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REDUCING EARTHQUAKE VULNERABILITY THROUGH ENVIRONMENTAL JUSTICE: A CASE COMPARISON FROM INDIA

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SUMMARY

The environmental justice framework which asks "who's exposed to what, and why?" guided this comparison of the Uttarkashi and Marathwada earthquakes in India. Decreased vulnerability and environmentally just outcomes emerged most strongly at the scale at which villages, NGOs and government organized reconstruction, so future engineering efforts should address multiple scales. Future activities to decrease earthquake vulnerability should intervene with the people of lowest social status.

INTRODUCTION

Guided by the environmental justice framework which asks "who's exposed to what, and why?" this study used three working hypotheses to compare the 1991 Uttarkashi and 1993 Marathwada earthquakes in India: 1) Persons of low social status occupy a disproportionately large percentage of houses with high earthquake risk. Similarly, persons of high social status are at least risk. 2) Individuals reside in systems of inequity in the family, village, district, region and nation that increase their vulnerability to earthquake hazards. 3) Earthquake relief and reconstruction reinforces, rather than alters, existing social hierarchies. This study tracked reconstruction in both areas through June 1998.

Uttarkashi Earthquake

According to topographic maps of the area surrounding the Uttarkashi earthquake epicenter, 338 of 563, or 60% of villages, sit on the convex portion of hillslopes which are more dangerous than concave slopes. Another 27 villages, or an additional 4.8%, occupy locations stretched across both convex and concave slopes. Ridgetops and valley centers are more likely to amplify earthquake motions than sites on a hill slope. About 20% of villages are located in valley bottoms and about 12% are located in the region of convex curvature at ridgetops.

The Uttarkashi case focused on four villages in a cross-section of the Bhagirathi River. The oldest of three villages across the river from Jagah was located the farthest up the mountain. The village nearest the river occupied the nose of a debris slope and an alluvial fan. Other villages in the area occupied alluvial terraces, convex slopes, glacial terraces, a saddle, and a hill-in-a-valley.

The traditional rectangular houses in the Uttarkashi earthquake area had random rubble masonry walls, and heavy slate roofs on unshaped timber beams and rafters. Most were two story houses. The oldest houses had the shortest stories, the most structural timber, and the most detailed woodcarving. Horizontal timber beams were placed at intervals in the height of the stone walls. One four story house with alternating courses of timber and dry stone masonry stood like a sentinel overlooking a valley as it had done for more than 150 years.

During the past generation, additions and new construction have often used building materials other than locally available stone, soil, and timber. Houses were expanded with reinforced concrete first floors on top of random rubble masonry ground floors. Owners believed they were upgrading houses by replacing pitched slate roofs atop random rubble masonry walls with flat reinforced concrete roofs which could be used for drying foods, sleeping, or household chores. Few houses had been built entirely of brick, concrete block, or reinforced

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concrete. In the past three decades, construction with new materials indicated no real understanding of how to combine materials, how to use steel and concrete effectively, or how to connect foundations, walls, and roofs.

The similarities in the sizes and building materials of the houses in Jagah, Kinara, Lungaon, and Bipur indicate that differences in the number of deaths and injuries between the villages cannot be explained solely by differences in house construction. In Jagah, Kinara, Lungaon, and Bipur, respectively, 2, 45, 8, and 8 people died. In Jagah, Kinara and Bipur, respectively, 2, 45, and 5 people were injured (GSI 1992). What differences among the sites can explain the differences in casualties?

Either directional effects on incident earthquake waves or different topographic and soil conditions could account for different numbers of casualties at village sites with similar building construction. In the Uttarkashi epicentral tract villages, directional effects on earthquake waves do not account for the casualty distributions. Jagah, Kinara, Lungaon and Bipur lie in a cross-section perpendicular to the Bhagirathi River so any earthquake waves moving up or down the valley would have similar incidence on all four villages. Directional effects on earthquake waves propagating across the river valley would have produced different damage and casualty patterns on opposite sides of the river, but would have generated similar patterns on the same side of the river; this was not upheld. Lungaon and Bipur, on the same side of the river as Kinara, had very different death tolls than Kinara. On the opposite side of the river, the number of deaths in Jagah, was more similar to those in Lungaon and Bipur than to that in Kinara.

