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Research

Contextualizing patterns in short-term disaster recoveries from the 2015 Nepal earthquakes: household vulnerabilities, adaptive capacities, and change

Jeremy Spoon [1], *Drew Gerkey* [2], *Alisa Rai* [1] *and Ram B. Chhetri* [3]

ABSTRACT. Disaster recovery is multidimensional and requires theoretical and methodological approaches from the interdisciplinary social sciences to illustrate short- and long-term recovery dynamics that can guide more informed and equitable policy and interventions. The 2015 Nepal earthquakes have had catastrophic impacts on historically marginalized ethnic groups and Indigenous households in rural locations, arising in the immediate aftermath and unfolding for years afterward. Analyzing factors that shape household recovery patterns can help identify vulnerabilities and adaptive capacities in addition to signaling potential future changes. We pursue this goal using survey data from 400 randomly selected households in 4 communities over 2 10-week intervals at 9 months and 1.5 years after the earthquakes. Building on previous research that used non-metric multidimensional scaling ordination to identify patterns among multiple indicators of recovery (Spoon et al. 2020a), we investigate associations among these patterns of recovery, hazard exposure, and four domains of household adaptive capacity: institutional participation, livelihood diversity, connectivity, and social memory. Our results suggest: (1) social inequality, high hazard exposure, and disrupted place-based livelihoods (especially for herders, farmers, and forest harvesters on the geographic margins) had strong associations with negative recovery outcomes and displacement; (2) inaccessibility and marginality appeared to stimulate ingenuity despite challenging circumstances through mutual aid and local knowledge; (3) recoveries were non-linear, differing for households displaced from their primary home and agropastoral practice and those displaced to camps; and (4) some households experienced rapid changes while others stagnated. We contribute a temporal dataset with a random sample collected following a disaster that uses a theoretically informed quantitative methodology to explore linear and non-linear relationships among multidimensional recovery, adaptive capacity and change and provide an example of how vulnerabilities interact with adaptive capacity.

Key Words: *adaptive capacity, disaster recovery, Nepal, non-metric multidimensional scaling, place-based rural and Indigenous peoples, short-term change, vulnerability*

INTRODUCTION

Disaster recovery is a highly dynamic, multidimensional, context-specific, non-linear process that unfolds over years and decades (Oliver-Smith 1986, Olshansky 2005a, b, Kates et al. 2006, Jordan and Javernick-Will 2013, Zhang 2016). Because household adaptive capacity can mediate the impacts of hazard exposure, it is a critical component in understanding disaster recovery dynamics and trajectories of change over the short- and long-term. Our goal is to understand how different forms of adaptive capacity shape short-term household recoveries for different ethnic groups from rural regions in Nepal, who were impacted by a series of devastating earthquakes and aftershocks in April/May 2015 with cascading effects, such as landslides, that persisted for years after the initial events. Variation in household recoveries could be due to vulnerabilities, such as social inequalities, exposure to hazards, or place-based livelihood strategies. Differential recoveries could also be influenced by adaptive capacities, such as mutual aid through work exchange and local knowledge. Understanding these links between recoveries, vulnerabilities, and adaptive capacities through practical applied participatory research (Smit and Wandel 2006, Tyler 2006) can help guide more informed and equitable policy for government and outside aid interventions pre- and post-disaster.

Research on disaster recovery illustrates different processes of restoring, rebuilding, and reshaping the physical/natural, built, social, and economic environments through pre-event planning and post-event actions (Smith and Wenger 2007). The ability of a household or community to recover from a disaster is influenced by vulnerabilities and mediated by adaptive capacity. Vulnerabilities, such as social inequality and place-based livelihoods that rely on hazardous geographies can turn a hazard into a disaster and intensify its impacts. Adaptive capacity is the ability to adjust internal and external disturbances to remain in the same state, which in this case includes disaster recovery from two catastrophic earthquakes and their cascading effects (Jones and Murphy 2009, Folke 2016). Vulnerability and adaptive capacity do not function independently from one another but rather interact to create solutions that alleviate disaster impacts and assist with recovery; however, in certain situations these "solutions" could alternatively be viewed as maladaptations to disturbances that perpetuate some of the difficult circumstances caused by systems of power such as living in dangerous inaccessible locations like steep Himalayan slopes without road access and limited water. To better understand these dynamics, recovery indicators must therefore extend beyond surface markers of safety, such as the rebuilding of housing units over time, to include multiple indicators of livelihood and well-being over the short- and long-term (Ganapati 2013, Jordan and Javernick-Will 2013, Hsu et al. 2015, Platt and Drinkwater 2016, Barrios 2017). A longitudinal approach also recognizes that a population may experience additional natural hazards that cascade from the original disturbance (e.g., landslides) or new hazards (e.g., climate

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change influenced extreme weather events or the Covid-19 pandemic) that compound with the previous events (Moolenaar 2022).

There are common patterns in household recovery outcomes, but how these patterns are produced is not well-understood, especially for rural, local, and Indigenous peoples, for whom ties to place are critical. Research on disaster recovery illustrates that those with generally higher socioeconomic status tend to return to a desirable pre-disaster state more quickly (Olshansky 2005a, b). Those at the lower end of the economic spectrum with high vulnerabilities often remain in this position throughout the recovery process, especially in poorer nations (Quarantelli 1999, Tierney 2012). Indeed, disasters often reveal and amplify pre-existing social, economic, and political inequalities evident in many global contexts (Kates et al. 2006, Gunderson 2010, Lopez-Marrero and Wisner 2012, Oliver-Smith 2012, Schuller 2012, 2016; Schuller and Morales 2012, Gamburd 2013, Willey 2015). In disaster contexts, the poor and marginalized often get labeled as vulnerable victims devoid of the ability to act within regimes of power instead of survivors with adaptive capacities (Ahearn 2001, Marino and Faas 2020). Indeed, it is the margins that can birth ingenuity, providing adaptive capacity and mitigating disaster impacts even in situations with high vulnerabilities. There is thus a need for research that contextualizes the dynamic nature of disaster recovery for place-based communities, such as Indigenous peoples, by illustrating how pre-existing social and economic conditions, as well as differential hazard exposures and household characteristics, correlate with multidimensional recovery indicators. It is also critical to understand variation within populations and avoid over-generalization by selecting multiple sites for comparison. Effective disaster recovery research therefore requires a robust, generalizable, multi-sited sample and a methodology that can analyze several variables and their associations with one another inductively over time. Our approach empirically illustrates patterns that identify multi-faceted vulnerabilities and the contexts in which these challenges interact with adaptive capacities to influence recovery outcomes.

Using the devastating April/May 2015 Nepal earthquakes and aftershocks as a case study, we investigate the ways different forms of adaptive capacity respond to hazard exposure to shape patterns of recovery. The Nepal earthquakes had catastrophic impacts on life and property, killing 8790 people and injuring more than 22,300, while also damaging or destroying more than 750,000 private houses and government buildings and approximately 30,000 classrooms (National Planning Commission 2015, Rasul et al. 2015). Within 9 months of the earthquakes, Nepal experienced more than 400 additional earthquakes and aftershocks with a magnitude of 4 or greater and within 1 year, 4000 landslides initially triggered by the earthquakes (Shrestha et al. 2016). In 2015 and 2016, the earthquakes pushed 2.5% to 3.5% of the population into poverty and caused NPR-706 billion (US$ 7 billion) in damages (National Planning Commission 2015). Focusing on the impacts in rural, primarily Indigenous communities, we conceptualize the social and environmental components of disaster recovery as an integrated system, which changes in hazard exposure trigger responses by individuals, households, settlements, and governmental and non-governmental aid programs that can either enhance, impede, or fail to impact recovery.

We systematically investigate associations between disaster recovery, vulnerability, and adaptive capacity, seeking to contextualize patterns in recovery over the short-term and identify potential drivers underlying these trends. Although our broader project combines mixed quantitative and qualitative ethnographic methods and community outreach, here we focus our analysis on the quantitative survey data and insights from research return workshops held 2.5 years after the earthquakes. We confirmed, discussed, and interpreted findings with collaborators and community leaders in Nepal. We share the qualitative findings in more detail and their relationships to the quantitative results in other research (Spoon et al. 2020a, b, 2021). We view our quantitative methods as illustrating critical trends, which our subsequent qualitative methods clarify and broaden.

The results from our empirical analysis of associations between patterns in recovery, hazard exposure, and adaptive capacity collectively confirm and expand on the findings of previous research on disaster recovery from the 2015 catastrophe. Arabinna et al. (2017) found that there was an assemblage of household factors and conditions influencing early and better recovery outcomes, including natural resource endowments, physical connectivity, access to development services, entrepreneurship, social homogeneity, and local economy. Household and livelihood recovery were found not to be mutually exclusive and that household assets, such as cultural, social, economic, physical, human, and natural, and strategies for generating capital played a critical role (Chatterjeea and Okazakia 2018). Remittances, borrowing, and the sale of assets were also found to be key coping strategies for short-term recovery (Raut 2021).

Building on and contextualizing these findings, our results illustrated connections between social inequalities, hazard exposure, and place-based livelihoods on the geographic margins, also generally identified in research in Nepal (Rigg et al. 2016, He et al. 2018, Hülssiep et al. 2021, Bajracharya et al. 2022) and globally (Hallegatte et al. 2020). Further, our work coincides with research on displacement and resettlement dynamics from the Nepal earthquakes (Kotani et al. 2020, Khattri 2021) and beyond (Olshansky 2005a, Schuller 2016, Faas 2017) as well as the role of mutual aid in Nepal after the earthquakes (Epstein et al. 2018, Panday et al. 2021) and elsewhere (Platt and Drinkwater 2016). Our results illustrate adaptive capacity for more historically privileged ethnic groups with market-based livelihoods and irrigated agriculture. We identified vulnerabilities or challenges for historically marginalized ethnic groups such as Dalits who are discriminated against as "untouchables" and Indigenous peoples with place-based livelihoods that embody extreme hazard exposure in marginal geographies. We add insights on how these vulnerabilities interact with adaptive capacity such as inaccessibility and marginality, which drives ingenuity and innovation, creating some adaptive capacity by mitigating disaster impacts and assisting with short-term recovery. This interaction helped in rebuilding homes and restarting displaced place-based livelihoods faster in certain situations, although it could also be viewed as an example of maladaptation that perpetuated the difficult conditions these rural households experience in their everyday lives pre- and post-disaster.

We therefore illustrate non-linearities of adapting to a shock (e.g., high magnitude earthquake) that includes multiple, long-term disturbances (e.g., landslides triggered by heavy monsoon rains).

We accomplish this by collecting information at multiple time intervals, an approach that can be extended to link short- and long-term recoveries and applied to inform pre- and post-disaster aid interventions and policies.

DISASTER RECOVERY AND ADAPTIVE CAPACITY

Disaster recovery occurs within complex social-environmental systems in which feedback between human populations and their environments create interdependencies in structure and function (Buergelt and Paton 2014). This perspective necessitates an interdisciplinary lens (Hughes et al. 2007, Liu et al. 2007) and rejects the false dichotomy between humans and the natural world. It is also conducive to the place-based connections that many of the world's Indigenous peoples and long-term settlers in rural locations embody with their ancestral and traditional homelands, especially in Nepal.

We consider disaster recovery as a process that combines pre-event planning and post-event actions, extending from the immediate relief and restoration of basic services directly following the event to the reconstruction and potential (albeit rare) betterment period over the short- and long-term, which can take many years depending on context (Kates et al. 2006, Smith and Wegner 2007, Gamburd 2013, Casagrande et al. 2015, Zhang 2016). These phases are fluid. Recovery is thus more of a process than a specific outcome and often has no clear endpoint (Olshansky 2005a, Jordan and Javenik-Will 2013, Matyas and Pelling 2015). Externally imposed conceptions of recovery phases may differ from those experienced by survivors. Time compression is the primary difference between recovery and development (Olshansky 2005a) and has been linked to negative recovery outcomes, including exacerbating social inequalities, shifting power dynamics between individuals and the state, and fostering the emergence of outside aid to fill gaps not provided by the state (Olshansky et al. 2012). Disasters can therefore create an additional abrupt vulnerability for place-based peoples, which compounds with existing power dynamics (Moolenaar 2022) including historical and contemporary geographic marginalization and disconnection from the land due to colonization and/or resettlement (de Vries 2017).

Because disaster recoveries can differ even when hazard exposures are similar among households and settlements, we focus on the role of adaptive capacity. Adaptive capacity, in this sense, is the ability of a household to adapt following a perturbation from natural hazards and their cascading effects (Jones and Murphy 2009, Folke 2016), including the robustness and redundancy of resources and the rapidity of accessing them (Norris et al. 2008, Daramola et al. 2016). Siders (2019) stated that adaptive capacity does not have a standard measure, and scholarship on adaptive capacity has been more informed by theory than empirical research. Research on how adaptive capacity links with disaster recovery has generally focused more broadly on climate change (Brooks et al. 2005, Smit and Wandel 2006, Seara et al. 2016, Mortreux and Barnett 2017) or a single event in isolation, and not acute, compound events with cascading effects (Leppold et al. 2022) such as multiple earthquakes and aftershocks as well as landslides that continually reoccur.

Adaptive capacities depend on certain conditions and can include an assemblage of different variables as indicators. To understand the conditions for adaptive capacities to emerge and function, we borrow from Norris et al. (2008) who focused on the ability to economically develop utilization of social capital, existence of information, and communication infrastructure as well as the operationalization of collective action, decision making, and local empowerment. We add Mortreux and Barnett's (2017) insights that adaptive capacity is influenced by household composition and dynamics and can include intangible personal experiences, knowledge, and attitudes associated with risks and hazards, place attachment, trust in authorities, and competing concerns (Spoon et al. 2021). Adaptive capacity can also be multifaceted. For example, a community may have success overcoming challenges posed by hazards immediately following the disaster but lack adaptive capacity in the long term (Vallance and Carlton 2015). We also borrow from Folke's (2016) more general definition of adaptation, which refers to human actions or adjustments that sustain development on current pathways, whereas transformation includes shifting development into other emergent and potentially new pathways.

We focus on the following assembled conditions in rural Nepal that influence adaptive capacity to sustain development on current pathways or shift to emergent ones: historical and contemporary poverty (social inequality or social vulnerability), communities living on unstable steep mountain slopes with high landslide probability (biophysical hazard vulnerability), families living in homes without proper building codes (structural vulnerability), and the practice of place-based livelihoods such as herding, farming, and forest product harvest as well as nascent market integration (livelihood and/or economic vulnerability). Our linked quantitative and qualitative research addresses additional intangible recovery dynamics that shape adaptive capacity such as perceptions of risk, hazards, uncertainty, place attachment, mental well-being, and relationships with external actors and government programs (Spoon et al. 2020b, 2021).

Marino and Faas (2020) argued that some previous social science of disaster research lacks contextualization by targeting specific types of vulnerability that manifest disaster impacts and the resulting recovery. Identifying only vulnerabilities (especially social vulnerabilities or a single vulnerability in isolation rather than multiple vulnerabilities interacting with one another) may obfuscate identifying and operationalizing adaptive capacities in challenging circumstances that mitigate disaster impacts and assist with recovery. For poor and marginalized peoples, governments and aid organizations often overlook potential existing or emergent adaptive capacities such as social capital and local knowledge (Daramola et al. 2016, Panday et al. 2021) and can hinder recovery helping to reinforce "one size fits all" recovery efforts. Top-down recovery goals can indeed be used to replicate and reinforce neoliberal development agendas instead of identifying root causes of vulnerability (Barrios 2016a, b, 2019, Bergman 2019) or may be used by a state to exert their authority (Parsons 2016). For example, the discourse on "building back better" may push a population to recover in some ways that support neoliberal economic approaches and forgo others (Barrios 2016a, 2019).

Marino and Faas (2020) therefore suggested orienting analysis around individuals, institutions, and systems that disproportionately structure risk, which in this case, create, replicate, and reinforce conditions that affect household adaptive capacity. We therefore focus on the linkages between social and spatial inequalities in Nepal as a result of historical and contemporary oppression and marginalization by certain powerful actors, groups, and

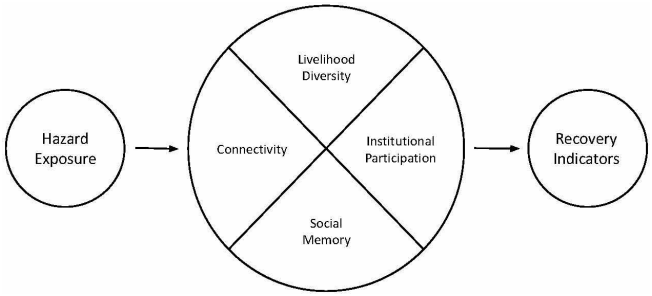
organizations such as members of the Brahmin and Chhetri ethnic groups, and lack of development and/or opportunities for market integration in rural geographically isolated locations, especially without road access and limited water. Research also points out that power and history help to produce disasters and impact recovery (Gamburd 2013, Shuller 2016, Barrios 2017, Spoon et al. 2021) and that disaster recovery is often driven by economics (Olshansky 2005a, b, Cutter 2016a, Platt and Drinkwater 2016) justifying the importance of using demographics and livelihoods to understand impacts and recovery trajectories. Additionally, previous research takes a cross-sectional less systematic approach when viewing recovery rather than focusing on how change occurs over the short- and long-term with a larger random sample. Qualitative research on disaster recovery in the social sciences is often descriptive, not generalizable to an entire population or too specific to be applicable to other contexts and has challenges in systematically illustrating variation and reporting these changes over time. We respond to these critiques by studying a random sample of households and using quantitative methods with multiple variables (more than 200) that we replicated over time, providing a longitudinal window into variation across short-term disaster recoveries at multiple rural locations with differing ethnic groups, religions, socioeconomic statuses, road access, education levels, literacy, livelihoods, among other variables. Our research is also conducive to a broader study comparing short-term to long-term recovery between these households.

NEPAL AND THE 2015 EARTHQUAKES

Nepal is situated between India and the Tibetan autonomous region of China with largely geographically isolated plain, hill, and mountain areas (Fig. 1). The region is seismically active, evidenced by infrequent high magnitude earthquakes, such as the catastrophic event of 1934 (Bhandari 2014). Because of the mountainous geography, Nepal is highly impacted by climate change-influenced hazards such as erratic and severe weather, landslides, avalanches, and glacial lake outburst floods (Zurick et al. 2006, Zimmerman and Keiler 2015). For example, landslides in the Himalayas that are cascading effects from earthquakes are reactivated annually by more severe storms, which are a product of climate change (Dikshit et al. 2020, Ahmed et al. 2021, Dimri et al. 2021). Climate change is also forcing households to adapt their ways of life by growing different crops or shifting from place-based agropastoralism to market labor (Merrey et al. 2018).

Nepal is considered by the United Nations as one of the world's least developed countries (United Nations 2022). Because disasters often bring to the surface and exacerbate pre-existing inequalities, factors in this context include Nepal's fragile political and economic status after a 2006 revolution, its reliance on aid from China and India (among others), a proliferation both pre/post-earthquakes of international and national nongovernmental organizations (INGOs and NGOs), extreme social inequalities caused by the hierarchical Hindu dominated social system, alongside disparities in class, gender, geographic terrain, and rural versus urban everyday lives, as well as a vulnerable, limited education system (Whelpton 2005, Jha 2016, Bajracharya et al. 2022). The proliferation of aid before and after the earthquakes created a situation that stunted the growth of civil society by fostering a dependency on outside organizations. Aid in Nepal is not distributed equally and often correlates with road access, creating differences between communities served by INGOs and NGOs and those that are not (Jones et al. 2015).

Fig. 1. Conceptual model of hazard exposure, four domains of adaptive capacity, and recovery indicators. Hazard exposure acts on four mitigating interrelated household characteristics that influence recovery indicators. Adapted from Spoon et al. 2021.



Indigenous ethnic groups and historically marginalized caste groups, such as Dalit, have nurtured soils, crops, forests, and found water in remote regions such as high elevations with steep slopes and less fertile soils (Whelpton 2005, Merrey et al. 2018). Road access to geographically marginal rural communities was limited prior to and after the 2015 earthquakes; however, governance shifts in 2017 and 2018 have led to an increase in road building supported by decentralized local governments (Coburn 2020). Indigenous peoples, such as Gurung, Tamang, and Magar, speak endemic languages specific to their ethnic groups with Nepali being a second language taught by the state in schools (Whelpton 2005). Historical and contemporary exploitation have occurred by the traditional dominant-ruling Hindu "high" caste groups through taxes, rent, and labor from non-Hindu rural and Indigenous peoples, such as the Tamang, Gurung, Ghale, and other historically marginalized caste groups, which includes Dalit peoples (March 2000, Whelpton 2005). Starting in the mid-19th century, the Hindu state institutionalized a civic code called "Muluki Ain," which categorizes many non-Hindu Indigenous peoples as alcohol drinkers, enslaveable, and untouchable (Gurung 2003). The feudal state reappropriated the land and labor of these ethnic groups, particularly the Tamang. This process excluded them from regional and national domains of influence, keeping them at a distance from Kathmandu, the economic center, and in relation to local and regional opportunities and representation in governance (Holmberg 1989, Tamang and Tamang 1994, Ghale 2015, Jha 2016). The Newar ethnic group can be considered between the higher status Brahmin and Chettri and lower status ethnic groups such as Tamang, Gurung, Ghale, and Dalit in terms of opportunities and representation in governance (Whelpton 2005).

Nepal is primarily rural with around 80% of the population reliant on farming, herding, and the gathering of forest products as part of their livelihoods. Most ethnic groups-such as the Newar, Gurung, Ghale, and Dalit engage in some form of agriculture with a few livestock used for fertilizer, as well as forest product harvest, although only certain ethnic groups, such as Tamang, practice primarily herding with multiple types of livestock such as cows, yaks, and yak/cow hybrids. These herders often grow fodder for livestock and may also have a home garden for vegetables. Some households also practice temporary or seasonal

wage labor or work in tourism as porters, guides, and shop and lodge owners. There is also increasing outmigration for labor abroad to locations such as India, Qatar, and Malaysia to send remittances back to Nepal. Remittances are critical in shaping household economic capacity (Tachibana et al. 2019, Mishra et al. 2022) and were found to be an integral short-term coping strategy after the 2015 earthquakes (Raut 2021). Few households also own shops and workshops that sell general goods, do blacksmithing, or tailoring.

