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Authors: Halvorson, Sarah J., and Hamilton, Jennifer Parker

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Sarah J. Halvorson and Jennifer Parker Hamilton

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Vulnerability to earthquake disasters in mountainous regions frequently escapes investigation and analysis. The tragic and costly earthquake disasters that have recently occurred in Central Asia have spurred important questions among local, regional, and international policymakers, scientists, and social activists regarding the root causes of earthquake vulnerability. Drawing on an analysis of recent earthquake disasters in Kyrgyzstan, Tajikistan, Afghanistan, and Pakistan, this article explores the concept of "seismic culture" (Degg and Homan 2005) in relation to vulnerability. Specifically, it argues that diminishing levels of indigenous hazard knowledge, demographic shifts, gendered livelihood transformations, and the lack of public access to science-based earthquake information have contributed to overall low levels of seismic cultures of prevention in the region. A major finding of the study points to the particular role of women in helping to redress the erosion of seismic culture, thereby bolstering local resilience, earthquake preparedness, and disaster risk reduction.

Keywords: *Earthquake disasters; vulnerability; seismic culture; women; Central Asia.*

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Introduction

Communities in mountainous Central Asia are vulnerable to earthquake disasters. The recent seismic events in Kyrgyzstan, Tajikistan, Afghanistan, and Pakistan have exacted a tremendous toll on lives, property, and infrastructure. The 7.6 magnitude 2005 Kashmir Earthquake was particularly catastrophic and underscored the need to expand vulnerability science in the region, especially given the high probability that within the next 2 decades an earthquake of similar magnitude will strike near a Central Asian population center (GHI 2006). Vulnerability research is critical at a time when natural disaster-related mortality figures since 1600 have reached an all-time high (Jackson 2006), with mountain-based populations in the less developed world experiencing greater post-earthquake vulnerability due to the remoteness of settlements, difficulty of access for humanitarian aid, and lack of funds for reconstruction in marginalized areas.

The damage and upheaval associated with major earthquakes in highland Central Asia exacerbate already challenging social and material realities. Present challenges are associated with several observable trends: 1) the destabilizing nature of colonial/postcolonial experiences and current geopolitical tensions; 2) intense internal struggles that manifest themselves in civil wars, violence, and weak institutions; 3) increasing dependency of local communities on the global economy via wage labor, markets, and foreign capital; 4) rapidly expanding urban construction and transportation networks to facilitate industrial development and global tourism; and 5) population pressures at lower elevations which drive the expansion of settlements into marginal areas and landslide-prone slopes (Kreutzmann 1995; Halvorson 2005; Jackson 2006; Olimova and Olimov 2007). The socio-environmental insecurities associated with these trends, as well as local struggles over access to natural resources and basic services, are intensified by earthquake disasters (IFRC 2006). These phenomena ultimately have implications for survival and sustainability in places facing post-earthquake reconstruction.

Against this complicated background, the present article examines factors that contribute to the high levels of vulnerability to seismic hazards in Central Asia. The factors addressed here include: diminishing levels of indigenous hazard knowledge; demographic shifts; gendered livelihood transformations; and the lack of public access to science-based earthquake information. We argue that the interactions between these complex factors are leading to the slow erosion of what Degg and Homan (2005) term "seismic culture." A seismic culture is one in which adaptations to seismic hazard become ingrained in society through knowledge sharing, indigenous building practices, vernacular architecture, and so forth (EUCCH 1993; Degg and Homan 2005). We use the notion of seismic culture as a broad concept that encompasses a range of cultural adaptations to seismic risk and hazard. We further bring the mountain-based experiences of women to bear on the relationship between vulnerability and seismic culture by underscoring women's roles in reducing seismic risk and "building the resilience of nations and communities to disaster" (UNISDR 2005, p 1).