Topographic and soil conditions primarily caused the differential damage and casualty patterns in Jagah, Kinara, Lungaon, and Bipur. Jagah sat on rock on a concave terrace about two-thirds of the way up a mountainside. The newest houses in Jagah were in a rockfall zone at the end of the village on the inside curve of the mountain because this was the only direction in which expansion had been possible. In Jagah, just one house and the panchayat ghar (building for functions of the elected village government) were concrete structures. All the other houses and chhanis (livestock sheds) were made of stone, soil, and timber. The earthquake rendered many Jagah houses uninhabitable, but collapsed none. Because of their location, the houses in Jagah probably did not experience earthquake wave amplification or the additional motion of wave diffraction and scattering.

Directly across the Bhagirathi River from Jagah, Bipur, the oldest village on the mountainside, perched at the highest elevation of the four villages in the cross-section. Bipur pre-dates the 1809 Garhwal earthquake. How had Bipur survived two earthquakes as well as it did? Bipur had very old two storied stone masonry houses made in the typical Garhwali way with long flat stones and sufficient wood banding. In 1991, Bipur had only one concrete house and one house with a veranda. The short story heights, long through stones, and wooden banding made the houses box-like, and therefore, earthquake resistant. Because of its location on flat solid rock site Bipur resists earthquake shaking relatively better than villages on sloping, debris filled, or ridgetop sites.

Bipur expanded down the mountainside into what became Lungaon. The 1991 earthquake damaged Lungaon slightly more than Bipur. The oldest houses in Lungaon were constructed almost identically with those in Bipur. Newer stone masonry houses had less structural timber than those in Bipur did. Lungaon occupies a steeper site than Bipur, but at midslope is not expected to experience topographic amplification of earthquake motion.

Downhill from Lungaon, Kinara occupies the lowest elevation among the four villages in the cross-section of the epicentral tract and suffered the most casualties and the greatest building damage. Kinara spreads across river terrace deposits and a gently sloping debris fan (GSI 1992). Naithani, Rawat, and Prasad's (1993) assessment of earthquake effects on landforms in the Bhatwari area of Uttarkashi District confirmed that villages like Kinara on fluvial deposits or moraines incurred comparatively greater damage in the October 1991 earthquake.

Kinara's random rubble masonry houses nearest the agricultural terraces next to the river totally collapsed, whereas houses on the next terraces up the slope usually lost their first floors while the damaged ground floors remained standing. The concrete temple and panchayat ghar suffered severe damage, but did not even partially collapse. The greater structural strength of reinforced concrete, as compared to random rubble masonry, may have helped prevent collapse of the temple and panchayat ghar. The collapsed buildings sat upon the most unconsolidated soil, while the temple and panchayat ghar sat upon the most stable material on a rock slope. The unconsolidated soil and the most acutely convex part of the fan would have tended to accentuate ground motions and seismic intensity, thus maximising the earthquake's impact in these areas.

The amplitude of seismic waves transmitted from basement rock to the alluviated area would have been greater than the amplitude of the incident waves (Okamoto 1984), thus causing more shaking in Kinara than in other villages in the cross-section. The high water content of Kinara's weak soils would also have amplified earthquake waves (Selby 1993). Kinara had more moist soil than the other villages in the cross-section, as attested by the springs along the footpath and the 12' high mud slide blocking the footpath on August 6, 1994.

In summary, Jagah, Bipur, Lungaon, and Kinara all had fragile physical environments which resulted in many severely damaged houses in the 1991 earthquake. However, the vulnerability of Kinara surpassed that of all

other villages in the cross-section of the epicentral tract, not because of differences in house construction or earthquake wave direction, but because of topographic and soil conditions.

