one-third of Nepal's annual Gross Domestic Product (GDP) [19]. The district of Dolakha in central Nepal was one of the regions hardest hit and the epicenter of the second earth-

quake (Figure 3). Approximately 87% of the houses in Dolakha were destroyed or heavily damaged [19].

Dolakha lies about 132 km northeast of Kathmandu and is a mountainous landscape with elevations ranging from 732 to 7148 masl. The population of the district is 186,557 and includes multiple ethnic groups and castes: Brahmin (49%), Tamang (15%), Newar (9%), Thami (7%), Dalit (7%), Sherpa (5%), and various smaller ethnic groups [20].

### *Study Region and Design*

This case draws from fieldwork conducted in Dolakha's mid-hills, a region geographically situated between the *terai* (plains) to the south and the *himal* (high mountains) to the north. The economy predominantly consists of smallholder agriculture. Smallholder farmers and farming systems in Dolakha and elsewhere in the mid-hills are highly adapted mountainous environments (Figures 4a, 4b), which function as tightly coupled systems linking on-farm activities with off-farm resources and ecosystem services [21]. Farmers grow subsistence crops of maize, wheat, rice, and millet on terraced plots. Many maintain livestock, including goats, oxen, and cows, which are fed by collecting fodder from community forests (Figure 5). The knowledge and skills associated with managing this landscape have co-evolved over centuries of exposure to disasters, including avalanches, landslides and earthquakes, and, more recently, glacier melt and changing climate and water regimes [22, 23].

Traditionally, farmers in the Himalaya have been subsistence based; however, many mountain communities and farming systems are integrating more market-based livelihoods [24]. In response to multiple factors including pressures from out-migration and increasingly globalized and cash-oriented economies, national-level policy and climate change, farmers are gradually introducing cash crops and new plant varieties to their planting regimes (Figure 6). Cash crops, which are typically low-labor and high-value compared with subsistence crops, have become increasingly attractive as out-migration has decreased the