Methodology

This article draws on an analysis of empirical data collected as part of a research project on the geological and societal impacts of earthquakes conducted in the predominantly Muslim cultural realm encompassed by the Tien Shan, Pamir, Hindu Kush, Karakoram, and Western Himalaya ranges. The methodology included: (1) monitoring seismic events and related disasters;

(2) conducting field-based visual surveys and assessment campaigns in Kyrgyzstan, Tajikistan, and Pakistani administered Kashmir between 2004–2007; (3) carrying out 40 interviews with Kashmir Earthquake survivors in May–June 2006 and numerous informal conversations with disaster management personnel, aid and relief workers, development practitioners, educators, government representatives, and community leaders throughout the research setting; and (4) an extensive analysis of secondary data sources such as international and regional media accounts, government and military documents and policy statements, and non-governmental organization (NGO) reports.

The difficult field conditions associated with the rugged terrain of this earthquake-prone area presented significant logistical challenges in terms of field data collection and access. Hence, the combination of methods was critical for advancing understanding of the root causes of vulnerability to earthquakes in this geographical context as well as exploring risk and exposure, protective measures, and women's roles in building community resilience.

Theorizing earthquake vulnerability

Vulnerability has received a substantial amount of scholarly attention in recent years (Cutter 1996; Hewitt 1997; Comfort et al 1999; Lewis 1999; Bankoff et al 2004). However, relatively few empirical studies examine the specifics of earthquake vulnerability in Central Asia. Here, vulnerability is taken to mean "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisner et al 2003, p 11). The central concern of this vulnerability analysis is the deeper-rooted political, cultural, and economic factors that influence overall societal exposure and susceptibility to seismic hazard.

Compounding vulnerability in Central Asia are the intense armed conflicts and political tensions that have undermined economies and destabilized social systems. War and conflict create a "dynamic pressure" (Wisner et al 2003) that interacts with earthquake hazards in several complex ways. They contribute significantly to the creation of special groups at risk such as the maimed and disabled (eg in relation to landmines) and the displaced. Second, vital infrastructure, local and national institutions, and communication systems are destroyed or fall into disarray. The defense-driven isolation and physical effects of war on disintegrating rural infrastructure in Afghanistan and Tajikistan are clearly profound. Moreover, political insecurities can disrupt everyday livelihood and family activities. Even in post-earthquake situations such as in Kochkor, Kyrgyzstan in December 2006, government attempts to control political demonstrations interfered with the provision of relief and recovery assistance (IFRC 2007).

In addition, vulnerability in the earthquake disaster process is fundamentally shaped by social divisions drawn along gender, class, clan, age, religion, and/or ethnic lines (Wisner et al 2003). As with environmental hazards in general, the differential vulnerability of women in particular is evident in the injury and mortality data associated with recent events (IFRC 2006). Seager (2005, pp 29–30) notes, "In the 1995 Kobe (Japan) earthquake, one and a half times more women died than men; in the 1991 floods in Bangladesh, 5 times as many women as men died; in the Southeast Asia 2004 tsunami, death rates for women across the region averaged 3 to 4 times that of men." These figures underscore the ways in which women experience disproportionate levels of risk and impact owing to spatial location, patriarchy, gendered social structures, and political marginalization (Enarson and Morrow 2000; Chew and Ramdas 2005).

The data collected for this study suggest that during earthquake disasters women's vulnerability is apparent in the following ways: they are more likely than men to die as a direct result of a seismic event; they are at increased risk of physical violence and domestic abuse following an earthquake; they do not have access to equal levels of healthcare as men; they may be denied relief aid or compensation for losses if male family members are not present to navigate the available aid channels; and they suffer from voicelessness in the political process of recovery and reconstruction (see also Hamilton and Halvorson 2007, in this issue). When women are forbidden to interact with men outside of their families in Afghanistan and northern Pakistan, they can be systematically marginalized from relief and food distribution. Where women are in their life course—that is, infancy, adolescence, pregnant or lactating, widowhood, elderly, and disabled—dramatically shapes exposure and susceptibility to damage, injury, or death. Widespread poverty (Kreutzmann 2001; Papola 2002) in combination with a highly patriarchal social structure that places constraints upon women's lives and mobility (Ishkanian 2003; Halvorson 2005; SGWRC 2006) results in women being least likely to have access to information prior to an earthquake. Similarly, women are the least likely to have a place to go in case of an evacuation; when given a safe place to go to, they are the least likely to have the means to get there.