Residents had built Upagiri, another village in the epicental tract, on the saddle of land between the temple hilltop and the tree-clad mountain towering at least three times higher to the east. The saddle site placed Upagiri near water, wood and cultivable land. Upagiri also looked out on a small hydroelectric dam, the 5 m diameter diversion tunnel of which passes 90 m deep under Upagiri (GSI 1992). As is often the case in India, construction materials from the dam and its accompanying residential colony, entirely a government undertaking, made their way off site and to Upagiri The residents of Upagiri considered the engineered concrete or brick houses modern, like the ones seen in cities by so many of the mountain men who migrate seeking work. Concrete was also known to be strong. With the cement and variety of steel available, but without any knowledge of how concrete should be used, Upagiri residents imitated the houses to which they aspired.

Unfortunately, in the earthquake, the strength of concrete contributed to Upagiri's death toll of 70, the highest in any single village (GSI 1992). With the limited materials available, only portions of houses had been constructed of reinforced concrete. Traditional slate roofs were easily replaced with 4" thick reinforced concrete slab roofs that remained nearly whole, crushing anyone trapped inside when the masonry walls underneath failed. Concrete stories of greater height and less wall thickness recently built on top of shorter traditional ground stories, but not tied to them, shook vigorously in the earthquake and partially or totally collapsed. Such wall failures produced large concrete pieces that could do more damage to humans than smaller stone masonry pieces might have. Concrete blocks also displayed the potential strength of this building material for they never failed. The mortar joints between concrete blocks failed, tumbling entire walls.

The structural failures in Upagiri can be attributed to misapplication of concrete and steel based on lack of information, not to defective materials. The cement mortar between concrete blocks could be brushed away with a finger, and aggregate pieces could be pulled out of the mortar or concrete walls, indicating, a too lean cement mix and inadequate moisture during curing. Masons used the correct types of mortar and aggregate, but were unaware of correct concrete proportioning and curing. Three or four sizes of steel reinforcing rod sometimes appeared in one slab or column. Chicken wire, steel cable, and even one-inch diameter pipe had been embedded in concrete. The use of reinforcing steel in such a way that it diminished structural strength and may even have heightened concrete cracking and spalling suggests that crucial information was lacking.

As in Kinara, the death toll in Upagiri may not have resulted from discriminatory intention. However, the way that government sponsored infrastructural projects work, and the way that information flows, privileges people with more social status, especially in decision making, and leaves others with lower quality environments.

Unsafe conditions arose from the combination of a fragile physical situation with a lack of protective measures. Reduced concern about building safety, a low resilience local economy, and no public earthquake monitoring or education program, even at the time foreshocks, all contributed to the lack of protective measures.

Everyday risks faced in the area easily overshadow concern for building safety. While children are frequently ill, respiratory problems affect much of the population in winter . Livestock, and women collecting firewood experience fatal falls from the slippery paths they traverse. Hail, frost, flood or lack of rain causing crop loss mean a loss of subsistence food or of cash from market produce. Most families have precarious livelihoods and little economic resilience because of non-existent or low savings and significant debts.

Reconstruction increased the status of all households through the type of building material, site, number of stories or houses built, or replacement rather than repair. However, reconstruction maintained the relative status of households according to caste, outside employment and house type.

The Rajputs gained more from rebuilding than lower caste households. The Vishwa Hindu Parishad (VHP) adopted Bipur and donated two-story frame structures cemented in the ground. The VHP expected each household to fill in the walls of the structure. The braced design of the steel frames made them earthquake resistant. If Rajputs had received houses from the VHP in the same proportion as the Scheduled Castes, they would have received ten houses, but they received eighteen. Three of five Rajputs with old stone houses received VHP houses. The difference in economic status of the Rajputs, manifested in the building material of their old houses, did not make any difference in the distribution of VHP houses. Rebuilding highlighted the vulnerability gap between the highest and lowest status households in Bipur. Of the five Rajput households with old concrete houses, three received VHP houses and two repaired their concrete houses. Of the five Scheduled Caste households only one received a VHP house, one repaired the stone house, and three remained in their old stone houses. As outsiders, the Nepali household had a low status and remained in the same old stone house. The Lohar household replaced its old stone house with a new concrete one with a lintel. Before and after the earthquake, the Nepali and Scheduled Caste households disproportionately lived in houses unresistant to earthquakes and therefore, lived with an environmental injustice.