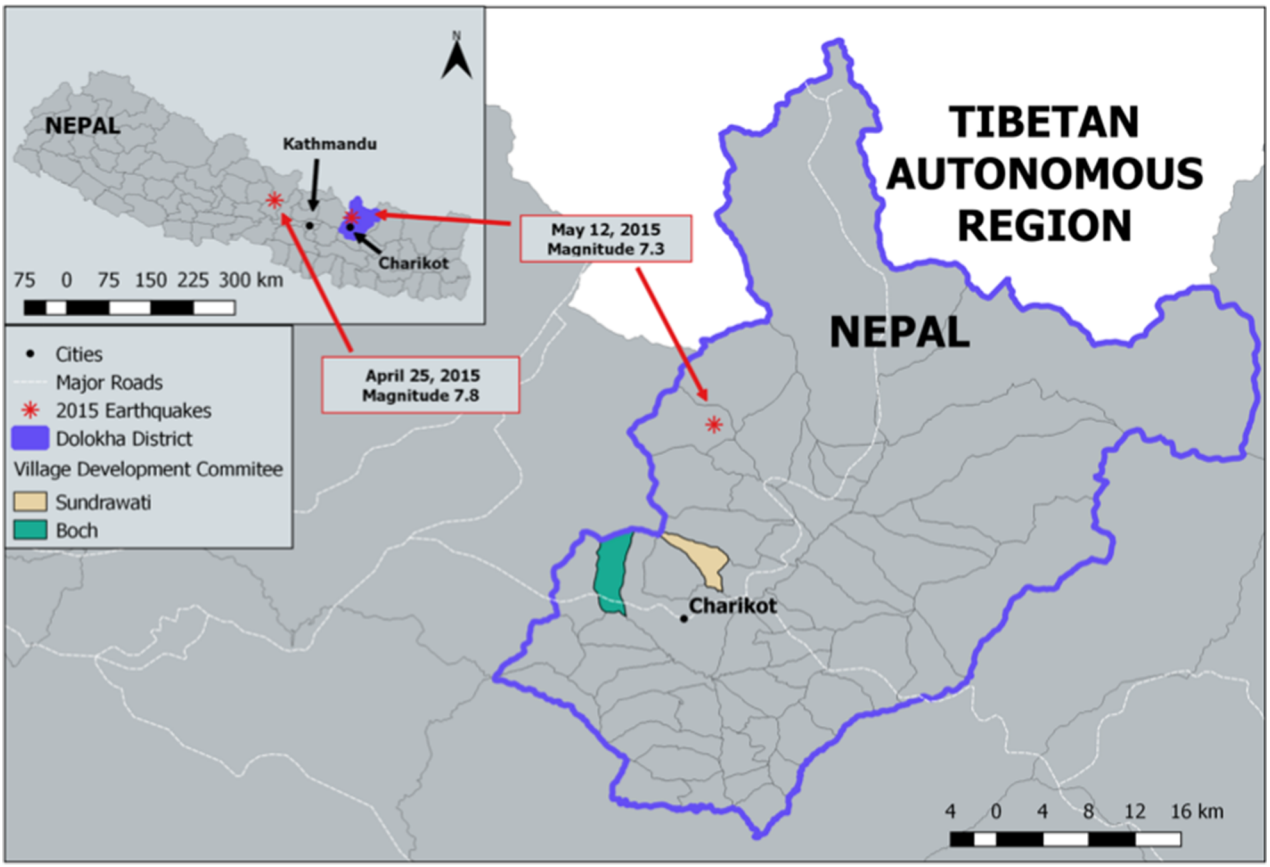


**FIGURE 3.** Map of the study region: Dolakha District, Nepal.


**FIGURE 4.** (a) Typical farming landscape in mid-montane Nepal. Farmers grow subsistence crops in terraced fields. (b) Hillsides are generally steep and a mixed-broadleaf forest dominates what land has not been cleared.