Agriculture in Nepal can generally be divided by whether or not the household has access to irrigation for their fields. Irrigated agriculture is called "khet" and non-irrigated agriculture is called "bari." Khet agriculture is generally practiced by more privileged households at lower elevations near market areas and road heads. It also yields more abundant and valuable crops. Bari agriculture is typically carried out by households in the most marginal geographies, with crop types being limited to barley, buckwheat, millet, potatoes, and other crops that need less water to survive. These households rely on annual rainfall, which can make them extremely vulnerable to drought (Whelpton 2005, Zurick et al. 2006, Zimmerman and Keiler 2015).

Before the earthquakes, most of the Indigenous ethnic groups in this study owned their land unless they migrated to the market area and road head for economic opportunities; however, Dalit peoples typically rented land or owned less than the other ethnic groups around them. This land was often more marginal, or harder to cultivate and less fertile, which means that Dalit mostly practice bari agriculture and own few, if any, livestock. There are also cases in which land is owned by a Buddhist monastery and the residents provide a tax or pay rent called the "guthi" system (Regmi 1978, Whelpton 2005), which was the case in one of the less accessible settlements in this study. After the earthquakes, the households that were completely displaced to camps also often rented the land from the private landowners where they were resettled.

Many rural peoples throughout Nepal also practice different configurations of "parma" or the customary institution of reciprocal labor exchange and mutual aid for work in agriculture, pastoralism, and forest product harvest. Depending on context, the parma system can extend beyond place-based agropastoralism to house building and assisting with rituals and ceremonies, among other functions (Gautam and Cortés 2021). Parma was a critical safety net for some populations to return to their homes and restart livelihoods after the earthquakes (Spoon et al. 2020a) and in other nearby areas also highly impacted by the earthquakes (Epstein et al. 2018, Panday et al. 2021).

METHODOLOGY

Data collection

The principal investigator, two project coordinators, five local and Kathmandu-based research assistants, and four translators conducted the data collection in the Nepali, Gurung, and Tamang languages. Our approach supported capacity building for Nepali staff and interactive dialogue with host communities. New master's degree graduates from Tribhuvan University were hired through a partnership with the Resources Himalaya Foundation to collaborate as research assistants. Capacity was built by teaching new ethical methodological skills and connecting staff with a broader network of scholars and practitioners to ensure that they had prospects for employment using skills learned and experience gained from the project. Our team met in fall and winter 2015 with local leaders and government representatives to help select study sites and obtain an accurate census for drawing a random sample. We also carried out in-depth interviews and focus groups to select recovery indicators and domains of adaptive capacity. We accomplished this by identifying key consultants with extensive knowledge and experience related to everyday life in the project area and elsewhere, as well as earthquake impacts and their cascading effects. These individuals helped us to identify and group the complex factors affecting recovery, which were in turn organized into domains with multiple variables in each.

Conceptual framework

Addressing disaster recovery as a multidimensional phenomenon (Oliver-Smith 2002), which unfolds over time, compels researchers to consider several factors and their interactions. To better contextualize short-term patterns in household recoveries and identify potential vulnerabilities and adaptive capacities over time, we explored multiple indicators of recovery, types of hazard exposure, and forms of adaptive capacity. We selected variables to represent recovery, hazard exposure, and adaptive capacity based on a pilot study, insights from the anthropological and social science literature on disaster, and local adaptations to climate change (Norris et al. 2008, DiGiano and Racelis 2012, Vallance and Carlton 2015, Cutter 2016b, Folke 2016, Mortreux and Barnett 2017), as well as our team's long-term ethnographic research and community collaborations in Nepal. Drawing on the resilience literature and using the "rule of hand," we selected four "domains" of adaptive capacity, each composed of multiple variables: (1) institutional participation, (2) livelihood diversity, (3) connectivity, and (4) social memory. This approach seeks to capture key functions and processes in an integrated social and environmental system with a limited number of components that establishes a balance between complexity and tractability in our analysis (Yorque et al. 2002, Walker et al. 2006). Figure 1 is a conceptual model that illustrates the relationship between hazard exposure, the four domains of adaptive capacity, and recovery indicators. We consider preexisting power dynamics, such as the connection between socioeconomic status and ethnic groups, hazard exposure, and the four domains selected to be critical to adaptive capacity, which sustain current development pathways not causing dramatic changes because of these short-term disturbances. Differences in household recovery experiences over the short-term help to illustrate vulnerabilities and varying levels of household adaptive capacity, as well as the dynamics of change and stagnation. Our study includes both coping strategies and adaptive capacities in the short-term under a single umbrella, which future research could address to better understand the differences over the short-term.

Although multiple variables representing recovery, hazard exposure, and adaptive capacity allow us to examine different dimensions of each, it can be difficult to examine the many possible associations among these variables and to provide insights on disaster recovery. In previous research (Spoon et al. 2020a), we used non-metric multidimensional scaling (NMDS; McCune and Grace 2002, Peck 2016) to identify patterns in disaster recovery and to interpret these patterns in relation to

specific indicators. We found substantial variation among households and communities in terms of their initial starting place in the recovery, as well as their progress during the short term. We also identified several patterns in recovery associated with indicators that suggest the influence of exposure to natural hazards (e.g., active landslides initially caused by the earthquakes), livelihoods, and displacement. Whether or not people are able to return to and rebuild their homes, renew place-based livelihoods, and restore nascent market activities could be due to pre-existing historical and contemporary social inequalities, hazard exposures, livelihood strategies, or other household factors, such as institutional participation, connectivity with internal and external actors, or social memory, including local knowledge and experience with previous hazards.

The household is a key space for understanding how intermediary variables, such as livelihood diversity and social memory, affect recovery outcomes. It is thus a key interface to understand integrated social and environmental system dynamics, therefore our primary unit of analysis. We define a household as a physical residence under one roof in which household members typically, although not exclusively, share economic resources and have kinship relationships. This definition was also used by the local government's census, which we used to select our random sample (see Spoon et al. 2021 for further discussion on household definition). Many of our impact measures are at the household level, a common focus of monitoring and evaluation in which aid and government relief are coordinated. All households in our study come from four clusters of settlements, which provide a secondary focus for our analysis (Fig. 2). Additional analysis at the level of our four settlement clusters allows us to incorporate broader social and environmental dynamics that are shared among households within a settlement but differ across settlements.

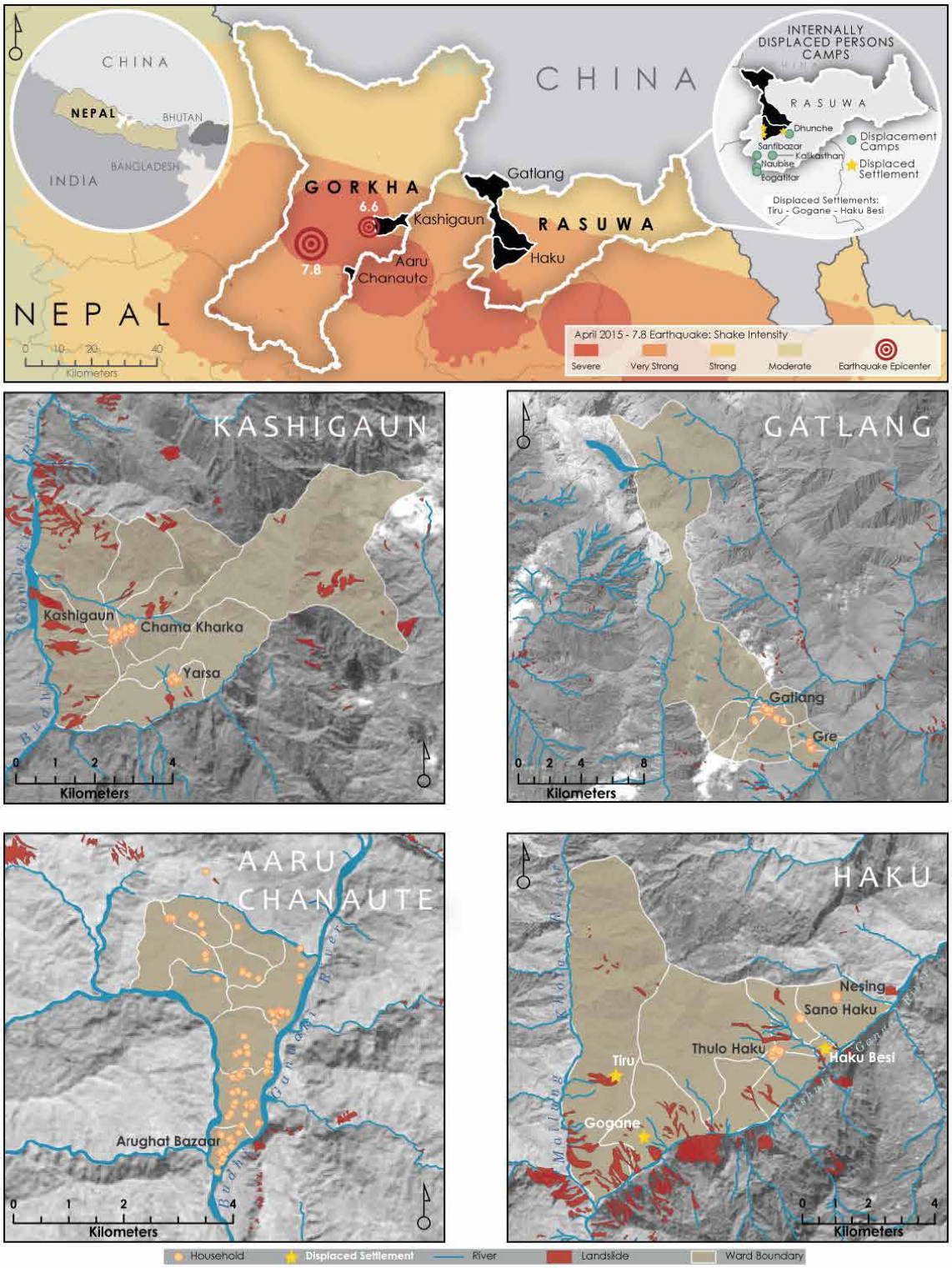
Site selection

To account for variation in the key parts of our conceptual model (Fig. 1), as well as links to the broader Nepal context impacted by the earthquakes, we selected two districts, Gorkha and Rasuwa, as study sites. Both had severe earthquake impacts: Gorkha was the epicenter of the April 2015 earthquake, and Rasuwa was decimated by earthquake-related landslides and had the highest number of deaths in relation to the entire population (Fig. 2). We selected 2 clusters of settlements to contrast in each district, corresponding to administrative areas called village development committees (VDCs) and conducted 2 phases of structured surveys with a random sample of 100 households from each community (400 total). The first phase began nine months after the earthquakes, coinciding with the end of the relief stage and the beginning of the Nepal reconstruction authority's national rebuilding program in late December 2015. The second phase occurred one and a half years after the earthquakes, allowing us to examine the progress in short-term recovery. Village development committees' boundaries by and large follow the physical landscape and group together settlements of resource users sharing a watershed or common topography, e.g., settlements that stretch from the top of a hill down to the river. Our project thus uses these clusters of settlements as the research universe or boundaries of the integrated social and environmental systems in the study areas. Each VDC includes settlements with internally and externally defined boundaries in which households share physical infrastructure, common pool resources, and work exchange. Our team had connections with some of the settlements and local leaders through previous conservation and development work conducted by the Mountain Institute, an international non-governmental organization (INGO). Starting in 2016, the VDCs we selected were reorganized into larger municipalities composed of additional VDCs. The original VDC boundaries became ward boundaries for the area within these municipalities except in one case where two wards within one of the VDCs were reorganized into a different municipality (see Spoon et al. 2021 for names and locations of new municipalities). We continue to use the VDC designation for clarity in the study. Once sites satisfied our criteria, we selected locations that appeared more "typical" of earthquake impacted VDCs and not outliers with exceptionally devastating experiences not comparable to others. To select the random sample, we used local censuses collected by VDC staff after the earthquakes and used a random number generator to select households. We used an inductive content analysis in Atlas.ti Mac v.8.4.5 software (Scientific Software Development 2019) to assess the qualitative data from the pilot studies to guide the design and analysis of our quantitative survey.

The two VDCs we selected as representative case studies in Gorkha were the more-accessible Aaru Chanaute (VDC 1) and less-accessible Kashigaun (VDC 2). Aaru Chanaute has a heterogenous Hindu and Buddhist population, which includes Newar, Brahman, Chhetri, Gurung, Ghale, and Dalit ethnic groups. There is a concentration of households in the market area. The remaining households in the VDC depend more on pastoralism and wage labor. Because of its accessibility, there appeared to be a host of international aid organizations providing post-earthquake assistance. Kashigaun is a rural VDC two-days walk from the road head in Aaru Chanaute VDC. Indigenous Gurung and some long-term settler Dalit populate the VDC (Macfarlane 1976, Regmi 1990), which has three settlements: Yarsa, Kashigaun, and Chamakharka. Residents generally practice agropastoralism and wage labor. The aid community was only sparsely represented in this area. In Rasuwa district, we selected Gatlang and Haku VDCs. Gatlang (VDC 3) is road accessible, has two settlements (Gatlang and Gre), and is populated by the Indigenous Tamang. Residents mostly practice agropastoralism, although tourism is a growing livelihood option. Many INGOs and NGOs provided relief materials in Gatlang after the earthquakes. Haku (VDC 4) is a less-accessible, rural VDC one- to three-days walk from the road head. Similar to Gatlang, the Indigenous Tamang populate Haku (Holmberg 1989, Fricke 1993, Campbell 2013). It has seven settlements: Nesing, Sano Haku, Haku Besi, Thulo Haku, Tiru, Gogane, and Mailung. Only sparse earthquake aid has reached households that remained in Haku, and there is far less of an NGO presence than in Gatlang.

Our previous research (Spoon et al. 2020a, 2021) found that the earthquakes damaged (18%) or destroyed (82%) the primary home of 396 out of the 400 (99%) randomly selected households across the 4 VDCs. These same households were also unable to return to their homes at nine months. By one and a half years, only 44% had been able to return to their homes from temporary shelters. The earthquakes also forced the relocation of 64 households in the sample (16%) to 7 internally displaced persons'

Fig. 2. Map of study area with shake intensity from the April 2015 earthquake with selected village development committees and internally displaced persons camps (see upper right). Proximity of settlements to landslides also illustrated (ICIMOD 2017). Map by Alicia Milligan. Adapted from Spoon et al. 2020a.



(IDP) camps. At 1.5 years, 63 of these households were still in camps. There were marked differences at this time in the number of households able to return to their primary houses at one and a half years as high as 92% in the less-accessible VDC Kashigaun and as low as 8.0% in the more accessible VDC Gatlang, contrary to expectations, and indicating significant variation in recovery outcomes within our sample. All primary homes that households returned to by one and a half years were not rebuilt to the new building codes created after the earthquakes. Each VDC had all infrastructure (micro-hydropower plants, schools, hospitals, health posts, monasteries, temples, and communal buildings) damaged or destroyed by the earthquakes or related landslides. At one and a half years, less than 40% of this infrastructure was rebuilt. We learned in our research return workshops that at two and a half years most households were in one of three stages of reconstructing new primary homes using payouts from the National Reconstruction Authority and loans. These homes were predominately constructed at a fraction of the size of the household's original dwelling due to the exorbitant cost of rebuilding in rural contexts with high inflation, especially those without road access (see Spoon et al. 2021 for more information on the national rebuilding program, housing designs, and building codes).

Rapport building and household survey

To build rapport with each community our methods included information-sharing meetings and a household survey. Information-sharing meetings were used to introduce the project to each site and share preliminary and final results. These were also opportunities to differentiate our research from government and aid community projects (Spoon et al. 2020a). To amplify impact, our pilot research and information-sharing meetings helped us to integrate local perspectives into our research design, ensuring that our use of terms such as "recovery" and the scale at which we assess it parallels the ways the term is used in practice, and not only theoretically to amplify impact (Welsh 2014). Our goal is to traverse the academic and practitioner divide (Browne et al. 2019) by using terminology accessible to all actors. We therefore used a quantitative methodology that searches for patterns rather than testing hypotheses. These patterns can be linked to recovery narratives generated by qualitative research, and together, these insights can be cross-checked and interpreted through participatory methods (Smit and Wandel 2006, Tyler 2006), such as our research return workshops carried out two and a half years after the earthquakes.

The household survey used structured and semi-structured questions to track household demographics, hazard exposure, recovery indicators, and four domains of adaptive capacity: institutional participation, livelihood diversity, connectivity, and social memory. At 9 months, we enrolled 400 randomly selected households from the 4 communities (100/settlement). At 1.5 years, we recontacted 397 of the original 400 households. We strove to locate the specific respondent who participated in the first phase but designed the survey to be able to be taken by any household member over the age of 18. We reidentified 357 out of the 400 original respondents. In the 43 cases in which we were unable to interview the original participant, we interviewed 40 alternative household members of the same household (397 total households recontacted). The survey used ordinal, yes/no, and multiple-choice questions for recovery indicators, demographics, hazard exposure, and four domains of adaptive capacity. We supplemented the survey data with publicly available satellite imagery collected pre/post the earthquakes (ICIMOD 2017) to identify the distance from each household to the nearest natural hazard (e.g., landslide) and other biophysical indicators relevant to hazard exposure (e.g., accessibility to grazing and agricultural areas). In our previous analysis, we found that household disaster recoveries in the short term were heterogenous and changing for better and for worse. Each of the four locations had its own starting point in the recovery and was either stagnant or moving in a positive or negative direction. These results suggested associations with hazards exposure, livelihood, and displacement (Spoon et al. 2020a). In this analysis, we explore factors underlying these patterns of recovery systematically using NMDS to search for relationships.

We selected the variables for the recovery indicators, demographics, hazard exposure, and four domains of adaptive capacity to include in the survey, using insights from our team's previous research in Nepal, feedback from key consultants, and pilot research, as well as published research on disaster recovery, resilience, and adaptive capacity (Walker et al. 2006, Norris et al. 2008, DiGiano and Racelis 2012, Vallance and Carlton 2015, Cutter 2016b, Folke 2016, Mortreux and Barnett 2017). "Recovery indicators" (34 variables) encompassed home reconstruction and rebuilding issues; recovery of agricultural, pastoral, or hunting practices; recovery of two types of agricultural fields, standing crops, seed storage, and sale of livestock and agricultural products; recovery of the ability to work as wage labor or in tourism; and access to electricity, cell phones, and internet. "Demographics" (34 variables) included Indigenous and local ethnic group, religion, household size, male or female head of household, location of settlement, displacement camp residence, accessibility, home ownership, literacy, educational level, and whether the household took a loan after the earthquakes. "Hazard exposure" (12 variables) incorporated distance to nearest landslide, landslide and other hazard threat, access to grazing, farming, forest, and firewood harvest areas. "Institutional participation" (12 variables) included household participation in local committees, government, community forest user groups, and disaster preparedness groups. "Livelihood diversity" (73 variables, divided into two domains in the analysis) contained the household livelihood portfolio, livestock by type, number, size, and type of agricultural fields, sale of livestock or agricultural products, and participation in businesses, wage labor, tourism, work exchange, or forest product harvest. "Connectivity" (16 variables) included the household origin and type of recovery help, use of outside ideas in the recovery, and the disaster preparedness learning and sharing network. "Social memory" (27 variables) comprised household and community use of previous experiences with natural hazards and local architectural engineering, farming, herding, or forest management knowledge and practices used in the recovery (see Appendix 1, A1.1-A1.8, for full lists of variables in each domain, 208 total).

Data analysis

Our team examined the quantitative household survey data using non-metric multidimensional scaling (NMDS) ordination with PC-ORD 7 software (McCune and Mefford 2016). Non-metric multidimensional scaling is a statistical method widely used in ecology to analyze complex datasets comprising many variables and to identify underlying patterns of variation (McCune and

Grace 2002). Rather than focusing on a single indicator of recovery, NMDS can incorporate information from a wide range of recovery indicators, assess similarity and dissimilarity in recovery among households, identify general patterns of recovery, and explore the role specific recovery indicators play in shaping these patterns. Non-metric multidimensional scaling can also be used to examine linear and non-linear associations between patterns of recovery and measures of adaptive capacity across multiple time intervals, illustrating the complex dynamics of change. Although ecologists typically use NMDS to understand the species composition of ecological communities, social scientists have applied similar dimension-reduction techniques to understand other complex social phenomenon, akin to "mapping" the ecology of social dynamics in which no single indicator is likely to be sufficient (Crona and Bodin 2006, Rusack et al. 2011, Paolisso et al. 2012, Reyes-Garcia et al. 2013, Lansing et al. 2014, Hruschka et al. 2017).

In previous research (Spoon et al. 2020a), we used NMDS to analyze 34 recovery indicators over 2 short-term time intervals (9 months and 1.5 years) to identify patterns among them and interpret those patterns in relation to the specific indicators that underlie them. We found that households differed in their ability to return to their homes and rebuild as well as the impacts the earthquakes had on their livelihoods and market participation. Specifically, we identified two dimensions in the recovery space, as represented in an NMDS ordination plot. The first dimension (recovery or axis 1) represented recovery linked to hazard exposure, livelihoods, and market participation (e.g., greater or fewer impacts to fields, farms, and forests as well as the livelihoods connected to them) with increasing values representing positive recovery and vice versa. The second dimension (displacement or axis 2) reflected displacement with negative values indicating households displaced from homes and place-based agropastoral practices to temporary shelters and camps. See Spoon et al. 2020a for detailed explanation of defining the two dimensions of recovery with visualization.