In Bipur, Rajputs and Scheduled Caste households repaired their old houses in about the same proportion: eight of fifty of the former and one of five of the latter. No disproportion or environmental injustice occurred along caste lines with respect to house repair in Bipur. Among the Rajputs, house repair rates varied with building material of their old houses, indicating that caste status alone did not determine what sort of living environment a household had after the earthquake. Two-fifths of those with old concrete houses, but less than one-seventh of those with old stone houses made repairs.

The VHP adopted Lungaon and gave each household at least one new house, but gave the Brahmins a disproportionately large share of the total number of houses and floors. The VHP gave forty-seven houses with a total of fifty-one floors to the Brahmins and two houses totalling three floors to the Scheduled Castes. Households with the higher status concrete houses received as many as four houses from the VHP, whereas those with stone houses received no more than two. Only Brahmin households received three or four VHP houses. The VHP reinforced social stratification in Lungaon by giving more to those who already had much.

About one-fourth of the households with old stone houses and about one-fifth of those with old concrete houses did not build any new house. Again, households with the least status, according to the material of their old house, rebuilt at a lower rate, remained more vulnerable in old houses, and therefore, experienced an environmental injustice. If rebuilding had changed social stratification in Lungaon all households would have rebuilt at the same rate.

Households with male members employed outside of Lungaon had a disproportionate share of old concrete houses, carried out the only repairs on houses after the earthquake, and disproportionately built multiple new houses. Only men had employment outside of Lungaon. Perhaps economic social status, improved by outside employment, helps one obtain a concrete house.

About one-half of the Scheduled Caste households in the old Kinara settlement had concrete houses while about one-fifth of the Brahmin and Rajput households did. In the new settlement all of the Rajput and Brahmin households had concrete houses and all but one of the nine Scheduled Caste households did. Judging by the concrete houses that they own, the Scheduled Caste households did not suffer disproportionately from unsafe physical conditions, and therefore, from environmental injustice. The concrete houses increased the status of otherwise vulnerable households.

Building in Kinara after the earthquake continued the simultaneous trends established in the new settlement: increasing status of building material for many and the maintenance of relative status between castes. In the old settlement, only four households built new houses of stone, while twenty-five households built with higher status brick or brick and stone. Almost one-half of the Brahmin and Rajput households built with brick or brick and stone, while only two of thirteen Scheduled Caste households did. Most importantly, less than one-third of the upper caste households remained in an unsafe physical environment without a house rebuilt by August 1994, while more than half of the Scheduled Caste households in the old settlement remained without a rebuilt house. In Kinara's new settlement only one Scheduled Caste household had not rebuilt by August 1994. The Scheduled Castes disproportionately remained in a less quality environment, without houses rebuilt in Kinara, and therefore, experienced an environmental injustice.

In contrast to rebuilding instigated by donors, Jagah's process to define a family and assign new houses displayed at least three elements of environmental justice: the community spoke for itself, all adults had a voice in decision making, and the number of rooms distributed to each household accounted for diversity without disproportionate benefit to one or another social status group. The two Scheduled Caste households in Jagah each received a three-room house. Two of the oldest male heads of household received two and three room houses, respectively, indicating no preference given to age status. A widow and a widower each received one room, indicating no gender discrimination. Among the three households containing two wives, only the one with a married son under the same roof received three instead of two rooms, so the economic status required to have multiple wives did not influence room allotment. The bearers of the village deity each received two-room houses, meaning that religious office holding did not garner more rooms for a household The status or economic resources associated with work outside the village does not align with the largest houses; even farmers without outside employment received three-room houses. Neither the size of a household's old house, nor political office holding influenced the number of rooms assigned. By assigning different sized houses to provide all households with equally quality environments, Jagah residents created an environmentally just allocation.