We attach particular importance to women's vulnerability in earthquake disasters because it is too often forgotten or unacknowledged. Since the 2002 "Celebrating Mountain Women" International Conference held in Thimphu, Bhutan, greater attention has been drawn to the vulnerability and resilience of mountain women in the face of natural hazards and disasters. In

TABLE 1 Selected earthquake events since 1887 in Central Asia. (Data source: USGS 2007)

Country	Region	Date	Magnitude	Fatalities
Afghanistan	Hindu Kush	3 Apr 2007	6.2	0
Kyrgyzstan	Kyrgyzstan–Tajikistan border	8 Jan 2007	5.9	0
Kyrgyzstan	SE of Bishkek	26 Dec 2006	5.8	0
Tajikistan	Khatlon District	29 Jul 2006	4.5	3
Afghanistan	Hindu Kush	12 Dec 2005	6.5	5
Pakistan	Kashmir	8 Oct 2005	7.6	86,000
Afghanistan	Hindu Kush	5 Apr 2004	6.6	3
Kyrgyzstan	Kyrgyzstan–Xingjiang border	25 Dec 2002	5.7	0
Pakistan	Kashmir	20 Nov 2002	6.3	19
Afghanistan	Hindu Kush	25 Mar 2002	6.1	1000
Afghanistan	Hindu Kush	3 Mar 2002	7.4	166
Tajikistan	Afghanistan–Tajikistan border	30 May 1998	6.6	4000
Afghanistan	Afghanistan–Tajikistan border	4 Feb 1998	5.9	2323
Pakistan	Northern Pakistan	28 Dec 1974	6.2	5300
Tajikistan	Khait	10 Jul 1949	7.5	12,000
Turkmenistan	Ashgabat	5 Oct 1948	7.3	110,000
Pakistan	Off coast	27 Nov 1945	8	4000
Pakistan	Quetta	30 May 1935	7.5	30,000
Tajikistan	Sarez	18 Feb 1911	7.4	90
Kyrgyzstan	Chong-Kemin	3 Jan 1911	7.8	450
Tajikistan	Qaratog	21 Oct 1907	8.0	12,000
Uzbekistan	Eastern Uzbekistan	16 Dec 1902	6.4	4700
Kazakhstan	Almaty	8 Jun 1887	7.3	0

recognizing the importance of women in earthquake response and reconstruction, communities, governments, and international agencies stand to gain key allies in their efforts to understand the elements of seismic culture in Central Asia and how seismic culture might be reinforced in ways that reduce vulnerability.

Characteristics of earthquake disasters in highland Central Asia

The characteristics of recent earthquake disasters in highland Central Asia and their consequences at local and regional levels are comparable to and illustrative of many earthquake-prone areas elsewhere in the world. Careful research has advanced scientific understanding of the dynamic processes associated with the high-energy tectonic collisions between the Eurasian, Arabian, and Indian plates (Dricker et al 2002; Cuiping et al 2003). Despite the progress in analyzing the seismic threat in Central Asia, mountain communities remain vulnerable to earthquake disasters.

Table 1 presents a listing of selected earthquakes and associated losses. Owing to the high relief and unstable geological structures, the secondary hazards triggered by earthquakes often cause large-scale environmental change and loss of life. This process was evident in October 2005 in Afghanistan and northern Pakistan, as hundreds of landslides disrupted critical infra-

FIGURE 1 The population of Balakot in the North-West Frontier Province was particularly vulnerable to the 8 October 2005 earthquake. A significant proportion of the damage to this urban area was attributed to the siting of structures on the active fault as well as to the lack of seismically appropriate engineering methods and poor quality construction. (Photo by L. Owen, November 2005)

structure, destroyed agricultural land, and buried villages. The Hattian Bala landslide, recorded to be over one kilometer long and over 200 meters wide, was of massive proportions (Owen et al 2007). Within seconds, 4 villages with approximately 450 residents were overtaken and completely buried in landslide debris. The landslide created dams that blocked 2 drainages of the Jhelum River and led to the formation of 2 potentially hazardous lakes (Owen et al 2007).