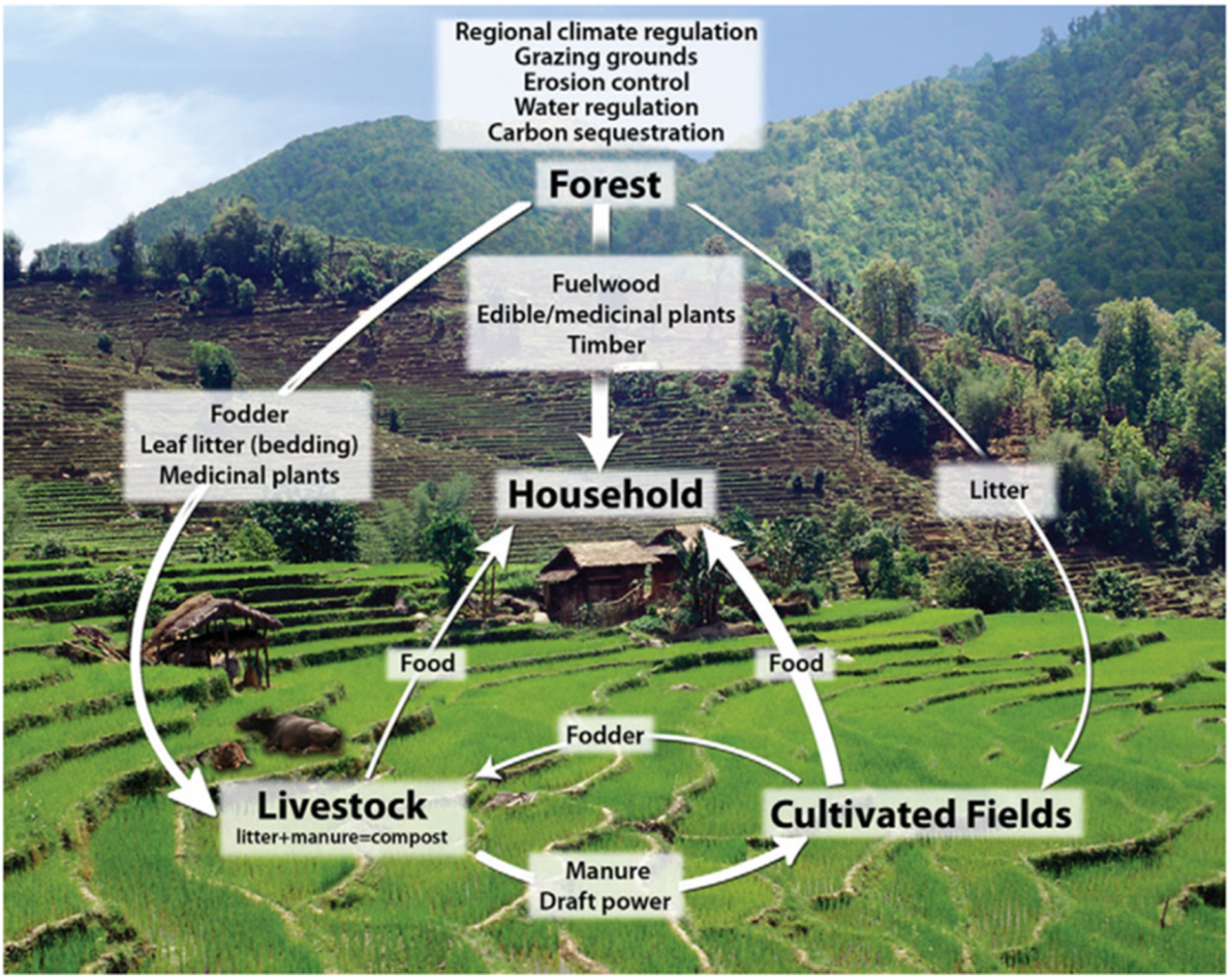


**FIGURE 5.** Schematic demonstrating the interconnected on-farm and off-farm inputs to Nepali farming systems (After Måren et al. 2013).

availability of labor on farms [25]. At the same time, the need for on-farm investments and goods, and educational and service-related expenses have increased the necessity of cash income. Several of Nepal's national plans have advocated for agricultural diversification and marketization. This includes the most recent 13th National Plan, which focuses on post-earthquake reconstruction in conjunction with economic prosperity achieved primarily through the integration of income generating agricultural products [26]. These economic and political realities occur alongside rising temperatures and shifting precipitation patterns. In response, farmers are increasingly adopting new technologies such as drought-resistant hybrid crop varieties and increasingly complex irrigation and piping systems [27].

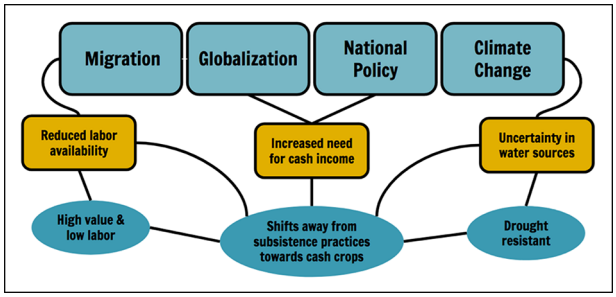


**FIGURE 6.** Schematic of on-going transitions in Nepal. Multiple macro-level factors are impacting smallholder farmers throughout the region. Pressures from these factors result in multiple transformations, including a shift toward the integration of more cash crops into subsistence farming systems.

This case draws from data collected in two villages in Dolakha: Sundrawati and Boch (Figure 3, Table 2) and is fundamentally exploratory (Table 3, Supplemental Information – Survey Instrument). Our goal is to generate hypotheses on community resilience and change for future work. We used qualitative techniques of open-ended and semi-structured interviews alongside a resilience assessment (described in Table 1) to track impacts from the earthquakes and perceived resilience of individual households and the wider community. We chose a purposive sampling frame and stratified our sample based on both ward (sub-neighborhood) and caste. Our aim was not to extrapolate findings to the greater district, but rather to use respondent recall to assess intra-community and cross-caste perceptions of change and resilience. For more information on our research methodology and approach, see the studies by Epstein et al. (*in revision*) and DiCarlo et al. (*in revision*).

### *Immediate Impacts to Farming Systems*

In mid-hills farming systems in the spring, maize and millet are harvested and rice paddies are prepared for planting. Because the earthquakes hit in late April and early May, these subsistence crops were the most heavily impacted. Large cracks and holes opened up in many fields and ruined the terrace infrastructure, which serves as good drainage for maize and millet and flooded plots for rice production. As one District Agriculture Development Officer noted: "Farming in Dolakha has been set back ten years."

Both study communities suffered widespread destruction of the infrastructure of houses and farms; 100% of our respondents noted some type of damage. Our respondents reported damages to seed stocks (86% across both communities), which are typically stored inside houses, as well as irrigation systems and canals (38% across both communities), which impeded reliable access to water for crops like rice. Almost half of our participants (46%) reported livestock loss, both directly from the earthquakes or because the family was forced to sell or put down animals for cash income (Table 4).