Every Jagah household had an earthquake resistant house at the end of reconstruction. Outside employment, age, caste, economic and educational status did not coincide with the order in which reconstructed houses reached completion. The Indian donor agency paid for reconstruction so completion rates did not depend on a household's economic status. Although one might suspect that higher educational attainment would give individuals better communication skills to oversee the work on their plot, or more access to information about building, higher education did not hasten house completion.

The spatial relationships in a completely reconstructed village embody reinforced or changed social stratification. If houses had the same relative elevation or proximity to the main footpath in reconstructed Jagah as they had in the damaged settlement, then reconstruction reinforced social stratification. Eleven households increased their relative elevation while nine decreased their relative elevation as they moved from earthquake damaged to reconstructed Jagah. With additional numbers of elevations, reconstruction opened up the social space by expanding the physical space. The households at the highest elevations maintained their position through reconstruction more than any other group. Five households remained in the top three elevations while only two households remained in the bottom three elevations of both damaged and reconstructed Jagah.

Marathwada Earthquake

The government of Maharashtra health directorate began relief operations at 6:00 am on October 1, 1993, and the injured were transported, for first aid (Parasuraman, Balasubramanian, and Keezhangatte 1995). Damaged local infrastructure delayed transport of the injured from interior villages. The average wait for first aid at Killari, Latur district, was ten hours, shorter than the wait in Osmanabad district (TISS1994). Thirty-seven percent of the injured in Osmanabad district and 39% in Latur district received first aid within 6 hours, whereas 19% of the injured in Osmanabad district and 12% in Latur district received first aid after 24 hours.

As a consequence of the various distribution efforts, all people received some, but not equal, relief. Distance from the road, economic status, gender, age, caste, community, and religion affected who received what, when. Villages near the road received more material provisions in the first few days than those further from the road, and Latur district villages received more relief than those in Osmanabad district (Parasuraman, Balasubramanian and Keezhangatte 1995). Villagers along the road stopped trucks with relief materials, evoking the sympathy of volunteers whose organisations lacked plans for distribution. Media reports of the concentration of relief in a few Latur villages resulted in the diversion of materials to interior Latur and Osmanabad and shortages in villages that received earlier attention. Families, like the nomadic Tandas who live away from the main village almost everywhere, received less relief than families residing nearer the roadside or panchayat office relief areas. People of less social position living near the road and less likely to have land or other valuable property to safeguard received more relief than those staying at their old sites.

Women received less relief than men because they were too shy to eat food on the road and because of problems for single women in accessing relief. For instance, food distribution proceeded on the basis of cards issued by the government, with separate queues for men and women (Parasuraman, Balasubramanian and Keezhangatte 1995). Women who had never been expected or permitted in traditional village life to handle official or business matters had difficulty approaching such a queue system.

While differential provision of temporary shelters by the government occurred along class and caste lines within villages, there is no evidence that it occurred between villages. Villages with the greatest percentage of upper castes and classes had neither the most sheds provided by the government nor the greatest number of sheds built by the villagers. Numerous high social status residents neither curried government favor nor guaranteed economic resources for rebuilding themselves. Within villages, households of different communities often had uneven access to temporary shelters. Three hundred of the 400 dalit houses in Jewri collapsed, yet only 100 received temporary sheds. The upasarpanch (deputy elected leader) of Karegaon reported that 170 of 1500 dalits' households had their houses destroyed but only 55 received temporary sheds.

An Indian "Map Showing Suitable Sites for Rehabilitation of Earthquake Affected Villages of Latur and Osmanabad Districts, Maharashtra" used by the Andhra Pradesh State Remote Sensing Applications Center (APSRSAC) indicates the location of 119 villages, and the isoseismal, geographic unit and damage classifications to which they belong. Most of the 89 villages proposed for relocation were to move within the same isoseismal or to a safer, isoseismal. Intending to achieve safe conditions, the state government planned to move 68 villages to higher geographic units than they occupied at the time of the Marathwada earthquake. The Maharashtra government planned to relocate even partially damaged villages. The four severely and moderately damaged villages not treated like the others in their damage classifications were relegated to less quality, more physically fragile environments.