In addition to reworking landscapes, recent earthquakes have dramatically reconfigured community dynamics. These calamities have torn families apart through sudden death and traumatic separation. One of the most striking examples of destruction is the city of Balakot, which was 80 to 90% destroyed during the Kashmir Earthquake (Figure 1). Cases of severe physical suffering and psychological stress associated with extremely trying post-disaster situations have been documented (Chew and Ramdas 2005). Families found themselves dramatically uprooted from their land and resource base; in some cases they became landless internally displaced refugees and were forced to relocate to urban centers that lacked the capacity and social services to absorb large numbers of earthquake victims. For example, the remote town of Rostaq, Afghanistan, with 10,000 residents, experienced a population increase of nearly 50% following the earthquake on 4 February 1998, which destroyed nearly 30 mountain villages. The Kashmir Earthquake experience has dramatically underscored the challenges of coordinating relief operations (Hicks and Pappas 2006; Ozerdem 2006) and addressing the needs of displaced populations (UNFPA 2006).

Given the lack of building codes and/or their enforcement in the countries of Kyrgyzstan, Tajikistan, Afghanistan and Pakistan, even relatively minor earthquakes have the potential to be disastrous. For example, 2 relatively localized earthquakes, magnitude 4.5 and 5.0 respectively, struck Tajikistan on 29 July 2006. Ten settlements with a population of over 21,000 in Kumsangir District, Khatlon Oblast were affected as many structures collapsed. Although the death toll was low (3 deaths), 2651 houses were partially or totally destroyed. The damage, estimated at US$ 22 million, received little attention from international media despite the crippling effect on already poor infrastructure and a weak regional economy.

The overall lack of resources, building codes, construction standards, and earthquake-resistant engineering methods has produced a seismically vulnerable built environment. Following the December 2006 earthquake in Kyrgyzstan, for example, government allocations of funds to construct dwellings were insufficient to construct seismically appropriate houses (IFRC 2007). Contributing to these unsafe building conditions is the lack of available economic resources among the population. Levels of poverty and economic hardship are pronounced. The per capita GDP for Afghanistan, Tajik-

istan, Kyrgyzstan, and Pakistan, respectively, is US$ 218, US$ 360, US$ 464, and US$ 697 per year (UNSD 2007). The Kashmir Earthquake further revealed the scale of human vulnerability as structures such as schools, hospitals, health centers, and government offices catastrophically failed (EERI 2006). Hospitals and health centers were destroyed exactly when they were desperately needed during the chaotic aftermath. Pakistan's building codes were adopted in 1986 yet were not enforced before the Kashmir Earthquake (Ghauri 2006, Khan 2007).

Factors contributing to the erosion of seismic culture

The analysis of data underscores several interrelated factors—diminishing levels of indigenous hazard knowledge, demographic shifts, gendered livelihood transformations, and the lack of public access to earthquake information—that interact in ways that reduce the capacity of mountain communities to resist or to recover from the harmful impacts of earthquakes.

Diminishing levels of indigenous hazard knowledge

Recent earthquake disasters have exposed evidence of diminishing levels of indigenous hazard knowledge. Knowledge specifically about geophysical hazards and approaches to coping with the high levels of seismicity is evident in indigenous building practices and vernacular architectural styles (Ambraseys et al 1975; Davis 1984; Spence and Coburn 1984; Szabo and Barfield 1991; Dekens 2007; Gardner and Dekens 2007). The traditional timber-laced construction pattern and stone masonry, for example, proved highly resistant to the earth movements caused by the Kashmir Earthquake (Rai and Murty 2006). Acquired from ancestors and personal experiences, the hazard knowledge base is embedded in local traditions, skills, and culture. Unfortunately, traditional approaches to home construction are being gradually replaced by "modern" architectural styles that rely less on indigenous engineering practices sensitive to seismic loading and more on quick construction and cheaper materials. An extremely dangerous situation is created as families forgo structural soundness in exchange for a modern appearance. The combination of modernization, urbanization, and shifts in housing preferences is producing communities that are dominated by these shoddily built undressed stone or cinderblock and mortar dwellings without sufficient reinforcements and the structural integrity needed to withstand extreme shaking (Zoback 2004). As Coburn and Spence (2002) and Wisner et al (2003) point out, these very elements of design and quality of construction are crucial for minimizing death and injury. Clearly, those we interviewed in northern Pakistan would like to see these seismic risk reduction measures adopted during post-earthquake rebuilding. As echoed by one male teacher near Muzaffarabad, "new buildings should be earthquake-resistant. Japan has large earthquakes and their buildings survive. Our construction should be similar to theirs."