We extend our analysis to examine associations between these two dimensions of recovery, hazard exposure, and four domains of adaptive capacity, using two methods: (1) vector fitting and (2) surface fitting. The results of vector fitting are simpler to interpret, but surface fitting better represents non-linear associations between recovery indicators and domains of adaptive capacity (McCune and Grace 2002, Oksanen 2015, Peck 2016). Finally, because each variable in our analysis is measured at 2 time points (9 months and 1.5 years), we can compare changes in these linear and non-linear associations over time to explore how different forms of adaptive capacity might shape recovery 9 months and 1.5 years after the earthquakes.

Vector fitting

Vector fitting estimates the linear correlation between a single variable in a particular domain of adaptive capacity (e.g., livelihood diversity, connectivity) and each dimension of recovery (recovery and displacement) identified through NMDS. Negative correlations ($r < 0$) indicate that increasing values of the adaptive capacity variable are associated with decreases in a dimension of recovery, while positive correlations ($r > 0$) indicate that increases in values of the variable are associated with increases in a dimension of recovery. Correlations with values far from 0 (positive or negative) indicate stronger associations. For example, when examining associations between adaptive capacity variables and the first dimension of recovery (recovery), positive correlations suggest that increasing values of this measure of adaptive capacity are associated with positive recovery outcomes linked to livelihood strategies and market participation. For the second dimension of recovery (displacement), positive correlations suggest increasing values of this measure of adaptive capacity are associated with less displacement. Interpreting the correlations between a single variable and each dimension of recovery can tell us how that measure of adaptive capacity is associated with different types of recovery indicators. Similarly, comparing these associations for variables within a domain of adaptive capacity can yield broader insights about what aspects of the domain might be driving recovery. Finally, comparing associations found among different domains of adaptive capacity can indicate the relative importance of livelihoods, social memory, institutional participation, and connectivity for short-term recovery.

Surface fitting

Although vector fitting focuses on linear associations between the two dimensions of recovery and measures of adaptive capacity, previous research on resilience suggests these relationships may be non-linear (Lansing et al. 2014). Surface fitting allows us to explore non-linear associations. Rather than generating a single line to indicate the relationship between a resilience variable and each dimension of recovery (i.e., vector fitting), surface fitting generates a series of contour lines on the ordination plot that can represent both linear and non-linear associations between variables (McCune and Grace 2002). These contour lines can be interpreted like a topographic map in which our two dimensions of recovery act as cardinal directions and the adaptive capacity variable is analogous to elevation. When the contour lines run straight and parallel in the same direction, this indicates a linear association that runs perpendicular to the contour lines. When the contour lines curve, this indicates a non-linear association. To assess whether linear (vector fitting) or non-linear (surface fitting) associations best represent the relationship between dimensions of recovery and the variables in each domain of adaptive capacity, we followed Nelson et al. (2015) in using a 5% improvement in the variance explained by surface fitting (cross-validated R-square) compared to vector fitting (R-square).

Temporal patterns

To investigate changes in associations between adaptive capacity and recovery over time, we analyze each hazard exposure and adaptive capacity variable separately at nine months and one and a half years. Then by comparing the correlations between each phase and the two dimensions of recovery, we can see whether the strength and direction of the correlations change during the short-term recovery. This approach is analogous to the ways ecologists use NMDS, vector fitting, and surface fitting to examine changes in community composition (e.g., succession) in plots measured at multiple time points (Peck 2016).

RESULTS

The following results begin with NMDS findings related to demographics, hazard exposure, and four domains of adaptive capacity that had the strongest associations with the recovery indicators. We consider an $R^2 > .05$ as a strong association because of the complexity of the integrated social and environmental system, particularly in response to acute and cascading

disturbances. The domains with the strongest associations include demographics, hazard exposure, and livelihood diversity. Less strong associations existed for the social memory and institutional participation domains. We report the top 10 variables for each domain with the strongest correlations in Figs. 3 and 4. Full results with correlations between all variables are included in Appendix 1. There was also strong non-linearity in recovery dynamics (e.g., different types of negative earthquake impacts and trajectories; see Table 1) and some evidence of potential changes in livelihoods over the short term influenced by extreme hazard exposures.

Demographics

For demographic variables, our analysis suggests that short-term recovery patterns differ across our four research sites, as well as by religious and ethnic groups. There was a strong, negative correlation with our first dimension of recovery (recovery) for households in Haku (VDC 4) and camps, Buddhists, and households from the Indigenous Tamang (Fig. 3a, Fig. 5, quadrant 3). Conversely, there was a strong, positive correlation with recovery for households from Aaru Chanaute (VDC 1), Hindus, Newar, Brahmin, and Chhetri illustrating elements of adaptive capacity (Fig. 3a, Fig. 5, quadrants 2 and 4). This indicates that households from Haku that were relocated to camps and households with traditionally lower socioeconomic statuses before the earthquakes were having difficulty recovering compared to those with higher statuses, reinforcing that this disaster impacted the poor and marginalized the most and amplified some of the inequalities. We also found that households with higher literacy positively correlated with recovery (Appendix 1, A1.2) and were thus having better recovery outcomes signaling a level of adaptive capacity but not as strongly as other demographics. Tamang households struggling in temporary shelters and camps from Haku had a strong negative correlation with our second dimension of recovery (displacement; Fig. 4a, Fig. 5, quadrant 3). Accessibility positively correlated with less displacement (Fig. 5, quadrant 2), which illustrates that more accessible households were less displaced from their homes and place-based livelihoods compared to less accessible ones. We consider accessibility to include proximity to roads, trails, and helipads. By this criterion, 44% (176) of the households in the entire sample were accessible and 56% (224) were inaccessible.

Collectively, our results indicate that recovery is distinct for households that remained in their settlements with the ability to rebuild their homes and adapt their agropastoral practice compared to those in the settlements and camps who had more difficulty returning to their homes and restarting their place-based lives (Figs. 5-7, quadrant 3). They also illustrate that more accessible households had an easier time adapting and restarting their agropastoral practice than inaccessible ones on the household level (Fig. 5, quadrant 2) but not necessarily at the settlement level (Spoon et al. 2020a; Fig. 4a, Fig. 5, quadrant 1).

Hazard exposure

For the hazard exposure domain, recovery is strongly negatively correlated with impeded access to grazing areas, firewood collection, forest product harvest, marginal bari (non-irrigated) fields, and threats from landslides (Fig. 3b; Fig. 6, quadrants 1 and 3). These correlations between hazard exposure and recovery indicators are relatively consistent across both time periods suggesting that the association between hazard exposure and recovery is similar across the two phases of the project. In other words, households with greater exposure to these hazards are experiencing difficulties in recovery both nine months and one and a half years after the earthquakes.

Livelihood diversity

Our analysis found livelihood to be a critical domain of adaptive capacity. Recovery is strongly negatively correlated with households whose livelihoods focus on livestock (e.g., bovines, sheep, goats, and pigs) and bari (non-irrigated) agriculture (Fig. 3c, Fig. 7, quadrants 1 and 3). Conversely, households with khet or irrigated agriculture and those that did not practice agropastoralism and participated instead in various businesses and tourism ventures correlated positively with recovery, having better recovery outcomes (Fig. 3c, Fig. 7, quadrants 2 and 4). As households rely more heavily on domesticated animals and non-irrigated fields, their recovery indicators lag behind.

Interestingly, each of the top nine strongest associations with livelihood diversity variables correlated with the first dimension of recovery (recovery) and are nine-month variables (Fig. 3c, Fig. 7, quadrants 1 and 3). However, the top 4 variables with the strongest associations (and 7 of the top 10 variables) correlated with the second dimension of recovery (displacement) and are all 1.5-year variables (Fig. 4c, Fig. 7, quadrants 1 and 3). These results suggest that displacement reflects variation in patterns of recovery that emerge over time, distinguishing households that were able to return to their homes and restart their agropastoral practice (Fig. 5, quadrant 1) and those that continue to struggle with displacement in temporary shelters and camps (displacement; Fig. 5-7, quadrant 3). Results for displacement also illustrate that households that owned livestock at one and a half years returned to herding faster (Fig. 7, quadrant 1), and households were purchasing more chickens than other livestock to replace what they lost (Figs. 3c and 4c, Fig. 7, quadrant 3). Lastly, households that practiced agricultural and pastoral work exchange at one and a half years were able to return to their place-based agropastoral lives faster (Fig. 4c, d).

Other domains of adaptive capacity

The remaining domains had weaker correlations with recovery and displacement, though there are some interesting trends that may become stronger during subsequent phases of recovery. For the social memory domain, previous experience with natural hazards and the utilization of local or traditional knowledge and practice in the recovery, such as architecture, farming, and pasture management, positively correlated with displacement (Fig. 4g, Appendix 1, A1.8). It appeared households using their knowledge and experiences from previous natural hazards and agropastoralism are those that remained in their settlements and not those displaced to camps. Of note, institutional participation variables with the strongest associations (e.g., participation in credit and savings groups) were all positively correlated with recovery, especially for variables at one and a half years (Fig. 3e). There were also positive correlations with displacement for households that remained in their villages, not in camps (Fig. 4e, Appendix 1, A1.4). The origin of a household's assistance in the recovery (connectivity) did not appear to be associated with recovery outcomes (Figs. 3f and 4f); however, correlations with displacement illustrated that households remaining in their villages received more help from family and friends, whereas those

Fig. 3. Results from non-metric multidimensional scaling (NMDS) vector fitting for the first dimension of recovery (axis 1 or recovery) show top 10 strongest linear associations for variables from demographics, hazard exposure, and each domain of adaptive capacity. R > 0 indicate associations with positive recovery indicators; r < 0 indicate associations with negative recovery indicators.

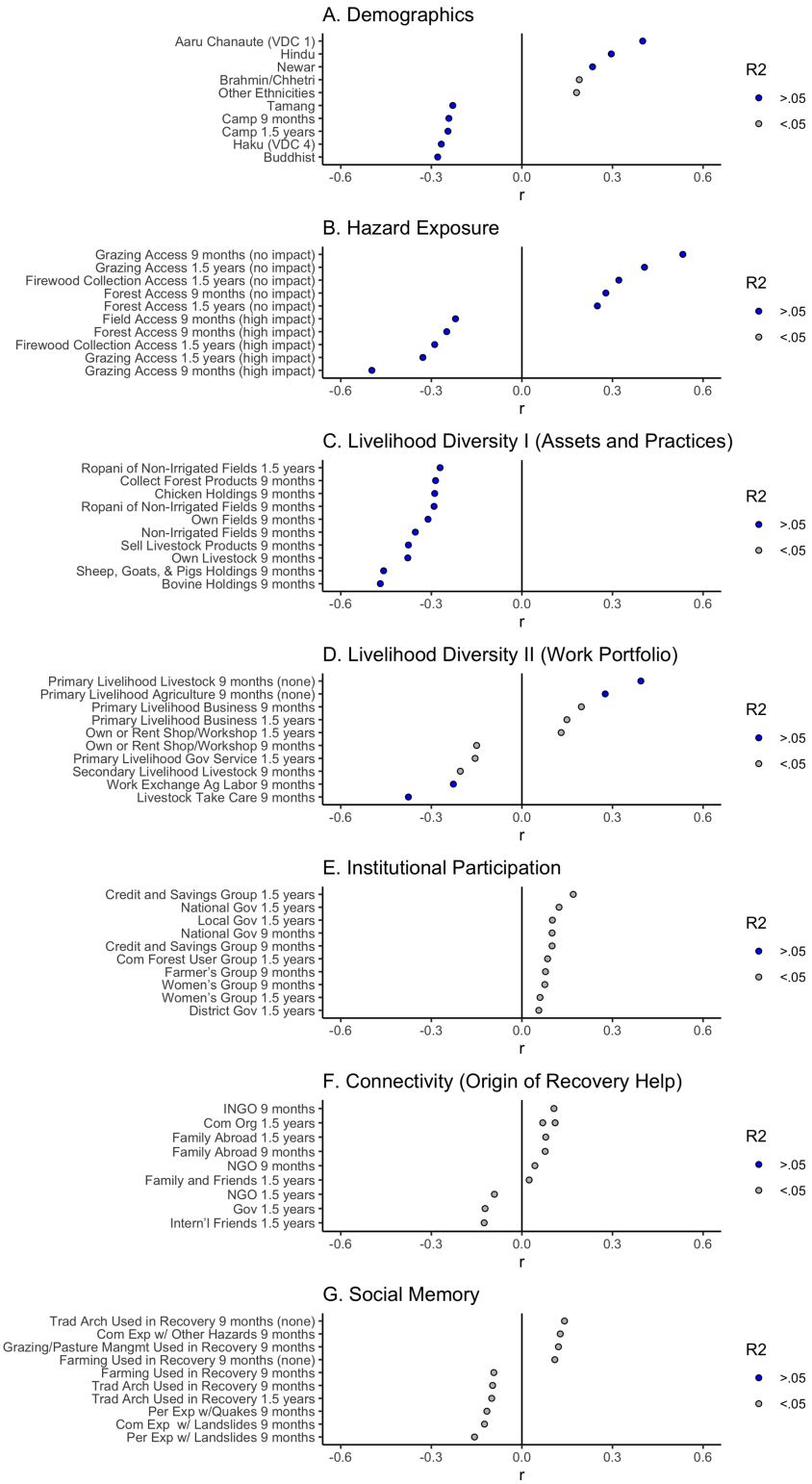


Fig. 4. Results from non-metric multidimensional scaling (NMDS) vector fitting for the second dimension of recovery (axis 2 or displacement) show top 10 strongest linear associations for variables from demographics, hazard exposure, and each domain of adaptive capacity. R > 0 indicate associations with less displacement; r < 0 indicate associations with more displacement.

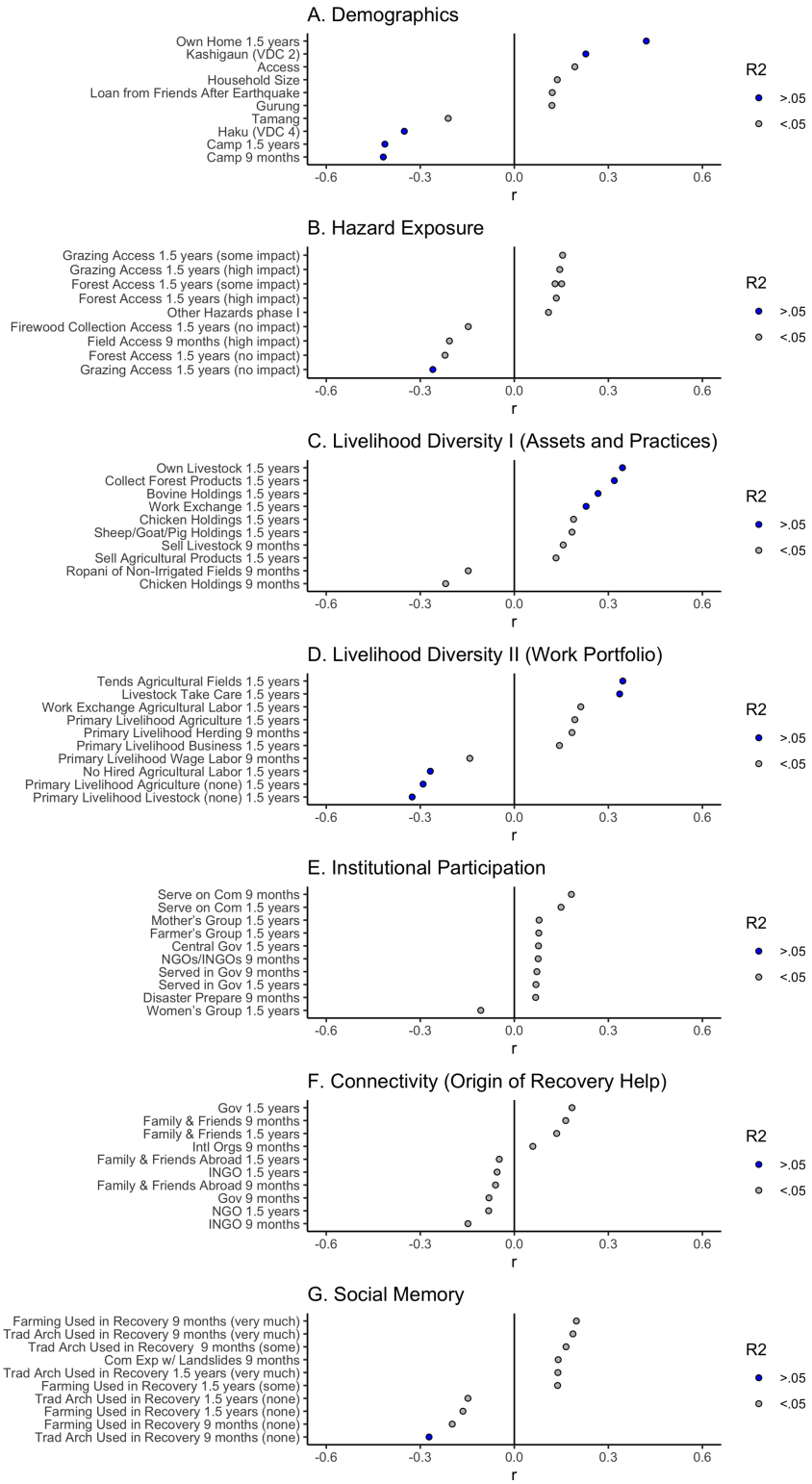


Table 1. Results from non-metric multidimensional scaling (NMDS) surface fitting for the first (recovery or axis 1) and second (displacement or axis 2) dimensions of recovery showing top five strongest non-linear associations with recovery indicators for variables from demographics, hazard exposure, and the livelihood diversity domain of adaptive capacity. Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating $R^2 > .050$. Non-linear associations combine axis 1 (recovery) and axis 2 (displacement) and include both R square (R^2) and cross-validated R square (XR^2). Bold indicates 5% improvement in the variance explained (R^2) by surface fitting compared to vector fitting. See Appendix 1 for full linear and non-linear results.

Select variables by demographic or domain of adaptive capacity with strongest correlations Questions are yes/no unless otherwise noted	Linear		Linear		Non-linear	Non-linear
	Axis 1		Axis 2			
	r	R^2	r	R^2	R^2	XR^2
Demographics						
Internal displaced persons camp (1.5 years)	**-.245**	**.060**	**-.413**	**.171**	**.309**	**.296**
Internal displaced persons camp (9 months)	**-.242**	**.059**	**-.418**	**.174**	**.302**	**.288**
Home owners (1.5 years)	.171	.029	**.421**	**.177**	**.250**	**.236**
Haku (VDC 4)	**-.267**	**.071**	**-.351**	**.123**	**.225**	**.211**
Accessibility (near road, trail, or helipad)	.096	.009	.193	.037	**.087**	**.072**
Hazard Exposure						
No household impact to access to grazing areas (9 months)	**.533**	**.284**	-.016	.000	**.332**	**.321**
No household impact to access to grazing areas (1.5 years)	**.406**	**.165**	**-.260**	**.067**	**.289**	**.276**
Household has significant impacted access to grazing areas (1.5 years)	**-.328**	**.108**	**.145**	**.021**	**.171**	**.155**
No household impact to access to forest product harvest areas (1.5 years)	**.250**	**.063**	-.221	.049	**.143**	**.128**
Household has impacted access to agricultural fields (9 months)	-.220	.048	-.207	.043	**.104**	**.086**
Livelihood Diversity						
Household collects forest products (1.5 years)	-.198	.039	**.319**	**.102**	**.188**	**.174**
Household owns livestock (1.5 years)	-.112	.013	**.345**	**.119**	**.185**	**.173**
Household total chickens-log (9 months)	**-.289**	**.084**	-.219	.048	**.180**	**.164**
Household total bovine (yak, cow, yak/cow hybrids)-log (1.5 years)	**-.238**	**.056**	.267	.071	**.171**	**.155**
Number of ropani of non-irrigated fields-log (9 months)	**-.291**	**.085**	-.147	.022	**.141**	**.126**

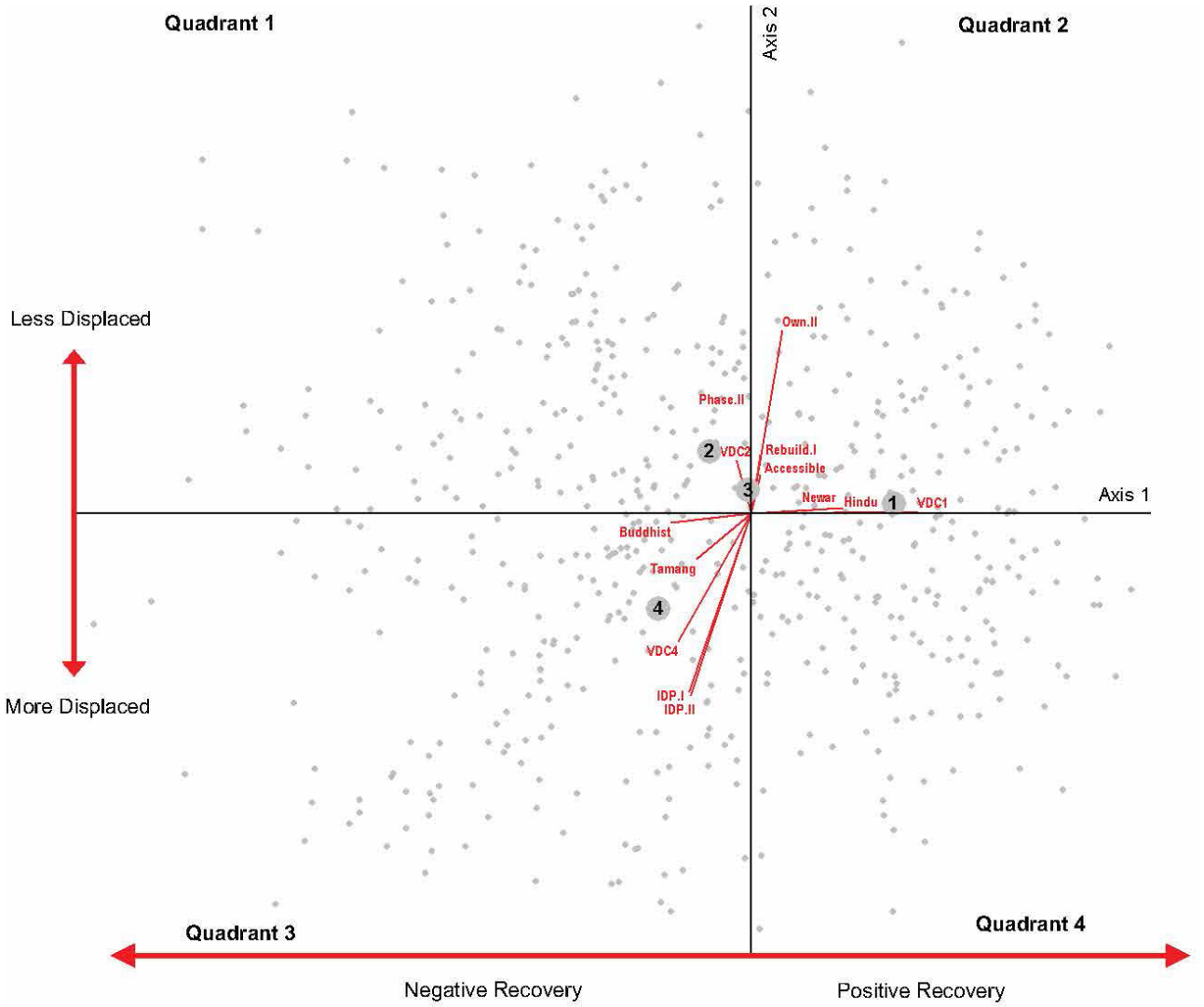
in the camps received help from the aid community across both phases (Fig. 4f). There were also positive correlations with displacement for households using new ideas from the government and aid community in the recovery (Appendix 1, A1.7). This means that new ideas were being operationalized in the villages but not as much in the camps where the flow of new ideas appeared more stagnant.