The greatest environmental injustice resulted indirectly from relocation that placed villages, and therefore, thousands of people, in more disadvantageous situations regarding distances to water resources, neighboring villages, and roads than they endured before the earthquake. According to the map prepared by APSRSAC, the average distance separating villages from their potential waters sources increased from .51 km before the Marathwada earthquake to .76 km with proposed relocation. Proposed relocation increased both the range of distances and the average distance between villages and water sources. At the time of the earthquake, villages ranged from 0-2.30 km from water sources. The rehabilitation plan proposed siting villages from 0.5-2.55 km from water sources.

The 50% increase in average distance between villages and water sources means that people in relocated villages will expend twice as much time collecting water from the sources or taking livestock to water. Because women and girls in Marathwada usually have the responsibility for collecting water for their households, the burden of increased travel and time expenditure to meet water needs will likely fall disproportionately on females. Therefore, the increased distance to water sources imposes an environmental injustice on females.

The potential water sources for villages at the time of the earthquake had both nearer proximity and greater reliability than the water sources for relocated villages. Streams and impoundments served as the potential water sources for fewer village relocation sites than for existing villages. Meanwhile, less reliable lineaments served as potential water sources for more relocation sites than for existing sites Proposing to relocate villages with less reliable potential water sources than they had before the earthquake constitutes an environmental injustice.

On average, the rehabilitation plan put villages farther from water sources, but nearer roads and neighboring villages. The clustering of villages created uninterrupted residential areas that exacerbated the problem of increased distance to agricultural fields. The increased proximity of greater numbers of people dependent on limited water resources allows diseases to spread very quickly. The decreased average distance between the road and the proposed village sites may benefit those with agricultural surplus to sell because transportation costs would decrease. The larger landowners, not the landless or marginal, would have surplus. The landless and marginal may benefit from decreased average distance to the road through decreased travel time to wage labor opportunities across a wider area. Relocated villages and households suddenly at the side of a road traversed by motor vehicles travelling much faster than traditional oxcarts face new traffic hazards. People with less visual or audio acuity, perhaps some of the elderly or children, and animals experience the most traffic risk. With easier access by outsiders, roadside villages may face more thefts and incur greater costs to insure security of property than interior villages. Government officials, NGO personnel, and other outside visitors reach roadside villages before reaching interior villages; sometimes they only reach the roadside. Relocation doubled the number of villages sited less than 250 m from a road. Relocation planners suggested a site away from the road for Killari, an important regional trading center and the largest town crumbled by the Marathwada earthquake. Losing a place near the road intensified the challenge of economic rehabilitation looming over seven villages.

The state government's use of remote sensing technology as the major means for assessing relocation sites not only "preselected" upland basalts, but the landowners that would be affected by land acquisition. The government acquired land from 33 villages, 15 in Latur District and 18 in Osmanabad District. The government acquired land from those owning 6 to 10.99 or 11 to 15.99 acres disproportionate to their numbers in many more villages than the government disproportionately acquired land from owners of larger or smaller amounts of land. Of those from whom the government acquired land, the proportion made landless or marginal (owning less than 2 hectares) decreased with increasing amount of land owned. The largest landholders, those with 16 or more acres, experienced the least landlessness and marginalization. Those owning 6 to 15.99 acres became marginal to a greater extent than they became landless. The smallest landholders, those with up to 5.99 acres, many of whom were already marginal, became landless to the greatest extent. The government disproportionately acquired land from Muslims, Scheduled Tribes, Scheduled Castes, and Other Backward Classes in 18 villages, indicating that people of low social status were more frequently negatively impacted than the higher status Marathas. Of those from whom the government acquired land, the proportion made marginal decreased with increasing caste or religious status. The Scheduled Tribes became landless to the greatest extent. Because government land acquisition made a large proportion of the Scheduled Caste landholders marginal, a smaller proportion remained to be made landless than remained among the Marathas.