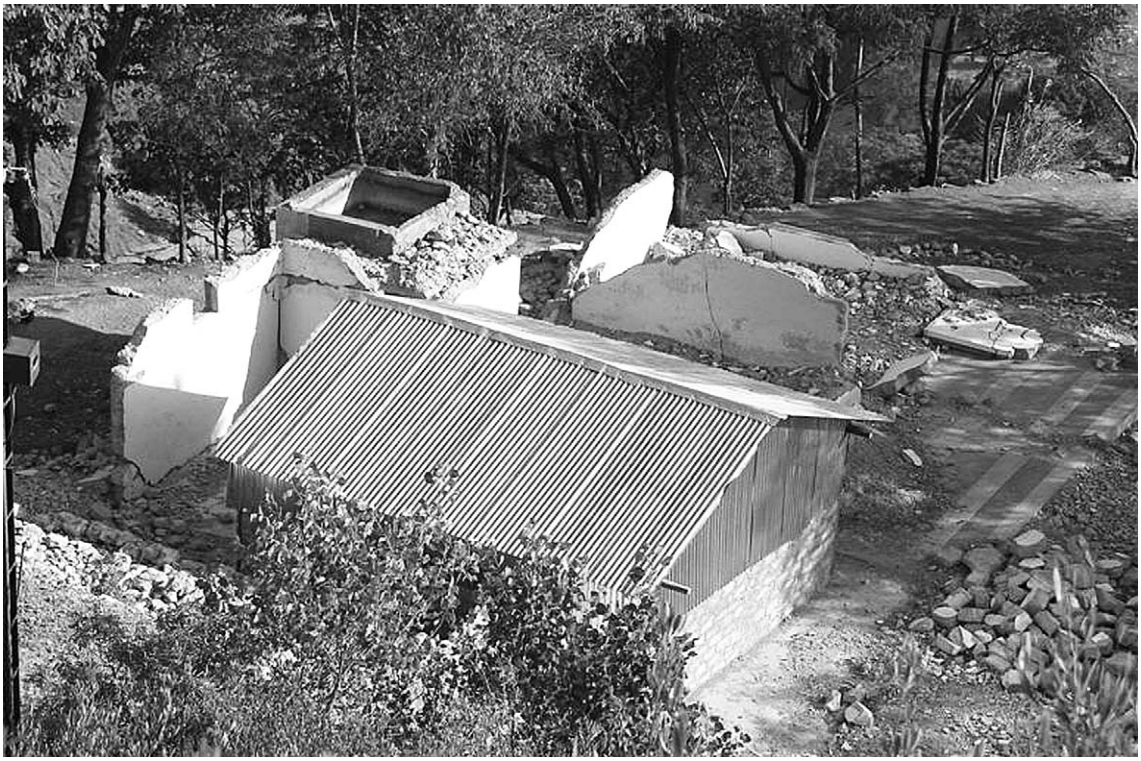
Adding to the diminishment of indigenous seismic knowledge is the fact that the strong systems of self-reliance and kinship and friendship networks utilized in house construction are increasingly being replaced by contractors who provide housing for payment. Individuals in low income categories, recent migrants, refugees, and women as a whole tend to have little to no role in designing and building the dwellings in which they live or in ensuring that construction meets codes.