Non-linear associations

Using surface fitting to examine the recovery indicators, we found non-linear results for most variables in the demographics, hazard exposure, and four domains of adaptive capacity, especially hazard exposure and livelihood diversity variables. These results demonstrate that negative patterns in recovery indicators were different for households relocated to temporary shelters and disrupted from place-based livelihoods within their settlements and those displaced to camps entirely that lost their house, livestock, crops, and much more. For example, Figure 8 shows the association between each recovery dimension and the extent that the earthquakes impacted a household's access to grazing areas for livestock. Households that report the least impacts on grazing access have a positive correlation with recovery, suggesting these households also generally exhibit positive recovery indicators. As impacts to grazing access increase, households move toward the negative space of recovery in a more or less linear fashion, until the lines begin to curve substantially, revealing two "peaks" in the recovery space, one located in the positive space of the second dimension of recovery (displacement) and the other located in the negative space of displacement. Recall that our pattern interpretation of recovery dimensions suggests that displacement distinguishes households that were forced into displacement camps and ceasing their agropastoral practices from households who were able to return at one and a half years to their primary residences in their villages and adapt their agropastoral practices at one and a half years. The two "peaks" identified by surface fitting suggest that both groups of struggling households share a common problem of limited access to grazing areas. However, their overall experiences of recovery differ depending on whether they remained within settlements or not and whether they were relocated to camps. Comparing these two groups of struggling households with additional measures of hazard exposure and adaptive capacity, such as severity of landslides and impacts on livestock survival, health, behavior, and productivity, illustrates that earthquake impacts and cascading effects were negative for both groups but not the same. This indicates a non-linear pattern.

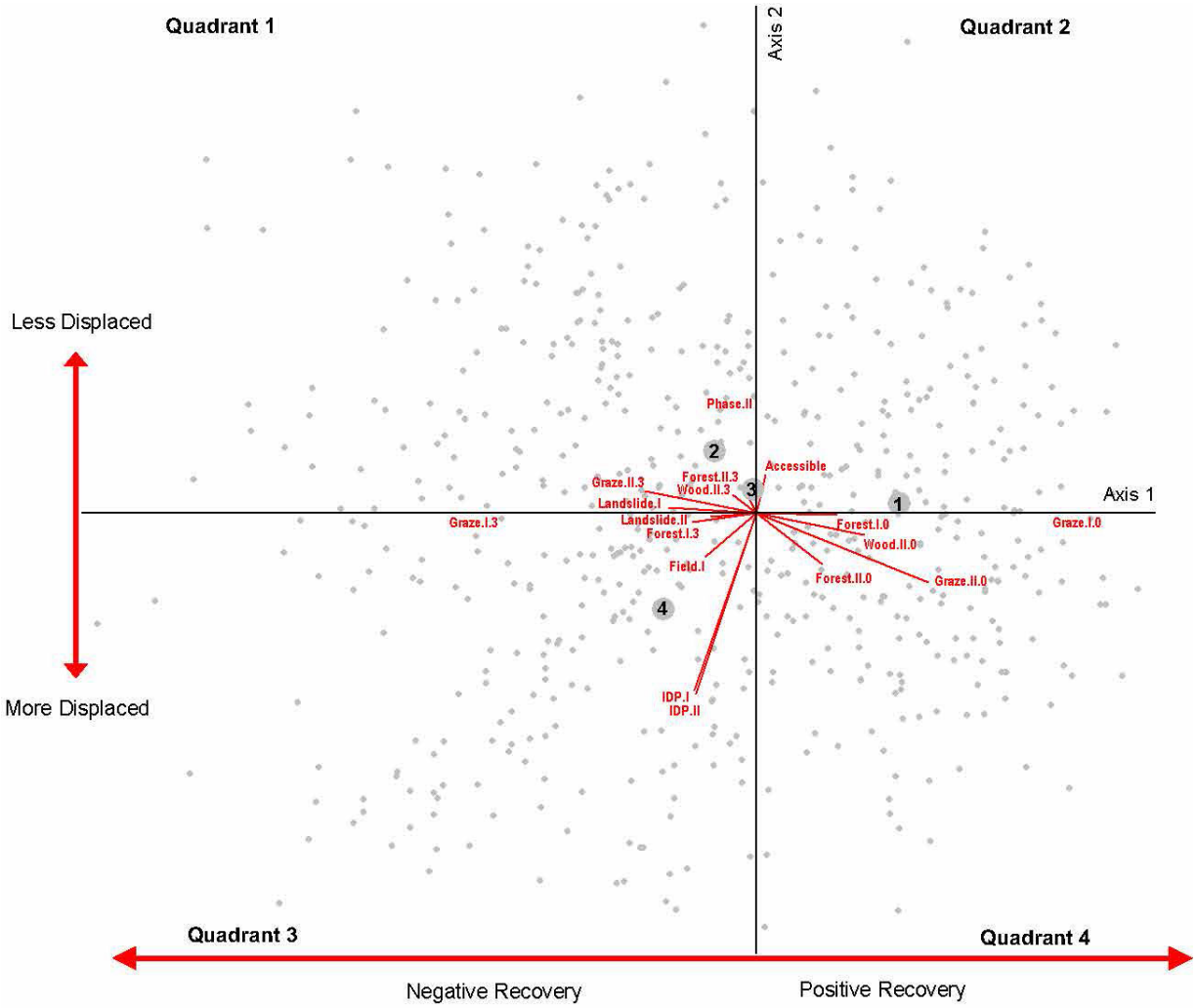
The top five strongest non-linear associations for demographics, hazard exposure, and livelihood diversity domains in Table 1 help to contextualize recovery dynamics in which households struggled in different ways for context-specific reasons. In this case, recovery differed depending on the severity of landslides, which caused total displacement to camps for some households while others remained in their villages in temporary shelters. The non-linear dynamics illustrated that households in the camps had total losses to their livestock and fields, whereas households that remained had impacts to livestock behavior, health, and productivity as well as impeded access to fields, pastures, and forests, but these activities were not completely halted (Table 1, Appendix 1, A1.1 and A1.3).

Fig. 5. Non-metric multidimensional scaling (NMDS) scatterplot of select demographics with highest recovery indicator associations (r-square values) for entire sample (n = 397 households) across both time periods (9 months and 1.5 years) with centroid (average positions) of households in each village development committee (VDC). Lines represent indicators that are most strongly associated with the two dimensions of recovery (recovery and displacement). Centroids used to show average positive of household in each VDC. To view variation in ordination by household in each VDC see Spoon et al. 2020a. (VDC 1 = Aaru Chanaute; VDC 2 = Kashigaun; VDC 3 = Gatlang; VDC 4 = Haku).



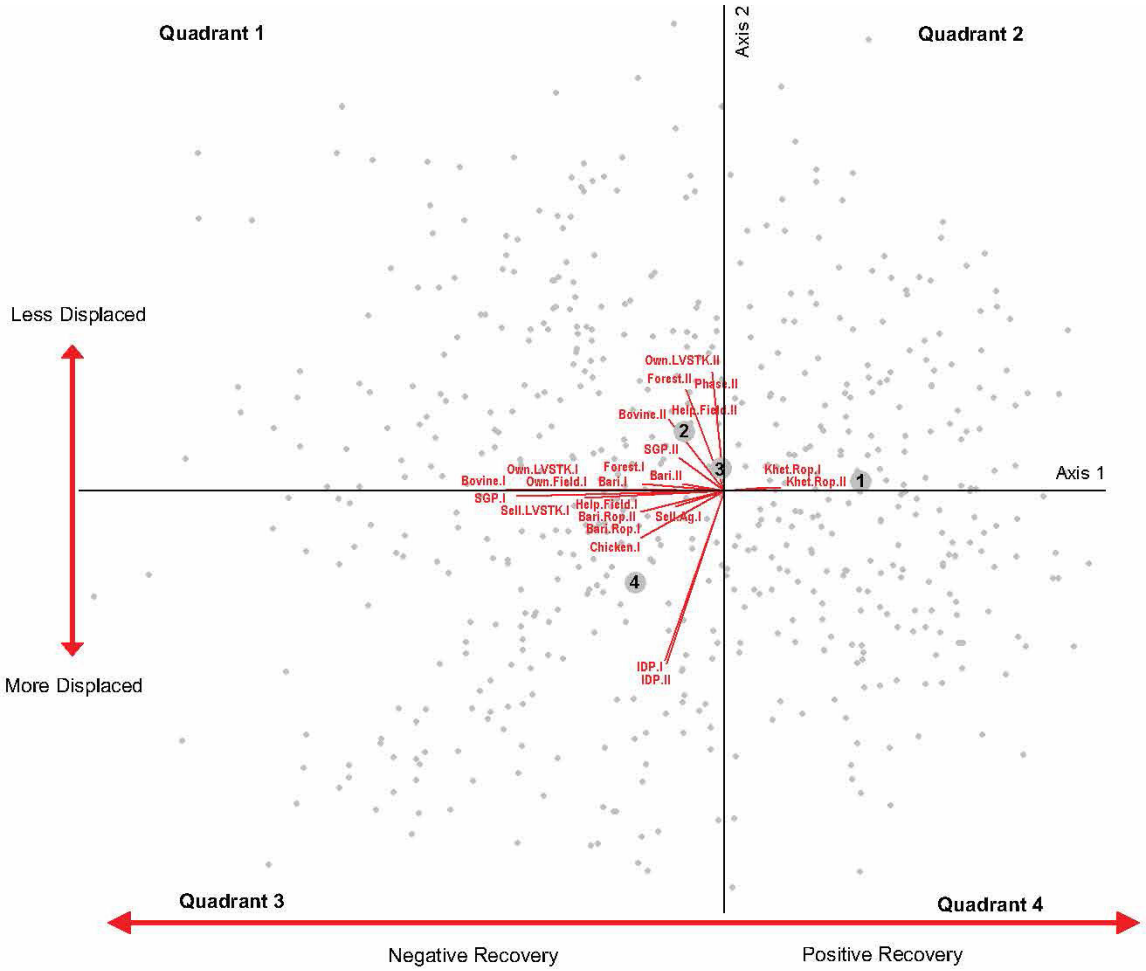
Code	Definition
VDC 1	Aaru Chanaute Households
VDC 2	Kashigaun Households
VDC 4	Haku Households
IDP.I	Internal Displacement Camp (9 months)
IDP.II	Internal Displacement Camp (1.5 years)
Accessible	Accessible Households
Rebuild.I	Household Having Issues Rebuilding (9 months)
Hindu	Hindu Households
Buddhist	Buddhist Households
Newar	Newar Ethnic Group
Tamang	Tamang Ethnic Group
Own.II	Homeowners (1.5 years)
Phase.II	Indicates Households at 1.5 years

Fig. 6. Non-metric multidimensional scaling (NMDS) ordination plot of hazard exposure for entire sample (n = 397 households) across both time periods (9 months and 1.5 years). Small dots represent households and lines represent indicators that are most strongly associated (R^2) with the two dimensions of recovery (recovery and displacement). Centroids used to show average positive of household in each village development committee (VDC). To view variation in ordination by household in each VDC see Spoon et al. 2020a. (VDC 1 = Aaru Chanaute; VDC 2 = Kashigaun; VDC 3 = Gatlang; VDC 4 = Haku).



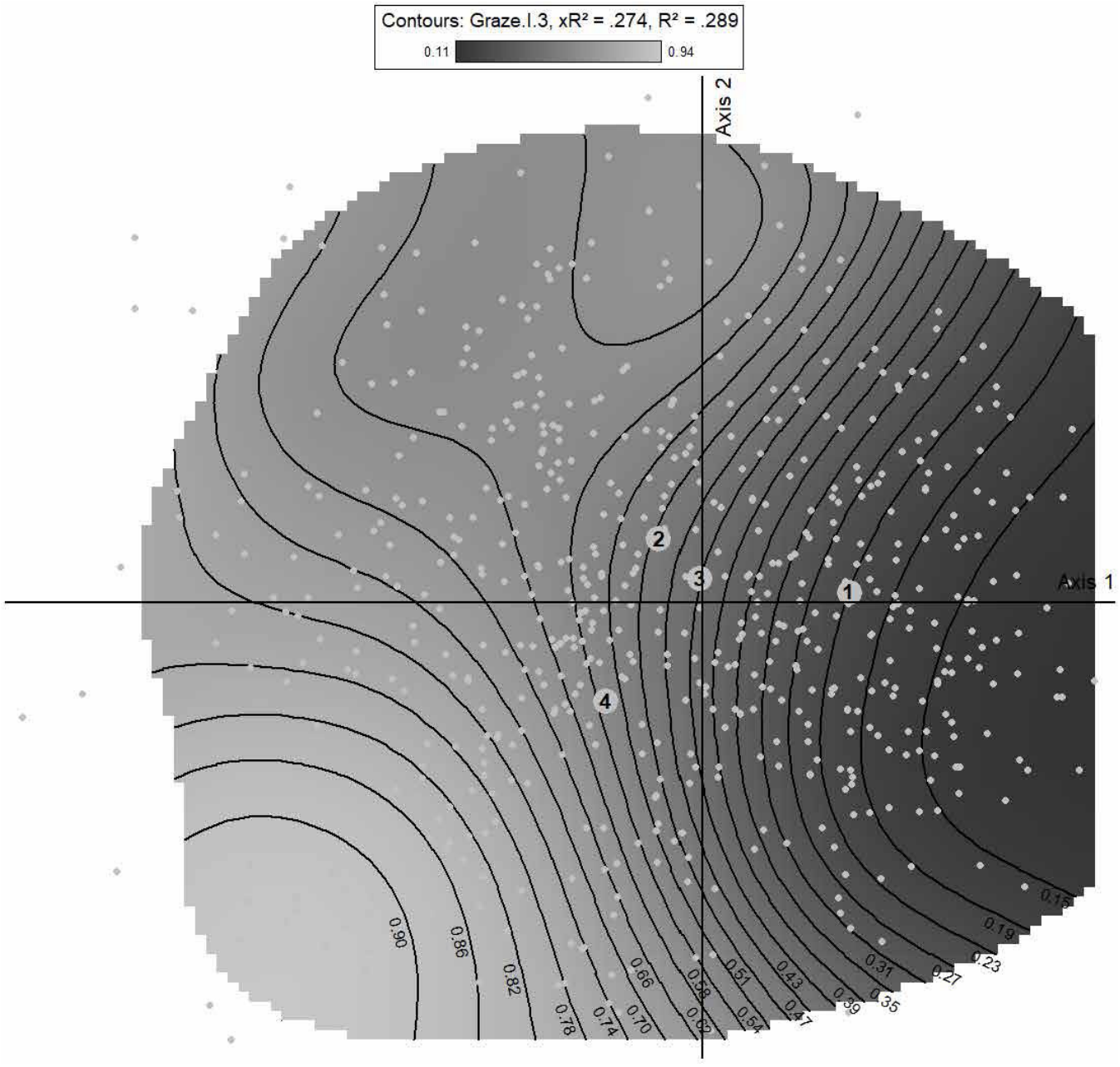
Code	Definition
Graze.I.0	No Earthquake Impacts on Grazing Area Access (9 months)
Graze.I.3	High Earthquake Impacts on Grazing Area Access (1.5 years)
Graze.II.0	No Earthquake Impacts on Grazing Area Access (1.5 years)
Graze.II.3	High Earthquake Impacts on Grazing Area Access (9 months)
Forest.I.0	No Earthquake Impacts on Forest Access (9 months)
Forest.I.3	High Earthquake Impacts on Forest Access (9 months)
Forest.II.0	No Earthquake Impacts on Forest Access (1.5 years)
Forest.II.3	High Earthquake Impacts on Forest Access (1.5 years)
Wood.II.0	No Earthquake Impacts to Firewood Collection Area Access (1.5 years)
Wood.II.3	High Earthquake Impacts to Firewood Collection Area Access (1.5 years)
Field.I	Earthquake Impacts to Agricultural Field Access (9 months)
Landslide.I	Landslides Threaten Community (9 months)
Landslide.II	Landslides Threaten Community (1.5 years)
IDP.I	Internal Displacement Camp (9 months)
IDP.II	Internal Displacement Camp (1.5 years)
Accessible	Accessible Households
Phase.II	Indicates Households at 1.5 years

Fig. 7. Non-metric multidimensional scaling (NMDS) ordination plot of livelihood diversity (assets and practices) for entire sample (n = 397 households) across both time periods (9 months and 1.5 years). Small dots represent households and lines represent indicators that are most strongly associated (R^2) with the two dimensions of recovery (recovery and displacement). Centroids used to show average positive of household in each village development committee (VDC). To view variation in ordination by household in each VDC see Spoon et al. 2020a. (VDC 1 = Aaru Chanaute; VDC 2 = Kashigaun; VDC 3 = Gatlang; VDC 4 = Haku).



Code	Definition
Bari.Rop.I	Ropani of Bari (9 months)
Bari.Rop.II	Ropani of Bari (1.5 years)
Khet.Rop.I	Ropani of Khet (9 months)
Khet.Rop.II	Ropani of Khet (1.5 years)
Sell.Ag.I	Household Sells Agricultural Products (9 months)
Own.Field.I	Household Owns Agricultural Fields (9 months)
Help.Field.I	Household Participates in Work Exchange for Agriculture (9 months)
Help.Field.II	Household Participates in Work Exchange for Agriculture (1.5 years)
Own.LVSTK.I	Households Owns Livestock (9 months)
Own.LVSTK.II	Households Owns Livestock (1.5 years)
Sell.LVSTK.I	Households Sells Livestock Products (9 months)
Bovine.I	Household Total Bovines (yak, cow, yak-cow hybrid) (9 months)
Bovine.II	Household Total Bovines (yak, cow, yak-cow hybrid) (1.5 years)
SGP.I	Household Total Sheep, Goats, and Pigs (9 months)
SGP.II	Household Total Sheep, Goats, and Pigs (1.5 years)
Chicken.I	Household Total Chickens (9 months)
Forest.I	Household Collects Forest Products (9 months)
Forest.II	Household Collects Forest Products (1.5 years)
IDP.I	Internal Displacement Camp (9 months)
IDP.II	Internal Displacement Camp (1.5 years)
Phase.II	Indicates Households at 1.5 years

Fig. 8. Unpivoted non-metric multidimensional scaling (NMDS) ordination plot of two dimensions of recovery (recovery and displacement) with contour overlay (surface fitting) illustrating non-linear association for a hazard exposure variable (household has significant impacted access to grazing areas at 9 months - Graze.I.3). Centroids used to show average positive of household in each village development committee (VDC). Notice increase in non-linear association moving from quadrants 2 and 4 to quadrants 1 and 3. (VDC 1 = Aaru Chanaute; VDC 2 = Kashigaun; VDC 3 = Gatlang; VDC 4 = Haku).



Change and stagnation

General changes over time show differences among struggling households. Our results express that hazard exposure associated with herding and forest product harvest continued to strongly correlate with negative recovery outcomes at one and a half years; however, forest access did slightly improve between the phases while grazing area access did not (Fig. 3b). The correlations with herding and farming livelihood diversity associated variables start to decline at one and a half years compared to nine months (Fig. 3c, d). We found that there was an increase at one and a half years of households restarting their pastoral practice with chickens rather than more expensive bovines, cows, goats, and sheep (Fig. 4c). Households with previous experiences with landslides and other hazards had positive recovery outcomes at nine months but

did not have a correlation at one and a half years (Fig. 3g). Households were also using more new outside ideas at 1.5 years, especially households that were in their villages and not in camps (Appendix 1, A1.7). Households that remained in settlements at one and a half years also had more informal conversations with people about disaster preparedness (Appendix 1, A1.7). Notably, institutional participation correlated with positive recovery outcomes predominantly at one and a half years (Fig. 3e). The vector fitting results for displacement (Fig. 4c) illustrated that households that remained in their villages were practicing more agropastoralism and selling more agricultural and pastoral products at one and a half years compared to those that remained displaced from their homes and settlements. This reinforces that stagnation was occurring for households in temporary housing and settlements compared to permanent homes and villages.