The use of remote sensing by scientists from outside of the earthquake affected area removed much of the relocation decision making from local village politics. The most powerful, those with large landholdings or high caste and religious status, could not insulate themselves from all of the negative impacts of land acquisition. Perhaps those with the least status experienced fewer of the negative impacts than they might have if government land acquisition had been based on information other than remotely sensed images.

Disproportionate numbers of Marathwada villages, according to their size, demographic make-up, landholding, and earthquake casualties, remained without reconstructed houses in July 1996, or received houses built with unusual techniques. By July 1996 families had taken possession of their houses in 20 of 31 relocated Latur District villages. These 20 villages ranged in size from 113 to 657 households (TISS 1994). The four largest relocated villages, with 2255, 1177, 714, and 675 households, respectively, did not have possession of reconstructed houses by July 1996. The villages that incurred the largest losses in the Marathwada earthquake reaped the earliest reconstruction benefits. Only two villages with more than 90% of the homes completely destroyed did not receive reconstructed houses by July 1996. Seven of the eleven relocated villages that did not have their new houses by July 1996 had less than 80% of their homes completely destroyed in the earthquake. The five Latur District villages not covered by the World Bank funds for reconstruction did not have houses handed over to the residents by July 1996. Among the relocated villages without houses by July 1996, those

without World Bank funds had a smaller percentage of Scheduled Tribes and Castes, Notified and Denotified Tribes, and Other Backward Classes than the villages included in World Bank funding. Villages with smaller percentages of households with the lowest caste did not have World Bank funding for reconstruction or their reconstructed houses, in part, because Maharashtra government officials administering the relocation plan could court vote banks for re-election by directing World Bank funds towards them. Only one village with a high percentage of large landholders, did not have houses handed over to the owners by July 1996. Villages with a lack of large landholders were also likely to lack reconstructed houses by July 1996. Large landholders had the means to travel, and the political and business contacts that permitted them to lobby for reconstruction and act as watchdogs over its implementation.

Of the 31 Latur District villages relocated, the government took sole responsibility for six, donors took sole responsibility for 19, and the government and donors worked together on six. Five of the 12, or almost half, of the villages with any government involvement in reconstruction remained without houses by July 1996. Six of the 25, or about one-fourth, of the villages with donor reconstruction remained without houses by 1996. According to official figures for Latur District, by August 21, 1996, the state government built 19% of the proposed houses, while donor agencies built 75% of the houses. Donor agencies completed their work on 41.6% of amenities such as schools, primary health care centers, and balwadis (creches), while the government completed 32% of its work (Bunsha 1996).

By July 1996, households in 15 of 26 relocated Osmanabad District villages ranging in size from 142 to 615 households possessed their reconstructed houses (TISS 1994). The six largest villages relocated in Osmanabad District did not possess reconstructed houses by July 1996; in fact, 10 of the largest 13 villages did not. In Osmanabad District, only one of seven villages with the highest percentages of Marathas did not have reconstructed houses by July 1996. Nine of the fourteen villages with the highest percentages of the lowest status castes and six of the nine villages with the highest percentages of Muslims remained without new houses in July 1996. As in Latur District, Osmanabad villages with the lowest percentages of large landholders generally had not received houses by July 1996. Five of the six villages with the largest percentages of landless households, and one of the six villages with the largest percentages of large landholders did not possess reconstructed houses by July 1996. Of the twenty-six villages actually relocated in Osmanabad District, donors stepped forward to rebuild thirteen, the Maharashtra state government took responsibility for ten, and donors combined efforts with the government to rebuild three. Only one of the villages for which the government took sole responsibility had houses by July 1996. Nine of the thirteen villages reconstructed by donors received houses by July 1996. Government and donor cooperation moved one village into new houses by July 1996. Donors moved villages into safer houses more quickly than did the government. The Maharashtra state government took sole responsibility for reconstructing five of the six largest villages relocated in Osmanabad District. All six villages remained without houses in July 1996.