Finding sufficient labor to harvest existing crops and prepare other fields for planting was difficult as many farmers and day-laborers had to prioritize rebuilding and relief efforts. The widespread loss of livestock used for tilling the fields compounded pressures on the labor force and contributed to a region-wide decline in agricultural productivity.

**TABLE 2.** Summary of demographic and socioeconomic characteristics of study sites collected through the assessment instrument.

| | Sundrawati (n=39) | Boch (n=40) |
|---|---|---|
| Respondent age | 49 (min 20, max 80) | 51 (min 22, max 78) |
| Household size | 4.97 | 5.75 |
| Respondent gender | n=16 (41%) female<br>n=23 (59%) male | n=15 (37.5%) female<br>n=25 (62.5%) male |
| Household caste | 5.13% Dalit<br>38.46% Brahmin<br>41.03% Thami<br>15.38% Chettri<br>0.00% Thamang | 10.00% Dalit<br>2.50% Brahmin<br>0.00% Thami<br>45.00% Chettri<br>42.50% Thamang |
| Household, primary livelihoods | 82.05% agriculture<br>10.26% cottage industry/ industry<br>5.13% casual labor (non-agriculture)<br>2.56% Service (government) | 95.00% agriculture<br>2.50% casual labor (non-agriculture)<br>2.50% others |
| Household, main source of income | 64.0% off-farm labor<br>15.4% sells animals<br>7.7% shop/business<br>5.1% remittances<br>5.1% labor | 30.0% off-farm labor<br>20.0% casual agricultural labor<br>20.0% sells crops<br>12.5% sells animals<br>5.0% remittances<br>5.0% others<br>2.5% shop/business<br>2.5% government |

### *Components of Resilience*

To understand smallholder household perceptions of impact and recovery after the earthquake, we interviewed 79 farmers on 10 different resilience indicators (Table 1) and asked whether different metrics of resilience (e.g., crop productivity), access to clean water, and their participation in social and religious events had improved or

**TABLE 3.** Summary of methodological approaches and research activities.

| Activity | Participants | Sample Size |
|---|---|---|
| Assessment | *Randomly selected villagers in Boch and Sundrawati VDC examining* | $n = 39$ Sundrawati, |
| | Crop productivity and schedules | $n = 40$ Boch |
| | Assessment of property damages | |
| | Water resources | |
| | Food security | |
| | Community institutions and post-disaster community dynamics | |
| Interviews | *Experts in* | $n = 24$ |
| | Disaster relief and recovery | |
| | Soil and water quality | |
| | Agricultural technology and adoption | |
| | Kiwi, cardamom, and potato farming | |
| | Climate change and geomorphology | |
| | Biodiversity and conservation | |
| | Forestry and forest management | |
| | Conservation area ranger districts | |
| | *Community leaders of* | |
| | Ward, VDC, and district government offices | |
| | Community forest user groups | |
| | Women's groups and cooperatives | |
| | Agricultural groups and cooperatives | |
| | *Community members and residents of* | $n = 30+$ |
| | Charikot | |
| | Sundrawati | |
| | Boch | |
| Focus groups | Leading farmers in Sundrawati (2) | |
| | Leaders farmers in Boch | |
| | Women's owned community forest (Sundrawati) | |
| | Women's development committee | |
| Observational | *Events include* | |
| | Village Development Committee meetings | |
| | Community Forest Group meetings | |
| | Cash crop/agricultural technology workshops | |
| | Festivals including a wedding and a funeral | |

**TABLE 4.** Summary of earthquake impacts to farming systems from survey data collected from 79 households in Sundrawati and Boch, Dolakha District, Nepal.

| Farm system structures and inputs | Sundrawati | Boch | Pooled |
|---|---|---|---|
| Housing structures | 100.0% | 100.0% | 100.0% |
| Seed stocks | 84.6% | 87.5% | 86.0% |
| Irrigation canals | 41.0% | 35.0% | 38.0% |
| Livestock loss | 56.4% | 35.0% | 45.7% |

declined at two key points: immediately following the earthquake and one year later. Respondents reported that housing and livestock suffered expected devastating impacts (Figure 7). Crop productivity and water and soil quality declined sharply and had still not yet fully recovered from the earthquake at the time of data collection.