DISCUSSION

Our findings demonstrate how vulnerabilities and adaptive capacities vary and interact among households in short-term disaster recovery. We now discuss the implications of our findings to policy and interventions in two interrelated thematic sections: (1) inequality, hazard exposure, and place-based livelihoods and (2) inaccessibility, marginality, and ingenuity versus maladaptation.

Inequality, hazard exposure, and place-based livelihoods

Our analysis found that different vulnerabilities intersect in disaster recovery. We found that historically and contemporarily marginalized ethnic groups and religions with lower socioeconomic status and literacy before the earthquakes, such as Tamang, Gurung, Ghale, Dalit, and Buddhist, were having more difficulty recovering. Conversely, those of higher status and literacy, such as Newar, Brahmin, Chhetri, and Hindu were experiencing better recovery outcomes indicating a degree of adaptive capacity. Non-linear results illustrated that negative recovery outcomes differed by degree of displacement with households in displacement camps having different experiences than households that remained in their settlements. These findings were consistent across demographics, as well as hazard exposure and livelihood diversity domains. Previous research also indicated that Dalit and Indigenous ethnic groups in geographically vulnerable rural areas were found to be struggling after the earthquakes over the short-term (He et al. 2018, Tamang 2020, Hülssiep et al. 2021), especially for Indigenous and Dalit women (Bajracharya et al. 2022). We argue that these differences stemmed from whether homes and place-based livelihoods were completely disrupted by catastrophic landslides, which persist after the earthquakes for years and get triggered annually by increasingly severe monsoon storms. These results illustrate that in future policy and interventions, special attention should be given to historically, socially, and economically marginalized populations (Yang et al. 2015). This will assist in ameliorating the bias of favoring wealthier or more privileged communities, which reinforces the conditions of poverty that existed prior to the disaster. Government and humanitarian efforts therefore need to focus on the root causes of the identified vulnerabilities to not replicate the conditions for these social and spatial inequalities to persist. Place-based connections should also be reinforced by helping households remain in temporary shelters within their settlements and not relocating them to displacement camps distant from their homes. Policy and interventions should therefore target communities in the camps differently than those in their original settlements, even if they are from the same ethnic group or have similar place-based livelihoods.

More specifically, we found household vulnerabilities related to exposure to natural hazards affected grazing areas, and forest access over both time intervals. Herders, bari (non-irrigated) farmers, and forest product harvesters were struggling the most compared to khet (irrigated) farmers and households participating in various business and tourism ventures. Indeed, most of the households in our study live a marginal life in biophysical extremes. Geologic risks from landslides, landslips, and falling boulders threatened these settlements prior to the earthquakes, similarly to other highly impacted rural locations (He et al. 2018). Mountainous environments provide opportunities but also many challenges. Indeed, mountains are contexts where natural hazards are intensifying, especially in relation to climate change (Zimmerman and Keiler 2015, Merrey et al. 2018, Dikshit et al. 2020, Ahmed et al. 2021). Linear and non-linear associations with recovery indicators existed over the short-term for households displaced from their primary home and agropastoral way of life to temporary shelters within their ancestral settlements and those displaced entirely from settlements to camps. Indeed, research in two nearby highly impacted districts found that a low percentage of communities showed evidence of early recovery or better recovery (Arabinna et al. 2017). Institutional participation appeared to correlate with more positive recovery outcomes, especially for households participating in credit and savings groups; however, similar to substantive results from the social memory domain, not as strongly as other domains of adaptive capacity such as hazard exposure or livelihood diversity.

We found that vulnerabilities existed for those most dependent on place-based livelihoods suffered the most from the earthquakes, particularly herders and marginal farmers. Households with more diversified livelihoods and market connections had more positive recovery outcomes, which was also evident in an adjacent district (Epstein et al. 2018). The households experiencing the most difficulty recovering had fewer options for their place-based livelihoods and relied primarily on highly impacted pastures and forests, rather than both herding and farming. The type of farming a household does also affected outcomes; khet (irrigated) farmers struggled less than bari (non-irrigated) farmers. Herders and marginal farmers live in places most in danger from seismic activity and its cascading effects, especially landslides, which are triggered by the earthquakes and remain active and exacerbated by unpredictable monsoon rains. These dynamics cause spatial inequalities (Finch and Geiger 2010, Checker 2016, Daly et al. 2017) with those living in the most marginal geographies experiencing the worst impacts from the catastrophe. This means that social inequality (the hierarchical positioning of a household often related to ethnic group and indigeneity in Nepal), spatial dynamics (where a household lives), exposure to hazards (often from less accessible settlements on steep mountain slopes), and place-based livelihoods (herding, farming, and forest product harvest) interrelate, creating challenges in recovery by reinforcing and potentially amplifying existing inequalities that were root causes of this hazard becoming a disaster in the first place (Barrios 2019). Indeed, inequality, spatial dynamics, and disaster vulnerability often compound for

Dalit and Indigenous populations in Nepal (Rigg et al. 2016, He et al. 2018) and elsewhere (Akter and Mallick 2013, Atallah 2016, Hallegatte et al. 2020).

We identified adaptive capacities for some households that had access to markets beyond subsistence agropastoralism, such as households with businesses as their primary livelihood; these had better recovery outcomes. This suggests that market integration through businesses and tourism provided some adaptive capacity. Households seemed more able to adapt to this disturbance when they had these economic advantages, especially in Aaru Chanaute where there are more historically privileged ethnic groups (Brahmin, Chhteri, and Newar), as well as a market area and a road head. Households from Aaru Chanaute also had the highest literacy rates and access to microcredit loans, which correlated with their more positive recovery outcomes. Displaced households from Haku, mostly from the historically marginalized Indigenous Tamang, were in the most difficult positions. The NMDS illustrated non-linear associations for more versus less displaced households. The more displaced Indigenous Tamang lost their livestock and many of their fields. These households had difficulty recovering throughout the study because they were severed from their place-based livelihoods. Indeed, previous research found that relocation hinders a population from recovering (Olshansky 2005a, Schuller 2016).

Our results showed some evidence of changes over the short term, which may signal shifts in lives and livelihoods later on. We found that hazard exposure associated with herding and forest product harvest strongly correlated with negative recovery outcomes at nine months and one and a half years. We interpret this finding as herders and marginal farmers having more difficultly recovering, which may materialize as shifts in herding practices or intensity because those with more impacts, such as Gatlang, have less diversity in their livelihoods (i.e., primarily herding instead of a more mixed agropastoralism; Spoon et al. 2020a). Households may replace their expensive bovines with cheaper domesticates, decide to grow different food crops, let agricultural fields go fallow, or conduct wage labor inside or outside of their settlement, as evidenced in other regions of Nepal (Sanstha and Global Water Partnership 2017, DiCarlo et al. 2018, Epstein et al. 2018). Along these lines, we found that there was an increase in households restarting their pastoral practice with chickens one and a half years after the earthquakes, compared to more expensive bovines, cows, goats, and sheep. These post-disaster adaptations also coincide with adaptations to climate change documented in nearby areas (Merrey et al. 2018) illustrating how the earthquakes and their cascading effects compound with other hazards (Moolenaar 2022). Many of the households that were shifting livelihoods are from the less accessible Haku, populated by the marginalized Tamang, illustrating non-linear dynamics compared to households that had pastoral impacts but did not catastrophically lose their holdings. These changes could signal opportunities to influence policy, government and outside aid interventions, or local initiatives that improve conditions for historically marginalized peoples.

Inaccessibility, marginality, and ingenuity versus maladaptation

Not only does our study identify how vulnerabilities intersect for the poor and marginalized, but it also illustrates how these contexts may help to push ingenuity and innovation creating adaptive capacity that mitigates disaster impacts and helps with recovery. These local "innovations" could also be considered a maladaptation, which perpetuates the challenging circumstances that these communities were in pre-disaster. Our results illustrate that some of the households with place-based livelihoods on the geographic margins with high hazard exposure were able by one and a half years to return to certain aspects of their pre-disaster lives and that the entire sample became less displaced. This is evidence of vulnerabilities, such as pre-existing social inequality, hazard exposure, and agropastoral ways of life interacting, as well as household characteristics, such as local knowledge and mutual aid, through parma mitigating certain disaster impacts despite the challenges. Our previous analyses showed that less accessible Kashigaun was heading in a positive direction in one and a half years even though they were inaccessible with high hazard exposure populated by more historically marginalized Dalit and Indigenous Gurung and Ghale peoples. Previously, we found mutual aid and local knowledge ameliorated some aspects of their situation (Spoon et al. 2020a, 2021). We now add that Kashigaun strongly positively correlated with displacement in one and a half years. This shows that they had more households back in their primary houses, practicing agropastoralism than the other settlements. Kashigaun also had more diversified livelihoods with a balance of herding and farming and primarily received loans from family and friends to rebuild compared to banks or microcredit, which created more debt, particularly in accessible settlements. Debt from loans was common in a nearby district (Le Billon et al. 2020).

Further, we found some adaptive capacities for the Indigenous Gurung/Ghale who primarily populate Kashigaun. They did not have strong associations with negative recovery outcomes even though they live in an extremely marginal area, multiple days from the road head without external assistance. The Indigenous Gurung did strongly positively correlate with displacement, which illustrates their collective effort in rebuilding homes using some aspects of traditional architecture and restarting and adapting agropastoral practices in their ancestral settlements, evident elsewhere in Nepal (Epstein et al. 2018, Hillig and Connell 2018, Panday et al. 2021). Kashigaun households also had the lowest literacy rates, which may explain why literacy correlated less strongly with positive recovery outcomes than variables representing Indigenous and local peoples or religions. Importantly, even though Kashigaun residents returned to their homes in the short term using these communal traditions, their conditions remained challenging. Indeed, a study from a nearby district found that social capital helped residents return to their homes faster but that the communal action eroded after external helped arrived (Panday et al. 2021). Indeed, disaster research illustrates that "communities of circumstance" may emerge in the short-term, post-disaster context and dissolve in the long term (Ntonis et al. 2020).

Communal action and creative problem solving may therefore be influenced by the inaccessibility of Kashigaun and Haku, illustrating some adaptive capacity; although these group responses may also be a short-term coping mechanism to help them adapt and respond to the challenging conditions afforded by systems of power. One way to see this is when the biophysical margins are contexts that push innovation and adaptation, potentially mitigating some of the vulnerability and illustrating

adaptive capacity. Another way to see this same phenomenon is when the community maladapts sufficiently enough that the systems of power do not need to change or address the root causes of vulnerability, such as social inequality or vulnerable settlement locations or living conditions. For Kashigaun (VDC 2), who returned to their homes and place-based livelihoods the fastest over the short-term (Spoon et al. 2020a), households used the cultural institution of parma or work exchange. In nearby districts, research found that social capital helped rebuild homes and improve farms in a short timespan after the earthquakes (Epstein et al. 2018, Panday et al. 2021). Various studies also identify aspects of social capital as important components of recovery (Norris et al. 2008, Cutter 2016b, Daramola et al. 2016, Faas 2017), which was also evident in Nepal after the 1934 earthquake (Bhandari 2014). Indeed, Hoffman (2019) argued that solutions to preventing and ameliorating catastrophic events are typically cultural and social. In the Nepal case, there is evidence that social capital through work exchange and loans in Kashigaun may provide some adaptive capacity.

Scaling out to all four locations, we found additional evidence of social memory and local knowledge mitigating earthquake impacts and helping households restart their place-based lives, providing some adaptive capacity for those most reliant on the biophysical landscape who had catastrophic impacts from the disturbance. Evidence of this exists in that all households experienced less displacement in one and a half years even though hazard exposure was consistent across both phases, such as the persistence of active landslides. Previous experiences with landslides and local knowledge of traditional architecture, farming, and pasture management also correlated with households returning to their primary homes and restarting their agropastoral practice, especially in one and a half years. We argue that this is evidence of mutual aid and local knowledge mitigating catastrophic disaster impacts by influencing less displacement. Circumstances also improved from nine months to one and a half years for place-based livelihoods. The strongest associations with negative recovery outcomes for herding, farming, and collecting forest products impacting recovery are with nine-month variables, and they improve in one and a half years. We see a similar pattern with households that use work exchange in agriculture and pastoralism having strong associations with negative recovery outcomes in nine months but not one and a half years. These households also had less displacement in one and a half years compared to nine months. Local ingenuity can therefore push adaptation that helps to mitigate hazards in biophysically vulnerable geographies. Ingenuity could also be viewed as a maladaptation that perpetrates inequalities that existed prior to the disaster, such as certain Tamang, Gurung, Ghale, and Dalit peoples continuing to live in difficult marginal circumstances that reinforce poverty and lack outside opportunities like market integration. Local ingenuity and innovation are exemplified in Kashigaun whose situation was improving in some ways over the short term even with high hazard exposure and less economic capacity and aid, a critical result of this study. Local knowledge has contributed to disaster risk reduction and recovery in multiple contexts (Rautela 2015). Integrating different knowledges, such as Indigenous and local knowledge, into earthquake risk reduction was also found to reduce vulnerability in disasters (Mercer et al. 2010). In the Nepal case, attention to reciprocal labor practices, social memory, and local knowledge may assist in creating more appropriate policy and external interventions responding to disasters, as well as pre-disaster planning and future mitigation.

Study limitations

We recognize that quantitative modeling in disaster zones can be reductionist and can overlook intangible dynamics, such as pre-existing power inequities, affect, place attachment, and mental health (Button 2010, Barrios 2016b, 2017, Faas 2016, González and Faas 2016, Jones and Faas 2016, Spoon et al. 2020b). However, governments and aid organizations often use generalized models in disaster preparedness, response, and recovery planning. We hope to provide an approach that captures the most critical aspects of historically marginalized caste and Indigenous ethnic group disaster recoveries and is generalizable to other contexts but flexible enough to include the nuances specific to studied settlements. For example, researchers studying disaster recovery in other locations could employ the conceptual model in Fig. 1 but change the domains, specific variables, and interview questions to fit a different context. We attempt to circumvent oversimplification by incorporating a diverse set of variables and triangulating and cross-referencing results with several forms of qualitative data collected at nine months, at one and a half and two and a half years (Spoon et al. 2020b, 2021). Accordingly, our modeling approach using NMDS focuses on identifying associations among these variables, rather than testing hypotheses with a more limited set of variables. Future research could build on the associations we have identified to develop more detailed causal models.

CONCLUSION

Disaster recovery is indeed multidimensional and depends on contextualized variables that follow broader patterns. This research aimed to understand similarities and differences in short-term household disaster recoveries and some of the reasons for these patterns, which assist in the identification of multifaceted vulnerabilities, adaptive capacities, and/or leverage points for transformative change. Our approach used previous and pilot research and the literature to select demographics, hazard exposure, and four domains of adaptive capacity, and then tested their correlations with critical recovery indicators. The NMDS analysis mapped the recovery for the 400-household samples and illustrated their change at about nine months and one and a half years after the events. Our research return workshops at two and a half years validated results and assisted with interpretation at multiple scales.

Our research supports and enhances existing literature on how acute disturbances and their cascading effects impact human-environment dynamics in non-linear ways. We make two primary contributions to disaster and resilience research: (1) providing a robust empirical dataset containing a random sample of households collected following an extreme disturbance over two short-term time intervals with a theoretically informed quantitative methodology that engages linear and non-linear relationships between multidimensional disaster recovery and adaptive capacity, as well as changes over time; and (2) illustrating an example of how vulnerabilities interact with adaptive capacity. We show how recovery is generally non-linear and identified some specific changes occurring in livelihoods, and less strongly in other

domains, influenced by extreme hazard exposure that may be signs of changes in the long term, as well as stagnation. These dynamics could therefore reinforce current development pathways or create the emergence of new ones. Future research will follow these short-term trends over the long term.

By incorporating information from multiple measures and identifying patterns of covariation among them, our NMDS approach can help identify and contextualize post-disaster short- and long-term patterns in recovery dynamics, such as relationships between social inequalities, hazard exposure, and place-based livelihoods. Our research therefore assists in the identification of the conditions that shape vulnerabilities, which can help address root causes. These patterns can in turn inform pre- and post-disaster policy, aid interventions, and community-based development programs. Our approach and results can also assist in identifying certain adaptive capacities, such as market integration, livelihood diversity, and local place-based knowledge, which are potential leverage points for more equitable and informed policy and interventions. Our approach can therefore help local communities, governments, and development/aid industries make more informed and equitable decisions in pre-disaster preparedness and risk reduction planning, as well as post-disaster responses, needs assessments, and future mitigation.

Author Contributions:

Jeremy Spoon: conceptualization, methodology, formal analysis, investigation, writing original draft and reviewing and editing, supervision, project administration, funding acquisition Drew Gerkey: conceptualization, methodology, formal analysis, writing original draft and reviewing and editing, visualization Alisa Rai: methodology, investigation, writing: reviewing and editing, supervision, project administration Ram B. Chhetri: conceptualization, methodology, writing: reviewing and editing

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Data Availability:

The data/code that support the findings of this study are available on request from the corresponding author, J.S. The data/code are not publicly available because they contain information that could compromise the privacy of research participants.

LITERATURE CITED

Ahearn, L. M. 2001. Language and agency. Annual Review of Anthropology 30(1):109-137. https://doi.org/10.1146/annurev.anthro.30.1.109

Ahmed, R., G. F. Wani, S. T. Ahmad, M. Sahana, H. Singh, and P. Ahmed. 2021. A review of glacial lake expansion and associated glacial lake outburst floods in the Himalayan region. Earth Systems and Environment 5(8):695-708. https://doi.org/10.1007/s41748-021-00230-9

Akter, S., and B. Mallick. 2013. The poverty-vulnerability-resilience nexus: evidence from Bangladesh. Ecological Economics 96:114-124. https://doi.org/10.1016/j.ecolecon.2013.10.008

Arabinda, M. R., A. M. Ghate, J. Gurung, G. Pathak, and A. N. Upraity. 2017. Building ex ante resilience of disaster exposed mountain communities: drawing insights from the Nepal earthquake. International Journal of Disaster Risk Reduction 22:167-178. https://doi.org/10.1016/j.ijdrr.2017.03.008

Atallah, D. G. 2016. Toward a decolonial turn in resilience thinking in disasters: example of the Mapuche from southern Chile on the frontlines and faultlines. International Journal of Disaster Risk Reduction 19:92-100. https://doi.org/10.1016/j.ijdrr.2016.08.027

Bajracharya, A., K. K. Shrestha, A. B. Zwi, and E. Baldry. 2022. Reframing gendered disaster: lessons from Nepal's Indigenous women. International Journal for Disaster Risk Reduction 83:103422. https://doi.org/10.1016/j.ijdrr.2022.103422

Barrios, R. E. 2016a. Resilience: a commentary from the vantage point of anthropology. Annals of Anthropological Practice 40 (1):28-38. https://doi.org/10.1111/napa.12085

Barrios, R. E. 2016b. Expert knowledge and the ethnography of disaster reconstruction. Pages 134-152 in G. V. Button and M. Schuller, editors. Contextualizing disaster. Berghahn Books, New York, New York, USA.

Barrios, R. E. 2017. Governing affect: neoliberalism and disaster reconstruction. University of Nebraska Press, Lincoln, Nebraska, USA.

Barrios, R. E. 2019. Unwieldy disasters: engaging the multiple gaps and connections that make catastrophes. Pages 23-40 in S. M. Hoffman and R. E. Barrios, editors. Disaster upon disaster: exploring the gap between knowledge, policy, and practice. Berghahn Books, New York, New York, USA.

Bergman, A. 2019. The future matter matters: disasters as a (potential) vehicle for social change. It is about time. Pages 356-377 in S. M. Hoffman and R. E. Barrios, editors. Disaster upon disaster: exploring the gap between risk and disaster knowledge and what enter policy and practice. Berghahn Books, New York, New York, USA.

Bhandari, R. B. 2014. Social capital in disaster risk management; a case study of social capital mobilization following the 1934 Kathmandu Valley earthquake in Nepal. Disaster Prevention and Management 23(4):314-328. https://doi.org/10.1108/DPM-06-2013-0105

Brooks, N., W. N. Adger, and P. M. Kelly. 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change 15(2):151-163. https://doi.org/10.1016/j.gloenvcha.2004.12.006

Browne, K. E., E. Marino, H. Lazrus, and K. Maxwell. 2019. Applying the anthropology of disaster to practitioner settings and policy creation. Pages 292-312 in S. M. Hoffman and R. E. Barrios, editors. Disaster upon disaster: exploring the gap between knowledge, policy and practice. Berghahn Books, New York, New York, USA.

Buergelt, P. T., and D. Paton, 2014. An ecological risk management and capacity building model. Human Ecology 42 (4):591-603. https://doi.org/10.1007/s10745-014-9676-2

Button, G. V. 2010. Disaster cultures. Knowledge and uncertainty in the wake of human and environmental catastrophe. Routledge, New York, New York, USA.