Another important area in which seismic culture is diluted is in the realm of indigenous monitoring of earthquake indicators. Women and men we met in northern Pakistan reported observing anomalous animal behavior in the days and hours preceding the earthquake. These types of behavior included birds flocking and leaving the area the day prior to the earthquake and normally docile buffalos breaking chains and escaping just hours before the earthquake struck at 8:50 AM. While similar earthquake indicators have been examined elsewhere in Asia (Tributsch 1984; Ikeya 2004), our observations suggest that little credence is given to locals' intimate knowledge and careful monitoring of physical surroundings and behavioral changes in animals. Interestingly, in Tajikistan scientists have successfully forecasted impending natural disasters using a set of natural cues; however, the Western scientific approach to disaster risk reduction tends to place the role of these macro-anomaly earthquake precursors in the realm of quackery.

Demographic shifts

The demographic picture of the region, especially the relatively young age of the population, has contributed to the erosion of seismic culture in several ways. All 4 countries of focus have low median ages: 23.9 years in Kyrgyzstan; 19.2 years in Tajikistan; 16.4 years in Afghanistan; and 20.3 years in Pakistan (UNDESA 2007). The relatively young age of the population influences the level of preparedness, planning, response, and recovery capacity of mountain communities. A significant portion of the population lacks experience and skills that would, first, help quell fears and encourage hope among earthquake victims that people have survived these events in the past; and second, serve as guides for what to do to stay alive or, at the very least, propagate what strategies worked in the past to help mitigate earthquake damages. Such experiences, skills, and memories are fundamental to the development,

FIGURE 2 The government recommended-rebuilding scheme incorporates the use of a wood frame with 90–120 centimeters of brick or concrete on the lower walls and corrugated galvanized iron (CGI) sheets for upper walls and roofs. Among those interviewed in Pakistani administered Kashmir, 80% felt that this was the best technique for rebuilding. (Photo by J.P. Hamilton, June 2006)



maintenance, and transmission of seismic culture. Our research suggests that hazard-related information is typically held and shared by elders and passed on orally to younger generations. One Kashmir Earthquake survivor commented, "children didn't previously, but now they ask why the earthquake happened so we [the teachers] talk about it." Yet, the trends in migration, human movement, and social change (Olimova and Olimov 2007) imply the uprooting and relocation of younger segments of the population with an overall erosive effect on cultural adaptations to seismic exposure.

Gendered livelihood transformations

Another important factor affecting earthquake vulnerability is gender dimensions of livelihood transformations. Mountain-based livelihood strategies are being fundamentally reoriented within the global economy (Kreutzmann 1995; Pandey and Misnikov 2001; Breu et al 2005). As such, the high rates of poverty noted above (eg, 64% of the population in Tajikistan live below the poverty line), unemployment, and increasing pressures for cash have encouraged men and boys to seek employment elsewhere in the region, in distant urban areas, or overseas. The result is that the outmigration of men from rural communities is now commonplace.

On the local level, the effects of male off-farm employment and male outmigration in weakening seismic culture in Central Asia are manifold. First, there is a marked increase in women's agricultural and household responsibilities given the absence of men. Women are left with little or no time for supervising house construction let alone community organizing or attending disaster preparedness information sessions. Second, there is a concomitant draining of skills, such as in the areas of literacy and community leadership, and able-bodied men to engage in physically demanding construction (and after an earthquake, in rescue and recovery work). This loss of skills and manpower affects all social and economic sectors, particularly the capacities to cope with disasters. We have found that post-earthquake health problems have been exacerbated by the sheer lack of residents trained in first aid and emergency medical assistance. Third, livelihood transformations affect demographic shifts as well. Communities become dominated by women, the young and the old, and their mere spatial location places them more at risk to seismic impact. And fourth, men who have left rural areas indefinitely to pursue opportunities in urban centers may gain access to skills, training, and knowledge, yet fail to pass these on to family members back home. This leaves one of the most vulnerable populations—mountain women and their children—isolated from information about seismic hazard, disaster preparedness, and emergency services.