Several key components of the SES bounced back quickly or were largely unaffected (Figure 7). For example,

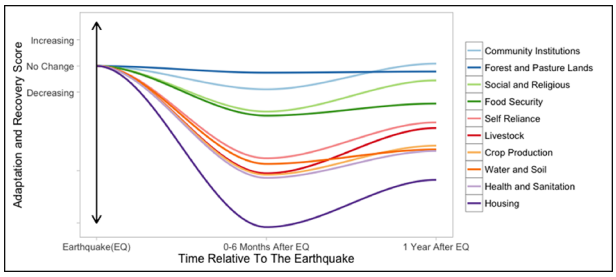


**FIGURE 7.** Resilience assessment diagram showing "bounce back" (adaptation and recovery score) of 10 components of the social–ecological system. Farmers were asked to assess various aspects of their social–ecological farming system at two points in time: 0–6 months after the earthquake and 1 year after the earthquake, compared with before the earthquake. Farmers responded whether various metrics (Table 1) had *improved*, *declined*, or *stayed the same* at each moment in time. It is important to note that this assessment tracks direction of change, as opposed to overall magnitude.

because *forests and pasture lands* were mostly unaffected, farmer-reported access to forest products remained stable. *Community institutions* and *social and religious* variables also exhibited limited decline and a substantial improvement over the course of the year following the earthquake (Figure 7). Our interviews helped to explain this pattern. Participants reported that in the days and weeks immediately following the earthquake, community members relied heavily on neighbors and local organizations. Families pooled materials and shared food and shelter. As one farmer reported, "We slept in our neighbor's shed and made our meals together." Interviews also revealed that broader support networks were very important. Respondents who had family members or friends working abroad or elsewhere in Nepal reported benefit from remittances and other cash donations. At the village level, community institutions like community forestry and women's groups were among the first to respond; and, because these groups had established social networks within the community, they were able to distribute monetary, food, and shelter donations (Figure 8). Over the course of our fieldwork, we also observed and participated in several religious and cultural events including local weddings and funerals. Our interviews at these types of events revealed that community members felt it was important to continue local traditions and participate in community gatherings even during the period of post-earthquake reconstruction and recovery. In summary, these interview and assessment findings support what past studies have identified to be the hallmarks of resilient communities, namely strong social networks and community institutions [8, 18, 28]. At the same time, the continuation of religious practices and ceremonies has shown to be an important resilience-enhancing mechanism giving communities both a sense of collectivism and bouncing back [29].

### *The Process of Reconstruction and Social–Ecological Change*

The need to rebuild homes and farms coupled with post-disaster labor realities made increased income a top priority for villagers. As one villager in Sundrawati explained: "We have plenty of food, but need money for shelter." In our interviews, participants discussed how multiple factors from the earthquake including labor shortages, land degradation, and the need for increased income encouraged them to consider adopting one of the three most important cash crops of the region, kiwi, cardamom, and potato. As one farmer noted: "my husband went to get work in Kathmandu. I'm going to start growing kiwi because they take less work than crops like maize or rice". Another farmer noted, "There are huge holes in my planting fields, but cardamom is one crop that grows well there."

Diversifying livelihoods through the adoption of new sources of income is a prevalent strategy in rural communities as it can help families manage risk and deal with the effects of environmental or socioeconomic shocks [24, 30]. In our study sites, diversification took many forms: families reported seeking off-farm labor in the community, sending family members to urban centers to increase income through remittances, and starting small businesses and adopting cash crops. Concerning diversification in agricultural systems, programs to incentivize cash crops—e.g., grants for greenhouses to grow vegetables or seeds to cultivate potatoes to sell in regional and national markets—have long been available (including prior to the earthquake) to farmers in Dolakha (interview data).

Our interview data suggests that interest in cash crops production has increased after the earthquake. In part, increased enthusiasm appeared to come with the influx of relief and recovery aid post-earthquake. Participants noted that local non-governmental organizations (NGOs) such as the Human Rights Awareness and Development Center (HURADEC), Tuki Nepal, and the Environment, Culture, Agriculture, Research, and Development Society, Nepal (ECARDS-Nepal) seem to privilege seed donations and loans for greenhouses to produce cash

**FIGURE 8.** Photograph of neighbors assisting with repairing damaged farmhouse. Farmers reported that in the days immediately following the earthquake, friends and neighbors as well as representatives from local institutions like community forestry groups, were among the first to respond. These types of practices build post-disaster resilience.

crops over subsistence crops. These aid opportunities, came alongside an increased need for cash income to supplement rebuilding efforts, and the material damages to fields, livestock, and other farming inputs. This transition is by no means immediate or comprehensive. Most farmers we interviewed in Sundrawati and Boch retained some form of subsistence cropping for home consumption, which past studies identify as an important strategy to ensure household food security [31]. However, our case study suggests that the social, material, and political responses to the earthquake's impacts underscore and accentuate the ongoing (though not complete) transition to cash crops (Figure 9). Thus, we hypothesize that farmers' post-disaster coping strategies may signal or be a precursor to long-term social–ecological transformation.