Campbell, B. 2013. Living between juniper and palm: nature, culture and power in the Himalayas. Oxford University Press, Oxford, UK. https://doi.org/10.1093/acprof:oso/9780198078524.001.0001

Casagrande, D. G., H. McIlvaine-Newsad, and E. C. Jones. 2015. Social networks of help-seeking in different types of disaster responses to the 2008 Mississippi River floods. Human Organization 74(4):351-361. https://doi.org/10.17730/0018-7259-74.4.351

Chatterjeea, R., and K. Okazakia. 2018. Household livelihood recovery after 2015 Nepal earthquake in informal economy: case study of shop owners in Bungamati. Procedia Engineering 212:543-550. https://doi.org/10.1016/j.proeng.2018.01.070

Checker, M. 2016. Tempests, green teas, and the right to relocate. The political ecology of superstorm Sandy. Pages 171-195 in G. V. Button and M. Schuller, editors. Contextualizing disaster. Berghahn Books, New York, New York, USA. https://www.berghahnbooks.com/downloads/OpenAccess/ButtonContextualizing/08_ButtonSchuller.pdf

Coburn, B. 2020. Nepal's road-building spree pushes into the heart of the Himalayas. Yale Environment 360, January 2. https://e360.yale.edu/features/paving-the-himalayas-a-road-building-spree-rolls-over-nepal

Crona, B., and Ö. Bodin. 2006. What you know is who you know? Communication patterns among resource users as a prerequisite for co-management. Ecology and Society 11(2):7. https://doi.org/10.5751/ES-01793-110207

Cutter, S. L. 2016a. Commentary: resilience to what? Resilience for whom? Geographical Journal 182(2):110-113. https://doi.org/10.1111/geoj.12174

Cutter, S. L. 2016b. The landscape of disaster resilience indicators in the USA. Natural Hazards 80:741-758. https://doi.org/10.1007/s11069-015-1993-2

Daly, P., S. Ninglekhu, P. Hollenbach, J. D. Barenstein, and D. Nguyen. 2017. Situating local stakeholders within national disaster governance structures: rebuilding urban neighborhoods following the 2015 Nepal earthquake. Environment and Urbanization 29(2):403-24. https://doi.org/10.1177/0956247817721403

Daramola, A. Y., O. T. Oni, O. Ogundele, and A. Adesanya. 2016. Adaptive capacity and coping response strategies to natural disasters: a study in Nigeria. International Journal of Disaster Risk Reduction 15:132-147. https://doi.org/10.1016/j.ijdrr.2016.01.007

de Vries, D. H. 2017. Temporal vulnerability and the post-disaster 'window of opportunity to woo': a case study of an African-American floodplain neighborhood after Hurricane Floyd in North Carolina. Human Ecology 45(4):437-448. https://doi.org/10.1007/s10745-017-9915-4

DiCarlo, J., K. Epstein, R. Marsh, and I. Måren. 2018. Post-disaster agricultural transitions in Nepal. Ambio 47(7):794-805. https://doi.org/10.1007/s13280-018-1021-3

DiGiano, M. L., and A. E. Racelis. 2012. Robustness, adaptation and innovation: forest communities in the wake of Hurricane Dean. Applied Geography 33:151-158. https://doi.org/10.1016/j.apgeog.2011.10.004

Dikshit, A., R. Sarkar, B. Pradhan, S. Segoni, and A. M. Abdullah. 2020. Rainfall induced landslide studies in Indian Himalayan region: a critical review. Applied Sciences 10(7):2466. https://doi.org/10.3390/app10072466

Dimri, A. P., S. Allen, C. Huggel, S. Mal, J. A. Ballesteros-Canovas, M. Rohrer, A. Shukla, P. Tiwari, P. Maharana, and T. Bolch. 2021. Climate change, cryosphere and impacts in the Indian Himalayan region. Current Science 120(5):775-790. https://doi.org/10.18520/cs/v120/i5/774-790

Epstein, K., J. DiCarlo, R. Marsh, B. Adhikari, D. Paudel, I. Ray, and I. Måren. 2018. Recovery and adaptation after the 2015 Nepal earthquakes: a smallholder household perspective. Ecology and Society 23(1):29. https://doi.org/10.5751/ES-09909-230129

Faas, A. J. 2016. Disaster vulnerability in anthropological perspective. Annals of Anthropological Practice 40(1):14-27. https://doi.org/10.1111/napa.12084

Faas, A. J. 2017. Enduring cooperation: time, discipline, and Minga practice in disaster-induced displacement and resettlement in the Ecuadorian Andes. Human Organization 76(2):99-108. https://doi.org/10.17730/0018-7259.76.2.99

Finch, J., and S. Geiger. 2010. Markets are trading zones: on the material, cultural, and interpretative dimensions of market encounters. Pages 117-137 in S. Araujo, L. Finch, J. and Kjellberg, Hans, editors. Reconnecting marketing to markets. Oxford University Press, Oxford, UK.

Folke, C. 2016. Resilience (republished). Ecology and Society 21 (4):44. https://doi.org/10.5751/ES-09088-210444

Fricke, T. E. 1993. Himalayan households: Tamang demography and domestic process. Book Faith India, New Delhi, India.

Gamburd, M. R. 2013. The golden wave: culture and politics after Sri Lanka's tsunami disaster. Indiana University Press, Bloomington, Indiana, USA.

Ganapati, N. E. 2013. Measuring the processes and outcomes of post-disaster housing recovery: lessons from Gölcük, Turkey. Natural Hazards 65(3):1783-1799. https://doi.org/10.1007/s11069-012-0442-8

Gautam, D., and G. Cortés. 2021. Reconstruction assistance in rural Nepal after the 2015 Gorkha Nepal earthquake through Aarma Parmah approach: a case study in Bijulikot, Ramechhap District. Progress in Disaster Science 10:100148. https://doi.org/10.1016/j.pdisas.2021.100148

Ghale, S. 2015. The heart of the matter. Record, September 10. https://www.recordnepal.com/the-heart-of-the-matter

González, T. K., and A. J. Faas. 2016. Afterward: preparing for uncertainties. Annals of Anthropological Practice 40(1):98-105. https://doi.org/10.1111/napa.12091

Gunderson, L. 2010. Ecological and human community resilience in response to natural disasters. Ecology and Society 15(2):18. https://doi.org/10.5751/ES-03381-150218

Gurung, H. 2003. Trident and thunderbolt: cultural dynamics in Nepalese politics. Social Science Baha, Kathmandu, Nepal.

Hallegatte, S., A. Vogt-Schilb, J. Rozenberg, M. Bangalore, and C. Beaudet. 2020. From poverty to disaster and back: a review of the literature. Economics of Disasters and Climate Change 4 (1):223-247. https://doi.org/10.1007/s41885-020-00060-5

He, L., J. C. Aitchison, K. Hussey, Y. Wei, and A. Lo. 2018. Accumulation of vulnerabilities in the aftermath of the 2015 Nepal earthquake: household displacement, livelihood changes and recovery challenges. International Journal of Disaster Risk Reduction 31:68-75. https://doi.org/10.1016/j.ijdrr.2018.04.017

Hillig, Z., and J. Connell. 2018. Social capital in a crisis: NGO responses to the 2015 Nepalese earthquakes. Asia Pacific Viewpoint 59(3):309-322. https://doi.org/10.1111/apv.12201

Hoffman, S. M. 2019. "The worst of times, the best of times": toward a model of cultural response to disaster. Pages 141-161 in A. Oliver-Smith and S. M. Hoffman, editors. The angry Earth. Routledge, London, UK.

Holmberg, D. H. 1989. Order and paradox: myth, ritual and exchange among Nepal's Tamang. Cornell University Press, Ithaca, New York, USA. https://doi.org/10.7591/9781501721779

Hruschka, D. J., C. Hadley, and J. Hackman. 2017. Material wealth in 3D: mapping multiple paths to prosperity in low- and middle-income countries. PLoS ONE 12(9). https://doi.org/10.1371/journal.pone.0184616

Hsu, M., R. Howitt, and F. Miller. 2015. Procedural vulnerability and institutional capacity deficits in post-disaster recovery and reconstruction: insights from Wutai Rukai experiences of Typhoon Morakot. Human Organization 74(4):308-318. https://doi.org/10.17730/0018-7259-74.4.308

Hughes, T. P., L. H. Gunderson, C. Folke, A. H. Baird, D. Bellwood, F. Berkes, B. Crona, A. Helfgott, H. Leslie, J. Norberg, M. Nyström, P. Olsson, H. Österblom, M. Scheffer, H. Schuttenberg, R. S. Steneck, M. Tengö, M. Troell, B. Walker, J. Wilson, and B. Worm. 2007. Adaptive management of the Great Barrier Reef and the Grand Canyon world heritage areas. Ambio 36(7):586-592. https://doi.org/10.1579/0044-7447(2007)36[586:AMOTGB]2.0.CO;2

Hülssiep, M., T. Thaler, and S. Fuchs. 2021. The influence of humanitarian assistance on post-disaster social vulnerabilities: early reflection on the Nepal earthquake 2015. Disasters 45 (3):577-603. https://doi.org/10.1111/disa.12437

International Centre for Integrated Mountain Development (ICIMOD). 2017. Annual report 2017. International Centre for Integrated Mountain Development, Kathmandu, Nepal. file:///C:/Users/lesli/Downloads/icimodAnnualReport2017%20(1).pdf

Jha, P. Battle for a new republic: a contemporary history of Nepal. Oxford University Press, Oxford, UK.

Jones, E. C., and A. J. Faas. 2016. Social network analysis of disaster response, recovery, and adaptation. Butterworth-Heinemann, Oxford, UK.

Jones, E. C., and A. D. Murphy. 2009. The political economy of hazards and disasters. Altamira, Lanham, Maryland, USA.

Jones, S., K. J. Oven, and B. Wisner. 2015. A comparison of the governance landscape of earthquake risk reduction in Nepal and the Indian State of Bihar. International Journal of Disaster Risk Reduction 15:29-42. https://doi.org/10.1016/j.ijdrr.2015.10.011

Jordan, E., and A. Javernick-Will. 2013. Indicators of community recovery: content analysis and Delphi approach. Natural Hazards Review 14(1):21-28. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000087

Kates, R. W., C. E. Colten, S. Laska, and S. P. Leatherman. 2006. Reconstruction of New Orleans after Hurricane Katrina: a research perspective. Proceedings of the National Academy of Sciences 103(40):14653-14660. https://doi.org/10.1073/pnas.0605726103

Khattri, M. B. 2021. Differential vulnerability and resilience of earthquake: a case of displaced Tamangs of Tiru and Gogane villages of Central Nepal. Progress in Disaster Science 12:100205. https://doi.org/10.1016/j.pdisas.2021.100205

Kotani, H., R. Honda, S. Imato, L. Shakya, and B. K. Shrestha. 2020. Transition of post disaster housing of rural households: a case study of the 2015 Gorkha earthquake in Nepal. International Journal on Disaster Risk Reduction 44:101443. https://doi.org/10.1016/j.ijdrr.2019.101443

Lansing, J. S., S. A. Cheong, L. Y. Chew, M. P. Cox, M. R. Ho, and W. A. Arthawiguna. 2014. Report: regime shift in Balinese subaks. Current Anthropology 55(2):232-239. https://doi.org/10.1086/675429

Le Billon, P., M. Suji, J. Baniya, B. Limbu, D. Paudel, K. Rankin, N. Rawal, and S. Shneiderman. 2020. Disaster financialization: earthquakes, cashflows and shifting household economies in Nepal. Development and Change 51(4):939-969. https://doi.org/10.1111/dech.12603

Leppold, C., L. Gibbs, K. Block, L. Reifels, and P. Quinn. 2022. Public health implications of multiple disaster exposures. Lancet Public Health 7(3):e274-e286. https://doi.org/10.1016/S2468-2667(21)00255-3

Liu, J., T. Dietz, S. R. Carpenter, M. Alberti, C. Folke, E. Moran, A. N. Pell, P. Deadman, T. Kratz, J. Lubchenco, E. Ostrom, Z. Ouyang, W. Provencher, C. L. Redman, S. H. Schneider, and W. Taylor. 2007. Complexity of coupled human and natural systems. Science 317(5844):1513-1516. https://doi.org/10.1126/science.1144004

López-Marrero, T., and B. Wisner. 2012. Not in the same boat: disasters and differential vulnerability in the insular Caribbean. Caribbean Studies 40(2):129-168. https://doi.org/10.1353/crb.2012.0034

Macfarlane, A. 1976. Resources and population: a study of the Gurungs of Nepal. Cambridge University Press, Cambridge, UK.

March. S. T., J. Pettigrew, M. Cameron, W. F. Fisher, and S. Hangen. 2000. Roundtable: the politics of culture and identity in contemporary Nepal. Himalayan Research Bulletin 20(1):7. https://digitalcommons.macalester.edu/cgi/viewcontent.cgi?article=1700&context=himalaya

Marino, E. K., and A. J. Faas. 2020. Is vulnerability an outdated concept? After subjects and spaces. Annals of Anthropological Practice 44(1):33-46. https://doi.org/10.1111/napa.12132

Matyas, D., and M. Pelling. 2015. Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. Disasters 39(s1):s1-s18. https://doi.org/10.1111/disa.12107

McCune, B. P., and J. B. Grace. 2002. Analysis of ecological communities. MJM Software Design, Gleneden Beach, Oregon, USA.

McCune, B., and M. J. Mefford. 2016. PC-ORD: multivariate analysis of ecological data. Version 7. MjM Software Design, Gleneden Beach, Oregon, USA. https://static1.squarespace.com/static/58f588c93e00be17785ced5d/t/5bcccc404785d3d9aac3e266-/1540148334020/PBooklet7.pdf

Mercer, J., I. Kelman, L. Taranis, and S. Suchet-Pearson. 2010. Framework for integrating Indigenous and scientific knowledge for disaster risk reduction. Disasters 34(1):214-239. https://doi.org/10.1111/j.1467-7717.2009.01126.x

Merrey, D. J., A. Hussain, D. D. Tamang, B. Thapa, and A. Prakash. 2018. Evolving high altitude livelihoods and climate change: a study from Rasuwa District, Nepal. Food Security 10 (4):1055-1071. https://doi.org/10.1007/s12571-018-0827-y

Mishra, K., O. Kondratjeva, and G. E. Shively. 2022. Do remittances reshape household expenditures? Evidence from Nepal. World Development 157:105926. https://doi.org/10.1016/j.worlddev.2022.105926

Moolenaar, E. N. 2022. "Not all crises are created equal": online narratives about COVID-19 and induced earthquakes in the province of Groningen, The Netherlands. Journal of Political Ecology 29(1):587-603. https://doi.org/10.2458/jpe.5121

Mortreux, C., and J. Barnett. 2017. Adaptive capacity: exploring the research frontier. Wiley Interdisciplinary Reviews: Climate Change 8(4):e467. https://doi.org/10.1002/wcc.467

National Planning Commission. 2015. Nepal earthquake 2015: post disaster needs assessment. Vol. A: key finding. Government of Nepal, Singha Durbar, Kathmandu, Nepal. https://reliefweb.int/report/nepal/nepal-earthquake-2015-post-disaster-needs-assessment-vol-key-findings

Nelson, P. R., B. McCune, C. Roland, and S. Stehn. 2015. Non-parametric methods reveal non-linear functional trait variation of lichens along environmental and fire age gradients. Journal of Vegetation Science 26(5):848-865. https://doi.org/10.1111/jvs.12286

Norris, F. H., S. P. Stevens, B. Pfefferbaum, K. F. Wyche, and R. L. Pfefferbaum. 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. American Journal of Community Psychology 41 (1-2):127-150. https://doi.org/10.1007/s10464-007-9156-6

Ntontis, E., J. Drury, R. Amlôt, G. J. Rubin, and R. Williams. 2020. Endurance or decline of emergent groups following a flood disaster: implications for community resilience. International Journal of Disaster Risk Reduction 45:101493. https://doi.org/10.1016/j.ijdrr.2020.101493

Oksanen, J. 2015. Multivariate analysis of ecological communities in R: vegan tutorial. R Foundation for Statistical Computing, Vienna, Austria. https://www.mooreecology.com/uploads/2/4/2/1/24213970/vegantutor.pdf

Oliver-Smith, A. 1986. The martyred city: death and rebirth in the Andes. University of New Mexico Press, Albuquerque, New Mexico, USA.

Oliver-Smith, A. 2002. Theorizing disasters: nature, power, and culture. Pages 23-47 in S. M. Hoffman and A. Oliver-Smith, editors. Catastrophe and culture: the anthropology of disaster. School of American Research Press, Santa Fe, New Mexico, USA. https://anthonyoliver-smith.net/images/downloads/catastropheandculture-theorizingdisasters.pdf

Oliver-Smith, A. 2012. Peru's five-hundred-year earthquake: vulnerability in historical context. Pages 74-88 in A. Oliver-Smith and S. M. Hoffman, editors. The angry Earth: disaster in anthropological perspective. Routledge, London, UK.

Olshansky, R. B. 2005a. How do communities recover from disaster? A review of current knowledge and an agenda for future research. Pages 1-19 in 46th annual conference of the association of collegiate schools of planning. Penn State University, State College, Pennsylvania, USA. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=8e2e80e1bc7ba1502848-04129bf1a89a517f9324

Olshansky, R. B. 2005b. San Francisco, Kobe, New Orleans: lessons for rebuilding. Social Policy 36(2):17-19.

Olshansky, R. B., L. D. Hopkins, and L. A. Johnson. 2012. Disaster and recovery: processes compressed in time. Natural Hazards Review 13(3):173-178. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000077

Panday, S., S. Rushton, J. Karki, J. Balen, and A. Barnes. 2021. The role of social capital in disaster resilience in remote communities after the 2015 Nepal earthquake. International Journal of Disaster Risk Reduction 55:102112. https://doi.org/10.1016/j.ijdrr.2021.102112

Paolisso, M., E. Douglas, A. Enrici, P. Kirshen, C. Watson, and M. Ruth. 2012. Climate change, justice, and adaptation among African American communities in the Chesapeake Bay region. Weather Climate and Society 4(1):34-47. https://doi.org/10.1175/WCAS-D-11-00039.1

Parson, N. 2016. Contested narratives: challenging the state's neoliberal authority in the aftermath of the Chilean earthquake. Pages 89-11 in G. V. Button and M. Schuller, editors. Contextualizing disaster. Berghahn Books, New York, New York, USA.

Peck, J. E. 2016. Multivariate analysis for ecologists: step-by-step. Second Edition. MjM Software Design, Glendon Beach, Oregon, USA.

Platt, S., and B. D. Drinkwater. 2016. Post-earthquake decision making in Turkey: studies of Van and Izmir. International Journal of Disaster Risk Reduction 17:220-237. https://doi.org/10.1016/j.ijdrr.2016.03.010

Quarantelli, E. L., 1999. The disaster recovery process: what we know and do not know from research. Disaster Research Center, University of Delaware, Newark, Delaware, USA. https://udspace.udel.edu/items/e5ed9d08-33fe-47b4-a1de-7a1e86ed2824/full

Rasul, G. S., B. Mishra, and B. N. Neupane. 2015. Strategic framework for resilient livelihoods in earthquake affected areas of Nepal. International Centre for Integrated Mountain Development, Kathmandu, Nepal. https://doi.org/10.53055/ICIMOD.611

Raut, N. K. 2021. An assessment of livelihood recovery status of earthquake-affected households in Nepal: a study of coping strategies and their effectiveness. Progress in Disaster Science 9:100147. https://doi.org/10.1016/j.pdisas.2021.100147

Rautela, P. 2015. Traditional practices of the people of Uttarakhand Himalaya in India and relevance of these in disaster risk reduction in present times. International Journal of Disaster Risk Reduction 13:281-290. https://doi.org/10.1016/j.ijdrr.2015.07.004

Regmi, M. C. 1978. Land tenure and taxation in Nepal. Ratna Pustak Bhandar, Kathmandu, Nepal.

Regmi, M. P. 1990. The Gurungs: thunder of Himal. A cross-cultural study of a Nepalese ethnic group. Nirala Publications, New Delhi, India.

Reyes-García, V., A. C. Luz, M. Gueze, J. Paneque-Gálvez, M. J. Marcía, M. Orta-Martínez, and J. Pino. 2013. Secular trends on traditional ecological knowledge: an analysis of changes in different domains of knowledge among Tsimane' men. Learning and Individual Differences 27:206-212. https://doi.org/10.1016/j.lindif.2013.01.011

Rigg, J., K. J. Oven, G. K. Basyal, and R. Lamichhane. 2016. Between a rock and a hard place: vulnerability and precarity in rural Nepal. Geoforum 76:63-74. https://doi.org/10.1016/j.geoforum.2016.08.014

Rusack, E. M., J. Dortch, K. Hayward, M. Renton, M. Boer, and P. Grierson. 2011. The role of habitus in the maintenance of traditional Noongar plant knowledge in southwest western Australia. Human Ecology 39(5):673-682. https://doi.org/10.1007/s10745-011-9420-0

Sanstha, J. V., and Global Water Partnership Nepal. 2017. Impact of earthquake on water resources in selected earthquake hit areas: adaptation practices and planning in Namobuddha municipality, Kavre-Palanchowk district. Nepal Water Partnership, Baluwatar, Kathmandu, Nepal. https://jvs-nwp.org.np/wp-content/uploads/2018/07/Impact-of-earthquake-on-water-resources2.pdf

Schuller, M. 2012. Killing with kindness: Haiti, international aid, and NGOs. Rutgers University Press, New Brunswick, New Jersy, USA.

Schuller, M. 2016. Humanitarian aftershocks in Haiti. Rutgers University Press, New Brunswick, New Jersy, USA.

Schuller, M., and P. Morales. 2012. Tectonic shifts: Haiti since the earthquake. Kumarian, Boulder, Colorado, USA.

Scientific Software Development GmbH. 2019. ATLAS.ti 8.4.4 (build 1135) for Mac OS. Berlin, Germany.

Seara, T., P. M. Clay, and L. L. Colburn. 2016. Perceived adaptive capacity and natural disasters: a fisheries case study. Global Environmental Change 38:49-57. https://doi.org/10.1016/j.gloenvcha.2016.01.006

Shrestha, A. B., S. R. Bajracharya, J. S. Kargel, and N. R. Khanal. 2016. The impact of Nepal's 2015 Gorkha earthquake-induced geohazards. International Centre for Integrated Mountain Development, Kathmandu, Nepal. http://www.flagship2.nrrc.org.np/sites/default/files/knowledge/The%20Impact%20of%20Nepal%202015%20Earthquake-Induced%20Geohazards%20-%20ICIMOD%20-%202016.pdf

Siders, A. R. 2019. Adaptive capacity to climate change: a synthesis of concepts, methods, and findings in a fragmented field. Wiley Interdisciplinary Reviews: Climate Change 10(3):e573. https://doi.org/10.1002/wcc.573

Smit, B., and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16(3):282-292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Smith, G. P., and D. Wenger. 2007. Sustainable disaster recovery: operationalizing an existing agenda. Pages 234-257 in H. Rodríguez, E. L. Quarantelli, and R. R. Dynes, editors. Handbook of disaster research. Springer, New York, New York, USA.