Lack of public access to earthquake information

The lack of public access to information about the geophysical processes which cause earthquakes and awareness of the steps individuals can take to protect themselves from impact produces a form of "informational vulnerability" (Degg and Homan 2005). Nearly half (45%) of the women and men we interviewed believed

FIGURE 3 If empowered and informed, Muslim women in Tajikistan as well as elsewhere in mountainous Central Asia can play a key role in helping to redress the erosion of seismic culture. (Photo by S.J. Halvorson, June 2006)

that the Kashmir Earthquake occurred because, as many put it, "it was God's will" and "God's will and destiny chooses who survives and what places get destroyed." There was also a disturbing campaign alleging that one of the reasons for the Kashmir Earthquake was women's sins, inappropriate behavior, and dress. The lack of sound information can lead to blaming these types of events on metaphysical phenomena or social groups rather than focusing attention on the physical hazard, preparedness, and planning. When asked from where they received information regarding relief and reconstruction, the majority of respondents indicated that they had no place to go to collect such information. Nevertheless, tremendous concern exists with regard to the safety of structures and communities in the future. One 30-year-old male teacher in a local school put it this way, "this area is not safe. People are tense and tremors make people worry. Areas should be planned to be safer."

Information dissemination among the public is heavily scrutinized and censored in Central Asian countries marked by powerful urban elites and hierarchical socioeconomic structures. Similar to the outcomes of Degg and Homan's (2005) study on earthquake vulnerability in the Middle East, we find that the existing power relations and informational disconnect between government officials, scientists, and the public tend to expand the gap between community members' weak perceptions of earthquake risk and vital life-saving information. Nonetheless, the individuals we interviewed in northern Pakistan hope for greater knowledge transfer and disaster risk reduction measures. As one 19-year-old mother optimistically observed, "there are lessons from the earthquake. We must help each other."

Concluding remarks: towards greater community resilience

Several practical and theoretical implications of this vulnerability analysis emerge. First, the weakening of seismic culture throughout mountainous Central Asia has increased earthquake vulnerability. This is largely due to the fact that vulnerability is being literally built into the social landscape. As such, mountain development should not be accepted as a risk-free process given the concomitant breakdowns in cultural adaptations to seismic hazard. Local perspectives point to the need for earthquake-resistant dwellings and the mandatory establishment and enforcement of building codes in order to reduce seismic risk and counteract the modernizing trend towards inappropriate construction practices (Figure 2).

Second, women play a vital role in reducing earthquake vulnerability in Central Asia (Figure 3). The long-term success of earthquake mitigation, response, and recovery efforts in this region is intimately linked to the degree of women's control, involvement, and

protection. Related to this is a major need for applying new frameworks and scientific tools for describing and analyzing vulnerability in the Central Asian context. The Hyogo Framework for Action (UNISDR 2005) offers a framework for building community resilience starting with the most vulnerable segments of the population.

Third, in order to reduce vulnerability in the earthquake disaster process in Central Asia, the need for integrating educational efforts to (re)establish a seismic culture of prevention seems apparent. A poster prepared in Urdu with simple and basic information on earthquakes and risk prevention presents an excellent approach to earthquake education that is being made available to communities in Pakistan (see Hamilton and Halvorson 2007, p 300 in this issue of *MRD*). The premise of this simple yet instructive poster (Bendick 2006) is that local people can learn about the causal mechanisms of the physical hazard and take effective steps to reduce risk. Empowered with sound information, women living in conservative patriarchal settings can demand that seismic standards be observed and provide oversight of reconstruction as they did in Kyrgyzstan following the December 2006 earthquake (IFRC 2007).

Finally, as this research shows, the mitigation of future earthquake disasters in many parts of Central Asia is linked to cultivating a climate of public participation. Teaming women and elders with disaster preparedness specialists would create a participatory and trusted model for blending indigenous hazard knowledge and science-based earthquake preparedness information. Political institutions and disaster management agencies need to be convinced that public participation, particularly the participation of women, in preparedness and disaster mitigation is essential for reducing the loss of life and property in the future.

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AUTHORS

Sarah J. Halvorson and Jennifer Parker Hamilton
Department of Geography, Social Science Building 203, The University of Montana, Social Sciences Building, Missoula, MT 59812-5040, USA.
sarah.halvorson@umontana.edu (S.J.H.);
jennifer.parker.hamilton@gmail.com (J.P.H.)

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