## CONCLUSION

The earthquakes that hit Nepal in 2015 devastated mountain farming communities. However, as these communities have long dealt with associated mountain hazards, several endogenous components of their SES, including mutual support and community institutions, strengthened adaptation, and recovery measures. Together, these components represent important resilience-enhancing mechanisms. Our interviews reveal that interest in cash crop adoption has increased after the earthquakes and that many farmers are planning to adopt cash crops in the future. We see these planned adoptions as a signal that impacts from the earthquake are hastening ongoing transitions toward commercialization in mountain communities. Widespread social–ecological change in subsistence-dominated communities becomes its own set inherent risks such as greater reliance on inputs and dependence on market stability [31]. As such, this case shows that understanding how communities cope with and adapt to events like earthquakes, may shed light on the types of support needed to recover and transition to less risk-prone states, in particular among the most vulnerable and resource-poor households.

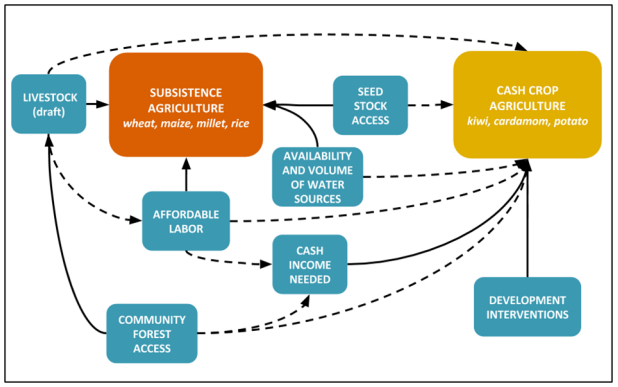


**FIGURE 9.** Framework showing inputs to the Nepali farming system and hypothesized feedback on subsistence and cash crop farming systems. Solid lines represent positive feedbacks, dotted lines represent negative feedbacks. Arrows and relationships demonstrate the ways in which reductions in key inputs to the subsistence farming social–ecological system decreases the capacity to conduct traditional and/or subsistence crop agricultural and creates the need or incentive for cash crop agriculture.

## CASE STUDY QUESTIONS

1. What factors contributed to community resilience in this case? Imagine you were in charge of a disaster-relief organization. How would you advise spending on DRR (pre-disaster) programing? Conversely, how would you prioritize spending immediately following an earthquake?

2. Resilience is sometimes referred to as the "new" sustainability, meaning that building or strengthening resilient livelihoods and ecosystems will buffer the negative impacts of the major changes societies will face in the future. After reading this case, how do you see the concept of resilience fitting into the concept of sustainability? Do you think resilience is the new sustainability? Why or why not?

3. From this case, what are some ways in which both disasters and response efforts might asymmetrically impact households?

4. What are the pros and cons of transitioning from traditional agricultural practices to more modern ones, and from subsistence farming to cash cropping in this case?

## AUTHOR CONTRIBUTIONS

| | |
|---|---|
| Conceptualization | IM, RM, IR, JD, KE |
| Data curation | JD, KE |
| Formal analysis | JD, KE |
| Investigation | JD, KE |
| Methodology | IM, RM, IR, JD, KE |
| Project administration | IM, RM, IR |
| Resources | KE, JD |
| Supervision | IM, RM, IR |
| Visualization | KE, JD |
| Writing (original draft) | KE, JD |
| Writing (review and editing) | IM, RM, IR, JD, KE |

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## COMPETING INTERESTS

The authors have no competing interests to report.

## ETHICAL APPROVAL

All fieldwork and procedures performed in this study involving human participants were in accordance with the ethical standards of the International Review Board (IRB), the University of California, Berkeley Office for the Protection of Human Subjects (CPHS), international best practice, and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

## INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

## SUPPORTING INFORMATION

Teaching Notes
Research Summary—*for practioners*
Survey Instrument
Post Disaster Resilience Slide Deck

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