Spoon, J., D. Gerkey, R. B. Chhetri, A. Rai, and U. Basnet. 2020a. Navigating multidimensional household recoveries following the 2015 Nepal earthquakes. World Development 135:105041. https://doi.org/10.1016/j.worlddev.2020.105041

Spoon, J., C. E. Hunter, D. Gerkey, R. B. Chhetri, A. Rai, U. Basnet, and A. Dewan. 2020b. Anatomy of disaster recoveries: tangible and intangible short-term household and settlement recovery dynamics following the 2015 Nepal earthquakes. International Journal of Disaster Risk Reduction 51:101879. https://doi.org/10.1016/j.ijdrr.2020.101879

Spoon, J., D. Gerkey, R. B. Chhetri, A. Rai, U. Basnet, and C. E. Hunter. 2021. Understanding short-term household recoveries from the 2015 Nepal earthquakes: lessons learned and

recommendations. Progress in Disaster Science 10:100169. https://doi.org/10.1016/j.pdisas.2021.100169

Tachibana, T., R. Goto, T. Sakurai, S. Rayamajhi, A. Adhikari, and W. H. Dow. 2019. Do remittances alleviate negative impacts of disaster on mental health? A case of the 2015 Nepal earthquake. Social Science and Medicine 238:112460. https://doi.org/10.1016/j.socscimed.2019.112460

Tamang, M. S. 2020. Community resilience capacity: a study on Nepal's 2015 earthquakes and aftermath. Central Department of Anthropology and USAID, Kirtipur, Kathmandu, Nepal. http://anthropologytu.edu.np/wp-content/uploads/2020/12/Community-Resilience-Capacity-Report-for-Web.pdf

Tamang, P., and J. Tamang. 1994. Kamaladi. Kathmandu: Nepal Royal Academy.

Tierney, K. 2012. Disaster governance: social, political, and economic dimensions. Annual Review of Environment and Resources 37:341-363. https://doi.org/10.1146/annurev-environ-020911-095618

Tyler, S. R. 2006. Communities, livelihoods and natural resources: action research and policy change in Asia. Practical Action Publishing, Rudby, UK.

United Nations. 2022. Least developed country category: Nepal profile. Department of Economic and Social Affairs, United Nations, New York, New York, USA.

Vallance, S., and S. Carlton. 2015. First to respond, last to leave: communities' roles and resilience across the '4Rs'. International Journal of Disaster Risk Reduction 14(Part 1):27-36. https://doi.org/10.1016/j.ijdrr.2014.10.010

Walker, B., L. Gunderson, A. Kinzig, C. Folke, S. Carpenter, and L. Schultz. 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. Ecology and Society 11(1):13. https://www.ecologyandsociety.org/vol11/iss1/art13/

Welsh, M. 2014. Resilience and responsibility: governing uncertainty in a complex world. Geographical Journal 180 (1):15-26. https://doi.org/10.1111/geoj.12012

Whelpton, J. 2005. A history of Nepal. Cambridge University Press, Cambridge, UK.

Willey, S. C. 2015. Gendered impacts of the earthquake and responses in Nepal. Feminist Studies 41(3):682-688. https://doi.org/10.1353/fem.2015.0028

Yang, W., T. Dietz, D. B. Kramer, Z. Ouyang, and J. Liu. 2015. An integrated approach to understanding the linkages between ecosystem services and human well-being. Ecosystem Health and Sustainability 1(5):1-12. https://doi.org/10.1890/EHS15-0001.1

Yorque, R., C. S. Holling, B. Walker, L. H. Gunderson, C. Folke, S. R. Carpenter, and W. Brock. 2002. Toward an integrative synthesis. Pages 419-438 in L. H. Gunderson and C. S. Holling, editors. Panarchy: understanding transformations in human and natural systems. Island, Washington, D.C., USA.

Zhang, Q. 2016. Disaster response and recovery: aid and social change. Annals of Anthropological Practice 40(1):86-97. https://doi.org/10.1111/napa.12090

Zimmermann, M., and M. Keiler. 2015. International frameworks for disaster risk reduction: useful guidance for sustainable mountain development? Mountain Research and Development 35(2):195-202. https://doi.org/10.1659/MRD-JOURNAL-D-15-00006.1

Zurick, D., J. D. Pacheco, B. Shrestha, and B. Bajracharya. 2006. Illustrated atlas of the Himalaya. University Press of Kentucky, Lexington, Kentucky, USA.

Appendix 1.

Full Results of Pattern Association: Linear Vector Fitting and Non-Linear Surface Fitting

A1.1: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and each recovery indicator. 9 months and 1.5 years are combined for each variable. Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (XR^2). Results with R^2>.050 in bold.

Recovery Indicator Variables **9 months (n=400): 34 variables** **1.5 years (n=397): 34 variables** Questions are Yes/No unless otherwise noted	**Linear**		**Linear**		**Non-Linear**	**Non-Linear**
	Axis 1		**Axis 2**			
	r (P1&P2)	R^2 (P1&P2)	r (P1&P2)	R^2 (P1&P2)	XR^2 (P1&P2)	R^2 (P1&P2)
1. Household having issues trying to rebuild	-.133	.018	**.368**	**.136**	**.183**	**.200**
2. Household able to return to primary house	.063	.004	**.380**	**.144**	.145	.160
3. Household has access to cell phone	.010	.000	.038	.001	.020	.041
4. Household has access to internet	.175	.030	.127	.016	**.062**	**.079**
5. Household has access to electricity	.059	.004	.087	.007	.031	.049
6. No earthquake and connected hazard impacts to *bari* (non-irrigated fields)	**.673**	**.453**	-.048	.002	**.485**	**.493**
7. Some earthquake and connected hazard impacts to *bari* (non-irrigated fields)	-.088	.008	.220	.049	**.062**	**.081**
8. High earthquake and connected hazard impacts to *bari* non-irrigated fields)	**-.613**	**.376**	-.113	.013	**.413**	**.425**
9. No earthquake and connected hazard impacts to *khet* irrigated fields)	-.037	.001	.058	.003	**.061**	**.086**
10. Some earthquake and connected hazard impacts to *khet* (irrigated fields)	.000	.000	.043	.002	**.003**	**.021**
11. High earthquake and connected hazard impacts to *khet* (irrigated fields)	.041	.002	-.090	.008	**.045**	**.069**
12. Earthquakes and connected hazards killed standing crops	**-.551**	**.303**	-.099	.010	**.338**	**.351**
13. Earthquakes and connected hazards affected seed storage	**-.288**	**.083**	**-.274**	**.075**	**.152**	**.169**
14. No earthquake and connected hazard impacts to livestock health, behavior, or productivity (primary impact)	**.433**	**.188**	**-.557**	**.311**	**.563**	**.571**
15. No earthquake and connected hazard impacts to livestock health, behavior, or productivity (secondary impact)	**.282**	**.080**	**-.323**	**.104**	**.204**	**.235**
16. Earthquake and connected hazard impacts to livestock health (primary impact)	**-.330**	**.109**	**.495**	**.245**	**.404**	**.417**
17. Earthquake and connected hazard impacts to livestock behavior (primary impact)	-.201	.040	.161	.026	**.112**	**.138**
18. Earthquake and connected hazard impacts to livestock behavior (secondary impact)	-.185	.034	**-.140**	**.288**	**.186**	**.219**
19. Earthquake and connected hazard impacts to livestock productivity (primary impact)	-.090	.008	**-.079**	**.093**	.013	.039
20. Earthquake and connected hazard impacts to livestock productivity (secondary impact)	-.209	.044	**-.137**	**.157**	.063	.098
21. Total household lost/recovered bovine (yak, cow, hybrid) - log	**-.393**	**.155**	**-.351**	**.123**	**.325**	**.343**
22. Total household lost/recovered sheep, goats, and pigs - log	**-.486**	**.237**	**-.364**	**.132**	**.412**	**.430**

23. Total household lost/recovered chickens - log	**-.275**	**.076**	**-.527**	**.278**	**.401**	**.416**
24. No earthquake and connected hazard impacts on household ability to keep livestock	**.685**	**.469**	-.214	.046	**.585**	**.592**
25. Some earthquake and connected hazard impacts on household ability to keep livestock	.063	.004	.161	.026	**.091**	**.110**
26. High earthquake and connected hazard impacts on household ability to keep livestock	**-.724**	**.524**	.103	.011	**.623**	**.630**
27. No earthquake and connected hazard impacts on household ability to sell livestock products	**.505**	**.255**	.075	.006	**.326**	**.347**
28. Some earthquake and connected hazard impacts on household ability to sell livestock products	-.148	.022	.062	.004	**.033**	**.065**
29. High earthquake and connected hazard impacts on household ability to sell livestock products	**-.495**	**.245**	-.134	.018	**.334**	**.357**
30. No earthquake and connected hazard impacts on household ability to go for outside work	**.244**	**.060**	-.026	.001	.064	.091
31. Some earthquake and connected hazard impacts on household ability to go for outside work	-.146	.021	.028	.001	.012	.022
32. High earthquake and connected hazard impacts on household ability to go for outside work	-.188	.035	.009	.000	**.042**	**.075**
33. No earthquake and connected hazard impacts on household ability to work with tourists	.083	.007	.003	.000	.011	.029
34. High earthquake and connected hazard impacts on household ability to work with tourists	-.075	.006	.026	.001	.021	.043

A1.2: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and demographic variables (35 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.05

Demographic Variables **9 months (n=400): 34 variables** **1.5 years (n=397): 2 variables** Questions are Yes/No unless otherwise noted	**Linear** **Axis 1**		**Linear** **Axis 2**		**Non-Linear** **Axis 1 & 2**	**Non-Linear** **Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
1. Aaru Chanaute (VDC 1)	**.400**	**.160**	.037	.001	.182	.195
2. Kashigaun (VDC 2)	-.120	.014	**.228**	**.052**	.073	.090
3. Gatlang (VDC 3)	-.009	.000	.087	.008	.015	.026
4. Haku (VDC 4)	**-.267**	**.071**	**-.351**	**.123**	**.211**	**.225**
5. Internal Displacement Camp (9 months)	**-.242**	**.059**	**-.418**	**.174**	**.288**	**.302**
6. Internal Displacement Camp (1.5 years)	**-.245**	**.060**	**-.413**	**.171**	**.296**	**.309**
7. Accessibility	.096	.009	.193	.037	**.072**	**.087**
8. Male head of household	-.030	.001	.104	.011	.009	.032
9. Female head of household	.030	.001	-.104	.011	.009	.032
10. Age of head of household - log	.053	.003	.079	.006	.010	.030
11. Single Family	-.016	.000	-.077	.006	.003	.017
12. Joint Family	.016	.000	.077	.006	.003	.017
13. Own home (9 months)	.029	.001	.042	.002	.003	.000
14. Own home (1.5 years)	.171	.029	**.421**	**.177**	**.236**	**.250**
15. Household size	-.072	.005	.137	.019	.021	.032
16. Literate	.144	.021	.065	.004	.018	.037
17. Education: none	-.116	.013	-.053	.003	.012	.025
18. Education: informal (read and write)	.007	.000	.039	.002	-.003	.000
19. Education: class 4 or less	.020	.000	-.015	.000	-.003	.000
20. Education: class 5 to 10	.100	.010	.012	.000	.010	.024
21. Education: intermediate	.045	.002	.062	.004	-.001	.005
22. Education: bachelor's degree	.066	.004	-.005	.000	-.001	.004
23. Hindu	**.296**	**.088**	.072	.005	.100	.116
24. Buddhist	**-.279**	**.078**	-.098	.010	.072	.088
25. Christian	.023	.001	.053	.003	.002	.012
26. Other Religion	.076	.006	-.021	.000	.001	.007
27. Brahmin/Chhetri	.190	.036	.108	.012	**.056**	**.073**

28.	Gurung	-.094	.009	.120	.014	.025	.044
29.	Ghale	-.021	.000	.114	.013	.005	.019
30.	Newar	**.234**	**.055**	.009	.000	.063	.079
31.	Tamang	**-.229**	**.052**	-.211	.044	**.111**	.**127**
32.	Other ethnic group	.181	.033	-.006	.000	.023	.032
33.	Household took loan from family after earthquake	-.170	.029	.003	.000	.024	.036
34.	Household took loan from friends after earthquake	-.077	.006	.121	.015	.014	.032
35.	Household took loan from bank after earthquake	.061	.004	.004	.000	.003	.012
36.	Household took microcredit loan after earthquake	.163	.027	.084	.007	.030	.047

A1.3: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and hazard exposure variables (12 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.050 in bold.

Hazard Exposure Variables **9 months (n=400): 10 variables** **1.5 years (n=397): 12 variables** Questions are Yes/No unless otherwise noted	**Linear**		**Linear**		**Non-Linear**	**Non-Linear**
	Axis 1		**Axis 2**		**Axis 1 & 2**	**Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
1. Distance to nearest slope failure (meters) (9 months) - log	-.087	.008	.005	.000	.013	.030
2. Landslides threaten community (9 months)	-.186	.035	.036	.001	**.040**	**.057**
3. Landslides threaten community (1.5 years)	-.211	.044	-.053	.003	**.056**	**.072**
4. Other hazards threaten community (9 months)	.063	.004	.109	.012	.006	.016
5. Other hazards threaten community (1.5 years)	.120	.014	.026	.001	.019	.034
6. Earthquakes affect access to grazing areas (none) (9 months)	**.533**	**.284**	-.016	.000	**.321**	**.332**
7. Earthquakes affect access to grazing areas (some) (9 months)	-.049	.002	.046	.002	.016	.035
8. Earthquakes affect access to grazing areas (very much) (9 months)	**-.497**	**.247**	-.015	.000	.273	.287
9. Earthquakes continue to affect access to grazing areas (none) (1.5 years)	**.406**	**.165**	**-.260**	**.067**	**.276**	**.289**
10. Earthquakes continue to affect access to grazing areas (some) (1.5 years)	-.109	.012	.154	.024	**.030**	**.050**
11. Earthquakes continue to affect access to grazing areas (very much) (1.5 years)	**-.328**	**.108**	.145	.021	**.155**	**.171**
12. Earthquakes hinder access to agricultural fields (9 months)	-.220	.048	-.207	.043	**.086**	**.104**
13. Earthquakes hinder access to agricultural fields (1.5 years)	-.197	.039	.019	.000	.033	.046
14. Earthquakes impact ability to collect forest products (none) (9 months)	**.278**	**.077**	-.038	.001	.078	.097
15. Earthquakes impact ability to collect forest products (some) (9 months)	-.101	.010	.151	.023	.020	.041
16. Earthquakes impact ability to collect forest products (very much) (9 months)	**-.249**	**.062**	-.089	.008	.079	.100
17. Earthquakes impact ability to collect forest products (none) (1.5 years)	**.250**	**.063**	-.221	.049	**.128**	**.143**
18. Earthquakes impact ability to collect forest products (some) (1.5 years)	-.149	.022	.130	.017	**.034**	**.054**
19. Earthquakes impact ability to collect forest products (very much) (1.5 years)	-.150	.023	.134	.018	.040	.051
20. Earthquakes impact ability to collect firewood (none) (1.5 years)	**.321**	**.103**	-.147	.022	.129	.144
21. Earthquakes impact ability to collect firewood (some) (1.5 years)	-.010	.000	.081	.007	.000	.013
22. Earthquakes impact ability to collect firewood (very much) (1.5 years)	**-.289**	**.084**	.072	.005	.097	.114

A1.4: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and institutional participation variables (12 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.050 in bold.

Institutional Participation Variables **9 months (n=400): 10 variables** **1.5 years (n=397): 12 variables** Questions are Yes/No unless otherwise noted	**Linear**		**Linear**		**Non-Linear**	**Non-Linear**
	Axis 1		**Axis 2**		**Axis 1 & 2**	**Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
1. Household members serve in government (9 months)	.100	.010	.072	.005	.017	.032
2. Household members serve in government (1.5 years)	.123	.015	.069	.005	.015	.030
3. Household members serve in local government (1.5 years)	.101	.010	.063	.004	.008	.023
4. Household members serve in district government (1.5 years)	.056	.003	-.015	.000	-.002	.003
5. Household members serve in central government (1.5 years)	.039	.002	.077	.006	-.001	.005
6. Household members serve on committees (non-government) (9 months)	.040	.002	.182	.033	.019	.038
7. Household members serve on committees (non-government) (1.5 years)	.040	.002	.149	.022	.012	.032
8. Household members participate in mother's group (9 months)	.036	.001	.006	.000	-.002	.006
9. Household members participate in mother's group (1.5 years)	.018	.000	.079	.006	-.001	.004
10. Household members participate in women's group (9 months)	.076	.006	.034	.001	.000	.006
11. Household members participate in women's group (1.5 years)	.060	.004	-.107	.011	.012	.031
12. Household members participate in credit and savings group (9 months)	.100	.010	.051	.003	.013	.032
13. Household members participate in credit and savings group (1.5 years)	.170	.029	-.058	.003	.025	.042
14. Household members participate in farmer's group (9 months)	.078	.006	.040	.002	.011	.032
15. Household members participate in farmer's group (1.5 years)	-.020	.000	.078	.006	.005	.025
16. Household members works with NGOs, INGOs, or international orgs (9 months)	.049	.002	.076	.006	.000	.009
17. Household members works with NGOs, INGOs, or international orgs (1.5 years)	.042	.002	-.033	.001	-.001	.007
18. Household members participate in community forest user group (9 months)	-.007	.000	-.030	.001	-.003	.000
19. Household members participate in community forest user group (1.5 years)	.085	.007	.054	.003	.013	.034
20. Household members on disaster or hazard preparedness committees (before earthquakes-9 months)	.028	.001	.047	.002	.000	.013
21. Household members on disaster or hazard preparedness committees (9 months)	.030	.001	.051	.003	-.002	.002
22. Household members on disaster or hazard preparedness committees (1.5 years)	.018	.000	.068	.005	.000	.016

A1.5: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and livelihood diversity (assets and practices) variables (14 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.050 in bold.

Livelihood Diversity Variables (Assets and Practices) **9 months (n=400): 13 variables** **1.5 years (n=397): 14 variables** Questions are Yes/No unless otherwise noted	**Linear**		**Linear**		**Non-Linear**	**Non-Linear**
	Axis 1		**Axis 2**		**Axis 1 & 2**	**Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
1. Household owns livestock (9 months)	**-.378**	**.143**	.017	.000	.183	.192
2. Household owns livestock (1.5 years)	-.112	.013	**.345**	**.119**	**.173**	**.185**
3. Household sells livestock products (9 months)	**-.376**	**.141**	-.083	.007	.164	.181
4. Household sells livestock products (1.5 years)	-.127	.016	.156	.024	**.039**	**.054**
5. Household total bovine (yak, cow, hybrid) (9 months) - log	**-.469**	**.220**	.039	.001	.240	.253
6. Household total bovine (yak, cow, hybrid) (1.5 years) - log	**-.238**	**.056**	**.267**	**.071**	**.155**	**.171**
7. Household total sheep, goat, pig (9 months) - log	**-.458**	**.210**	-.074	.005	.232	.249
8. Household total sheep, goat, pig (1.5 years) - log	-.214	.046	.184	.034	**.089**	**.111**
9. Household total chickens (9 months)- log	**-.289**	**.084**	-.219	.048	**.164**	**.180**
10. Household total chickens (1.5 years)- log	.037	.001	.189	.036	.033	.048
11. Household owns agricultural fields (9 months)	**-.311**	**.097**	.030	.001	.118	.128
12. Household owns agricultural fields (1.5 years)	-.133	.018	.081	.007	**.037**	**.070**
13. Household has non-irrigated fields (bari) (9 months)	**-.353**	**.125**	.037	.001	.140	.151
14. Household has non-irrigated fields (bari) (1.5 years)	-.206	.042	.080	.006	.060	.076
15. Number of ropani of non-irrigated fields (bari) (9 months) - log	**-.291**	**.085**	-.147	.022	**.126**	**.141**
16. Number of ropani of non-irrigated fields (bari) (1.5 years) - log	**-.271**	**.074**	-.050	.002	.082	.099
17. Household has irrigated fields (khet) (9 months)	.094	.009	-.008	.000	**.038**	**.058**
18. Household has irrigated fields (khet) (1.5 years)	.211	.044	.059	.003	**.075**	**.093**
19. Number of ropani of irrigated fields (khet) (9 months) - log	.057	.003	-.061	.004	**.042**	**.058**
20. Number of ropani of irrigated fields (khet) (1.5 years) - log	**.236**	**.056**	.062	.004	.082	.101
21. Household sells agricultural products (9 months)	-.221	.049	-.125	.016	**.061**	**.079**
22. Household sells agricultural products (1.5 years)	-.042	.002	.133	.018	.016	.034
23. Household collects forest products (9 months)	**-.286**	**.082**	.083	.007	.092	.108
24. Household collects forest products (1.5 years)	-.198	.039	**.319**	**.102**	**.174**	**.188**
25. Household hunts for food and other uses (1.5 years)	-.141	.020	.066	.004	.014	.029
26. Household participates in work exchange for agriculture (9 months)	**-.254**	**.065**	-.039	.002	.067	.083
27. Household participates in work exchange for agriculture (1.5 years)	-.074	.005	**.229**	**.053**	.078	.094

A1.6: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and livelihood diversity (portfolio) variables (59 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.050 in bold.