The fault line of vulnerability ran between those villages receiving load bearing houses and those villages receiving non-load bearing houses. Marathwada households had experience repairing and expanding their vernacular, stone and mud mortar load bearing houses. Even with the overall shift from stone to concrete between the vernacular and reconstructed houses, villagers receiving load bearing houses could more readily repair or expand their houses themselves, or supervise such work, because of their familiarity with the structures, than those receiving non-load bearing houses. Without additional training or tools, villagers receiving non-load bearing houses face greater future vulnerability.

Both national and international NGO relief contributions to Marathwada far exceeded those to Uttarkashi. Marathas have higher social status than Paharis, and to a greater degree than the Paharis, have spread across India and the world. Marathas with relatives in the earthquake affected area or an affinity for their cultural home base could draw on their personal leadership and economic circumstances to arrange relief contributions.

Politically aspiring Maharashtra Chief Minister, Mr. Sharad Pawar, responded to the incentives of increasing party stature and electoral popularity to finesses a mammoth reconstruction effort. Reporting as expansive earthquake losses as possible, even short of exaggeration, helped Pawar obtain as large World Bank loan as possible for reconstruction. The alignment of state and central governments made it more likely for Maharashtra to receive, and therefore, more worth while to pursue, a World Bank loan than it would have been for Uttar Pradesh Chief Minister, Mr. Kalyan Singh, at the time of the Uttarkashi earthquake. The World Bank makes loans to national governments so any Indian state requesting World Bank funds requires central government support. Prime Minister P.V. Narasimha Rao and a Congress Party government led India at the time of both earthquakes. Leading a Bharatiya Janata Party (BJP) state government opposed to the center, Kalyan Singh would have had a more difficult task obtaining a World Bank loan than did Pawar. An ambitious Congress politician leading a state aligned with the central government. Thus, a backward region, Uttarkashi, in a politically unempowered state remained marginalized while a backward region, Marathwada, in a politically powerful state tapped into global financial resources.

Environmentally just outcomes emerged most strongly at the scale at which villages, NGOs and government organised reconstruction. More environmentally just outcomes occurred within villages in Uttarkashi and between villages in Marathwada. The government provision of cement and steel reinforcing rods to households, and no prescribed Uttar Pradesh state government plan for rehabilitation led to residents and NGOs organising reconstruction at the village level. The more overarching Maharashtra Earthquake Rehabilitation program arranged financing for, and directed relocation of villages, not households. Planners and implementers of reconstruction intend their efforts to have positive outcomes, but could induce more encompassing environmental justice by working at multiple scales.

Even an exception indicates that environmental justice emerged most clearly at the scale at which reconstruction was organised. Residents of Rampur village pooled their resources to buy land for relocating their village after learning that the state rehabilitation plan excluded them. Each Rampur household had a new house plot, a shelter, and a kitchen garden by July 1996. Surrounded by reconstruction organised with villages as basic units, Rampur organised with households as basic units and reaped the benefits of environmental justice within the village. If all villages had done their own decision making like Rampur, perhaps more households would have had better quality living environments sooner, and environmental justice would have blossomed both within and between Marathwada villages.

CONCLUSIONS

No environmental justice came to light between districts, between state or regions or between nations in the Indian earthquake cases. All but one of the environmental injustices at district scale or larger were associated with the relief and reconstruction phases of the earthquakes. The environmentally unjust distribution of electricity and earthquake resistant construction know-how between regions preceded the Uttarkashi earthquake, but resulted in disproportionate deaths in the earthquake and uneven economic resources for rehabilitation.

Decreased vulnerability and environmentally just outcomes emerged most strongly at the scale at which villages, NGOs and government organised reconstruction, so future engineering efforts should address multiple scales. Where an NGO catalysed land exchange and trained masons, and where reconstruction decisions were made by all of the adult village residents, rather than by government, household livelihood needs were fulfilled without disproportionate gain or loss for any social group. Future activities to decrease earthquake vulnerability should intervene with the people of lowest social status.

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