Livelihood Diversity Variables (Portfolio) **9 months (n=400): 59 variables** **1.5 years (n=397): 57 variables** **Questions are Yes/No unless otherwise noted**	**Linear** **Axis 1**		**Linear** **Axis 2**		**Non-Linear** **Axis 1 & 2**	**Non-Linear** **Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
1. Household primary livelihood agriculture (none) (9 months)	**.276**	**.076**	-.062	.004	.082	.096
2. Household primary livelihood agriculture (none) (1.5 years)	.030	.001	**-.291**	**.085**	.115	.130
3. Household primary livelihood agriculture (9 months)	-.114	.013	.105	.011	.020	.031
4. Household primary livelihood agriculture (1.5 years)	-.060	.004	.193	.037	**.063**	**.080**
5. Household secondary livelihood agriculture (9 months)	-.096	.013	.105	.011	.003	.012
6. Household secondary livelihood agriculture (1.5 years)	.027	.001	.055	.003	-.002	.002
7. Household tertiary livelihood agriculture (9 months)	-.014	.000	-.054	.003	.003	.001
8. Household tertiary livelihood agriculture (1.5 years)	.053	.003	-.002	.000	-.002	.001
9. Household primary livelihood horticulture (none) (9 months)	.001	.000	-.061	.004	-.002	.005
10. Household primary livelihood horticulture (none) (1.5 years)	.006	.000	-.060	.004	-.003	.000
11. Household primary livelihood horticulture (9 months)	.014	.000	.035	.001	.003	.000
12. Household secondary livelihood horticulture (9 months)	-.015	.000	.051	.003	-.003	.000
13. Household secondary livelihood horticulture (1.5 years)	-.020	.000	.056	.003	-.003	.000
14. Household tertiary livelihood horticulture (1.5 years)	.047	.002	.023	.001	-.002	.002
15. Household primary livelihood herding (none) (9 months)	**.394**	**.155**	-.076	.006	.181	.192
16. Household primary livelihood herding (none) (1.5 years)	.130	.017	**-.326**	**.106**	**.156**	**.169**
17. Household primary livelihood herding (9 months)	-.134	.018	.054	.003	.018	.042
18. Household primary livelihood herding (1.5 years)	-.116	.013	.074	.006	**.042**	**.063**
19. Household secondary livelihood herding (9 months)	-.204	.042	.100	.010	**.053**	**.072**
20. Household secondary livelihood herding (1.5 years)	-.082	.007	.184	.034	**.063**	**.081**
21. Household tertiary livelihood herding (9 months)	-.109	.012	-.081	.007	.008	.017
22. Household tertiary livelihood herding (1.5 years)	.002	.000	.124	.015	.008	.025
23. Household primary livelihood traditional crafts (none) (9 months)	-.046	.002	.006	.000	-.002	.002
24. Household primary livelihood traditional crafts (none) (1.5 years)	-.063	.004	.007	.000	-.001	.003
25. Household primary livelihood traditional crafts (9 months)	.066	.004	-.010	.000	-.001	.003
26. Household primary livelihood traditional crafts (1.5 years)	.069	.005	-.001	.000	-.001	.006
27. Household secondary livelihood traditional crafts (9 months)	-.001	.000	-.008	.000	-.001	.008
28. Household secondary livelihood traditional crafts (1.5 years)	.020	.000	-.009	.000	-.002	.006
29. Household tertiary livelihood traditional crafts (9 months)	.007	.000	.005	.000	-.003	.000
30. Household primary livelihood agricultural wage labor (none) (9 months)	-.017	.000	.045	.002	.003	.021

31. Household primary livelihood agricultural wage labor (none) (1.5 years)	.110	.012	-.043	.002	.009	.028
32. Household primary livelihood agricultural wage labor (1.5 years)	-.093	.009	-.093	.009	.020	.042
33. Household secondary livelihood agricultural wage labor (9 months)	.031	.001	-.074	.006	.005	.020
34. Household secondary livelihood agricultural wage labor (1.5 years)	.030	.001	-.024	.001	-.003	.000
35. Household tertiary livelihood agricultural wage labor (9 months)	-.015	.000	.027	.001	-.003	.000
36. Household tertiary livelihood agricultural wage labor 1.5 years)	-.083	.007	.114	.013	.018	.037
37. Household primary livelihood local wage labor (none) (9 months)	.001	.000	.087	.008	.001	.012
38. Household primary livelihood local wage labor (none) (1.5 years)	.114	.013	.022	.000	.005	.013
39. Household primary livelihood local wage labor (9 months)	-.015	.000	-.142	.020	.016	.032
40. Household primary livelihood local wage labor (1.5 years)	-.045	.002	-.106	.011	.014	.031
41. Household secondary livelihood local wage labor (9 months)	.059	.004	.016	.000	-.001	.004
42. Household secondary livelihood local wage labor (1.5 years)	-.052	.003	-.005	.000	-.002	.001
43. Household tertiary livelihood local wage labor (9 months)	-.016	.000	.031	.001	-.003	.000
44. Household tertiary livelihood local wage labor (1.5 years)	-.088	.008	.083	.007	.007	.029
45. Household primary livelihood non-local wage labor (none) (9 months)	.096	.009	-.022	.001	.004	.017
46. Household primary livelihood non-local wage labor (none) (1.5 years)	-.006	.000	.096	.009	.014	.035
47. Household primary livelihood non-local wage labor (9 months)	-.051	.003	.009	.000	.000	.015
48. Household primary livelihood non-local wage labor (1.5 years)	.008	.000	-.122	.015	.020	.041
49. Household secondary livelihood non-local wage labor (9 months)	-.005	.000	-.025	.001	-.003	.000
50. Household secondary livelihood non-local wage labor (1.5 years)	-.005	.000	-.025	.001	-.002	.011
51. Household tertiary livelihood non-local wage labor (9 months)	.001	.000	.046	.002	.007	.020
52. Household tertiary livelihood non-local wage labor (1.5 years)	.001	.000	.046	.002	.000	.021
53. Household primary livelihood hotel/lodge business (none) (9 months)	-.080	.006	-.018	.000	.001	.008
54. Household primary livelihood hotel/lodge business (none) (1.5 years)	-.117	.014	-.045	.002	.007	.016
55. Household primary livelihood hotel/lodge business (9 months)	.087	.008	.021	.000	.002	.009
56. Household primary livelihood hotel/lodge business (1.5 years)	.092	.009	.047	.002	.005	.013
57. Household secondary livelihood hotel/lodge business (9 months)	-.005	.000	-.004	.000	-.003	.000
58. Household tertiary livelihood hotel/lodge business (1.5 years)	.089	.008	.001	.000	-.001	.006
59. Household primary livelihood business (none) (9 months)	-.141	.020	-.064	.004	.029	.045
60. Household primary livelihood business (none) (1.5 years)	-.121	.015	-.040	.002	.011	.021
61. Household primary livelihood business (9 months)	.197	.039	-.013	.000	**.042**	**.053**
62. Household primary livelihood business (1.5 years)	.149	.022	-.055	.003	.020	.031
63. Household secondary livelihood business (9 months)	.081	.007	.001	.000	.000	.006
64. Household secondary livelihood business (1.5 years)	.065	.004	-.041	.002	.000	.036
65. Household tertiary livelihood business (9 months)	-.042	.002	.110	.012	.023	.045
66. Household tertiary livelihood business (1.5 years)	-.015	.000	.144	.021	.007	.018
67. Household primary livelihood service (government) (none) (9 months)	-.091	.008	.000	.000	.001	.016
68. Household primary livelihood service (government) (none) (1.5 years)	-.155	.024	-.087	.008	.021	.032
69. Household primary livelihood service (government) (9 months)	.042	.002	-.013	.000	-.003	.000

70. Household primary livelihood service (government) (1.5 years)	.118	.014	.044	.002	.011	.024
71. Household secondary livelihood service (government) (9 months)	.048	.002	-.015	.000	-.003	.000
72. Household secondary livelihood service (government) (1.5 years)	.099	.010	.007	.000	.010	.019
73. Household tertiary livelihood service (government) (9 months)	.072	.005	.029	.001	.000	.006
74. Household tertiary livelihood service (government) (1.5 years)	.059	.003	.080	.006	.002	.018
75. Household primary livelihood service (private) (none) (9 months)	-.063	.004	-.041	.002	-.001	.003
76. Household primary livelihood service (private) (none) (1.5 years)	-.037	.001	.054	.003	-.000	.007
77. Household primary livelihood service (private) (9 months)	.121	.015	-.069	.005	.013	.023
78. Household primary livelihood service (private) (1.5 years)	.069	.005	-.079	.006	.002	.010
79. Household secondary livelihood service (private) (9 months)	.080	.006	-.016	.000	.001	.008
80. Household secondary livelihood service (private) (1.5 years)	.000	.000	-.071	.005	-.002	.004
81. Household tertiary livelihood service (private) (9 months)	-.066	.004	.116	.013	.004	.014
82. Household tertiary livelihood service (private) (1.5 years)	-.027	.001	.064	.004	.010	.023
83. Household primary livelihood foreign employment (none) (9 months)	.020	.000	-.041	.002	-.003	.000
84. Household primary livelihood foreign employment (9 months)	.044	.002	-.013	.000	-.003	.000
85. Household primary livelihood foreign employment (1.5 years)	.105	.011	-.084	.007	.014	.027
86. Household secondary livelihood foreign employment (9 months)	.060	.004	-.009	.000	-.002	.003
87. Household tertiary livelihood foreign employment (9 months)	-.105	.011	.075	.006	.008	.016
88. Household tends livestock (9 months)	**-.376**	**.141**	.017	.000	.178	.188
89. Household tends livestock (1.5 years)	-.095	.009	**.336**	**.113**	**.166**	**.178**
90. Household work exchange (parma) tends livestock (9 months)	-.100	.010	-.057	.003	.006	.029
91. Household work exchange (parma) tends livestock (1.5 years)	-.050	.003	.034	.001	.004	.027
92. Household hires outside labor to tend livestock (9 months)	.056	.003	.046	.002	.000	.010
93. Household hires outside labor to tend livestock (1.5 years)	-.042	.002	-.006	.000	-.002	.003
94. Household members go outside the area for work (9 months)	-.095	.009	.058	.003	.006	.019
95. Household members go outside the area for work (1.5 years)	.012	.000	.040	.002	-.001	.007
96. Household tends to agricultural fields (9 months)	**-.311**	**.097**	.030	.001	.118	.128
97. Household tends to agricultural fields (1.5 years)	-.011	.000	**.346**	**.119**	.149	.163
98. Household work exchange (parma) tends agricultural fields (9 months)	**-.227**	**.052**	-.044	.002	.054	.071
99. Household work exchange (parma) tends agricultural fields (1.5 years)	-.064	.004	.212	.045	**.091**	**.107**
100. Household hires outside labor to tend agricultural fields (9 months)	.083	.007	.040	.002	.003	.018
101. Household hires outside labor to tend agricultural fields (1.5 years)	.003	.000	.132	.017	.014	.032
102. Household does not hire agricultural labor (1.5 years)	.022	.000	**-.268**	**.072**	**.100**	**.115**
103. Household does not own shop or workshop (9 months)	-.128	.016	-.072	.005	.018	.034
104. Household does not own shop or workshop (1.5 years)	-.150	.023	-.045	.002	.020	.035
105. Household owns shop or workshop (9 months)	.091	.008	-.005	.000	.003	.011
106. Household owns shop or workshop (1.5 years)	.070	.005	-.106	.011	.007	.020
107. Household rents shop or workshop (9 months)	.107	.011	.075	.006	.011	.028
108. Household rents shop or workshop (1.5 years)	.130	.017	.095	.009	.024	.037

109. Household does not own a tourist lodge or homestay (9 months)	-.061	.004	-.027	.001	-.001	.009
110. Household does not own a tourist lodge or homestay (1.5 years)	-.080	.006	-.042	.002	.001	.009
111. Household rents a tourist lodge or homestay (9 months)	.061	.004	.027	.001	-.001	.009
112. Household rents a tourist lodge or homestay (1.5 years)	.080	.006	.042	.002	.002	.020
113. Household does not own a tea shop (9 months)	.008	.000	-.037	.001	-.001	.023
114. Household does not own a tea shop (1.5 years)	.031	.001	-.038	.001	-.001	.005
115. Household rents a tea shop (9 months)	-.008	.000	.037	.001	-.001	.023
116. Household rents a tea shop (1.5 years)	-.031	.001	.038	.001	-.001	.005

A1.7: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and connectivity (origin of recovery help, flow of outside ideas, disaster preparedness) variables (16 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.050 in bold.

Connectivity Variables **9 months (n=400): 16 variables** **1.5 years (n=397): 16 variables** Questions are Yes/No unless otherwise noted	**Linear** **Axis 1**		**Linear** **Axis 2**		**Non-Linear** **Axis 1 & 2**	**Non-Linear** **Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
Origin of Recovery Help						
1. Help from family and friends (9 months)	-.037	.001	.164	.027	.016	.034
2. Help from family and friends (1.5 years)	.024	.001	.135	.018	.015	.032
3. Help from the government (9 months)	-.028	.001	-.081	.007	.004	.022
4. Help from the government (1.5 years)	-.122	.015	.184	.034	.052	.069
5. Help from community organizations (9 months)	.069	.005	.042	.002	.000	.007
6. Help from community organizations (1.5 years)	.110	.012	.047	.002	.006	.012
7. Help from non-governmental organizations (NGOs) (9 months)	.043	.002	.021	.000	.009	.028
8. Help from non-governmental organizations (NGOs) (1.5 years)	-.091	.008	-.082	.007	.026	.047
9. Help from international non-governmental organizations (INGOs) (9 months)	.106	.011	-.148	.022	.035	.047
10. Help from international non-governmental organizations (INGOs) (1.5 years)	-.038	.001	.055	.003	.016	.035
11. Help from international agencies (9 months)	-.014	.000	.059	.004	.002	.022
12. Help from international agencies (1.5 years)	.034	.001	.039	.002	-.003	.000
13. Help from family abroad (9 months)	.077	.006	-.028	.001	.001	.009
14. Help from family abroad (1.5 years)	.079	.006	.003	.000	.003	.009
15. Help from international friends (9 months)	-.007	.000	-.060	.004	.003	.018
16. Help from international friends (1.5 years)	-.125	.016	-.048	.002	.007	.046
Flows of Outside Ideas						
17. Community using news ideas from other communities in recovery (9 months)	.043	.002	.012	.000	-.002	.002
18. Community using news ideas from other communities in recovery (1.5 years)	-.016	.000	.042	.002	-.002	.006
19. Community using new ideas from government in recovery (9 months)	.068	.005	.078	.006	.008	.025
20. Community using new ideas from government in recovery (1.5 years)	-.051	.003	.217	.047	.035	.047
21. Community using new ideas from NGOs/INGOs in recovery (9 months)	.097	.010	.049	.002	.008	.022
22. Community using new ideas from NGOs/INGOs in recovery (1.5 years)	.030	.001	.169	.029	.023	.040
23. Community using new ideas from local NGOs in recovery (9 months)	.104	.011	.041	.002	.009	.022
24. Community using new ideas from tourists/international friends in recovery (1.5 years)	-.084	.007	.101	.010	**.025**	**.104**
25. Community using new ideas from other sources in recovery (9 months)	.046	.002	-.051	.003	.001	.008
26. Community using new ideas from other sources in recovery (1.5 years)	-.033	.001	-.078	.006	.001	.011

Disaster Preparedness						
27. Before earthquakes household participated in disaster preparedness activities (9 months)	.008	.000	.093	.009	.004	.022
28. Before earthquakes children participated in disaster preparedness at school (1.5 years)	.018	.000	.051	.003	-.003	.000
29. Household member talked informally with others about disaster preparedness (9 months)	.075	.006	.080	.006	.010	.030
30. Household member talked informally with others about disaster preparedness (1.5 years)	-.094	.009	.138	.019	.020	.040
31. Household members were talked to about disaster preparedness (9 months)	.058	.003	.058	.003	.001	.009
32. Household members were talked to about disaster preparedness (1.5 years)	-.113	.013	.155	.024	.027	.039

A1.8: Linear and non-linear associations between NMDS dimensions of recovery (Recovery or Axis 1, Displacement or Axis 2) and social memory (experience with previous hazards, local knowledge)variables (27 total). Linear associations are represented by a correlation coefficient (r) and R square (R^2) for each axis, with bold indicating R^2>.050. Non-linear associations combine Axis 1 and Axis 2 and include both R square (R^2) and cross-validated R square (xR^2). Results with R^2>.050 in bold.

Social Memory Variables **9 months (n=400): 27 variables** **1.5 years (n=397): 18 variables** Questions are Yes/No unless otherwise noted	**Linear** **Axis 1**		**Linear** **Axis 2**		**Non-Linear** **Axis 1 & 2**	**Non-Linear** **Axis 1 & 2**
	r	R^2	r	R^2	XR^2	R^2
1. Personal experience with earthquakes prior to 2015 earthquakes (9 months)	-.116	.013	.083	.007	.015	.028
2. Personal experience with landslides prior to 2015 earthquakes (9 months)	-.157	.024	.122	.015	.041	.052
3. Previous experience with natural hazards helped lessen earthquake impacts (none) (9 months)	-.087	.008	-.024	.001	.009	.020
4. Previous personal experience with natural hazards helped lessen earthquake impacts (some) (9 months)	.087	.008	.024	.001	.009	.020
5. Previous personal experience with natural hazards helped lessen earthquake impacts (none) (1.5 years)	-.035	.001	-.026	.001	.001	.018
6. Previous personal experience with natural hazards helped lessen earthquake impacts (some) (1.5 years)	.037	.001	.024	.001	.003	.021
7. Previous personal experience with natural hazards helped lessen earthquake impacts (very much) (1.5 years)	.004	.000	.011	.000	-.003	.000
8. Community experience with earthquakes prior to 2015 earthquakes (9 months)	-.090	.008	.039	.002	.003	.016
9. Community experience with landslides prior to 2015 earthquakes (9 months)	-.124	.015	.140	.020	.031	.043
10. Community experience with glacial lake outburst floods prior to 2015 earthquakes (9 months)	.010	.000	.001	.000	-.001	.008
11. Community experience with avalanches prior to the 2015 earthquakes (9 months)	.022	.000	.041	.002	-.002	.016
12. Community experience with other natural hazards prior to the 2015 earthquakes (9 months)	.127	.016	.007	.000	.015	.030
13. Previous community experience with natural hazards help in recovery (9 months)	.087	.008	.045	.002	.011	.025
14. Previous community experience with natural hazards help in recovery (none) (1.5 years)	.057	.003	.014	.000	-.002	.025
15. Previous community experience with natural hazards help in recovery (some) (1.5 years)	-.088	.008	-.017	.000	.001	.036
16. Previous community experience with natural hazards help in (very much) (1.5 years)	.026	.001	.001	.000	-.003	.000
17. Community using traditional architecture in recovery (none) (9 months)	.141	.020	**-.272**	**.074**	.102	.117
18. Community using traditional architecture in recovery (some) (9 months)	-.084	.007	.165	.027	.025	.044
19. Community using traditional architecture in recovery (very much) (9 months)	-.097	.009	.187	.035	.055	.071
20. Community using traditional architecture in recovery (none) (1.5 years)	.019	.000	-.148	.022	.020	.032
21. Community using traditional architecture in recovery (some) (1.5 years)	.053	.003	.076	.006	.012	.028
22. Community using traditional architecture in recovery (very much) (1.5 years)	-.100	.010	.139	.019	.027	.045
23. Traditional architecture helped to lessen earthquake impacts (none) (9 months)	-.015	.000	-.014	.000	-.003	.000
24. Traditional architecture helped to lessen earthquake impacts (some) (9 months)	.053	.003	.008	.000	-.002	.004

25. Traditional architecture helped to lessen earthquake impacts (very much) (9 months)	-.062	.004	.013	.000	-.002	.002
26. Community using knowledge about farming in recovery (none) (9 months)	.079	.006	-.198	.039	**.075**	**.091**
27. Community using knowledge about farming in recovery (some) (9 months)	.020	.000	.000	.000	-.003	.000
28. Community using knowledge about farming in recovery (very much) (9 months)	-.086	.007	.198	.039	.070	.086
29. Community using knowledge about farming in recovery (none) (1.5 years)	.012	.000	-.129	.017	.009	.028
30. Community using knowledge about farming in recovery (some) (1.5 years)	-.055	.003	.040	.002	.000	.010
31. Community using knowledge about farming in recovery (very much) (1.5 years)	.040	.002	.130	.017	.016	.037
32. Community using grazing or pasture management practices in recovery (none) (9 months)	-.014	.000	-.035	.001	-.003	.000
33. Community using grazing or pasture management practices in recovery (some) (9 months)	.014	.000	.035	.001	-.003	.000
34. Community using grazing or pasture management practices in recovery (none) (1.5 years)	.121	.015	-.140	.020	.039	.057
35. Community using grazing or pasture management practices in recovery (some) (1.5 years)	-.090	.008	.109	.012	.017	.029
36. Community using grazing or pasture management practices in recovery (very much) (1.5 years)	-.078	.006	.081	.007	.010	.030
37. Forest management practices helped to lessen earthquake impacts (none) (9 months)	.004	.000	-.075	.006	-.001	.019
38. Forest management practices helped to lessen earthquake impacts (some) (9 months)	-.039	.002	.049	.002	-.001	.021
39. Forest management practices helped to lessen earthquake impacts (very much) (9 months)	.057	.003	.062	.004	.002	.014
40. Community using forest management practices in recovery (none) (9 months)	.109	.012	-.128	.016	.029	.047
41. Community using forest management practices in recovery (some) (9 months)	-.056	.003	.093	.009	.003	.011
42. Community using forest management practices in recovery (very much) (9 months)	-.093	.009	.082	.007	.017	.036
43. Community using forest management practices in recovery (none) (1.5 years)	.025	.001	-.164	.027	.023	.041
44. Community using forest management practices in recovery (some) (1.5 years)	-.031	.001	.138	.019	.016	.034
45. Community using forest management practices in recovery (very much) (1.5 years)	.004	.000	.077	.006	-.002	.003