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Should I stay or should I go? Mitigation strategies for flash flooding in India

Sudha Arlikatti[a,*], Praveen Maghelal[b], Neera Agnimitra[c], Vaswati Chatterjee[d]

[a] Faculty of Resilience, Business Continuity Management and Integrated Emergency Management Programs, Rabdan Academy, P.O. Box. 114646, Abu Dhabi, United Arab Emirates
[b] Department of Industrial and Systems Engineering, Khalifa University of Science and Technology, MI Campus, P.O. Box 54224, Abu Dhabi, United Arab Emirates
[c] Department of Social Work, Delhi School of Social Work, University of Delhi, India
[d] Department of Public Administration, University of North Texas, 410 Avenue C, Chilton Hall Suite 204, Denton, TX 76203, USA

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ABSTRACT

Post-disaster rehabilitation and rebuilding efforts are oftentimes spearheaded by government agencies rather hastily, to meet the urgent demands of disaster survivors. However in the absence of pre-planning for disaster recovery, they may increase community vulnerabilities due to a break down in social ties and livelihood needs. There is a growing recognition that adhoc top down policies should be replaced with an understanding of the preferences and needs of disaster survivors. This research is aimed at gauging the intended mitigation strategies that survivors from the Himalayan region of North India expressed, following the devastating flash flooding in 2013. A semi-structured questionnaire was used to interview 316 residents from 17 villages in the State of Uttarakhand to measure demographic characteristics, risk perception, prior flash flood hazard experience, evacuation experience, damage to home, and intended structural (relocate/ building back better) and non-structural (investing time and effort in emergency planning or raising self-awareness and knowledge of threats knowledge) mitigation measures. Findings suggest that relocation is not a preferred mitigation strategy. Rather, an overwhelming majority of the respondents are interested in emergency planning at the household and village levels. Investing in revising and updating the plans at all levels of government, reviewing the existing forecasting and warning system and creating a robust risk communication plan with local input, strictly enforcing the provisions of Flood Plain Zoning Act, 2012, improving hazard awareness programs and creating village level task forces with direct linkages to the State Disaster Management Agency are some of the recommendations made.

1. Introduction

The month of June 2013 saw the entire State of Uttarakhand in north India hit by torrential rains coupled with glacial melting and increased runoff causing rivers to swell and the breach in the Chorabari Lake. This resulted in a devastating flash flood and landslides on June 16–17, termed by the media as the *Himalayan Tsunami* [12,7]. A National Institute of Disaster Management report titled, "Uttarakhand Disaster 2013″ (2015, pp. 5) cited loss estimates received from the Uttarakhand State Government on 09 May 2014 as, "169 people died and 4021 were reported missing (presumed to be dead), about 4200 villages affected, 11,091 livestock were lost and 2513 houses completely damaged." More than nine million people were affected and the worst impacted districts were Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi.

The State of Uttarakhand includes parts of the Himalayan Mountains and foothills and is home to approximately 10 million people [6]. The State shares international borders with Nepal and Tibet and is well known for rivers large and small, with two of the most important Indian rivers the Ganga and the Yamuna originating in the Gangotri and Yamunotri glaciers in the Uttarkashi district of the state. The four pilgrimage towns of Badrinath, Kedarnath, Gangotri and Yamunotri forming the *'Char Dh*am' (four abodes) circuit sacred to Hindus, are also located in the state. As such this region is considered hallowed ground for millions of Hindu pilgrims from India and South Asia who refer to it as "Dev Bhumi" (i.e. Land of the Gods). Tourism statistics for the state put domestic tourists visiting Uttarakhand in 2010, at 30 million. The flash flood coincided with the peak pilgrimage season to Kedarnath Dham, home to the revered Kedarnath (Shiva) temple, resulting in high fatality rates among pilgrims who were natives of other states in India. Hotels, public buildings and housing, both in the rural and urban areas on the banks of the Alaknanda, Bhagirathi and Mandakini rivers were severely damaged. Road and electricity connectivity were lost, and hundreds of villages remained disconnected from relief workers for weeks due to damaged infrastructure.

On account of its distinct geo-climatic, ecological and socio

* Corresponding author.
E-mail addresses: sarlikatti@ra.ac.ae (S. Arlikatti), pmaghelal@masdar.ac.ae (P. Maghelal), neeraagnimitra@gmail.com (N. Agnimitra), vaswati.ju@gmail.com (V. Chatterjee).

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economic characteristics, Uttarakhand is one of the most disaster prone states in India (NIDM, 2014). Natural hazards like earthquakes, landslides, avalanches, cloudbursts, hailstorms, glacial lake outburst floods, flash floods and forest fires have caused major losses to life, property and resources and adversely impacted the economic development of the state. Additionally, various human activities including construction of hydropower projects, growth of the tourism sector, and riverbed mining have contributed to deforestation and the degradation of this fragile eco-geological system. These have made the residents of this region even more vulnerable to multiple natural hazards (NIDM [16] pg 3). In 2008 an Uttarakhand Tourism Development Master Plan 2007–2022 [13] was jointly prepared by the union and state government to guide planning and sustainable development. However flagrant disregard of this plan and guidelines therein are evidenced in the haphazard development and encroachment of the fragile mountain slopes, increasing the devastation from the disaster (Hindustan Times, June 29, 2013).

The Government of India (GoI) under the guidelines of the Disaster Management Act (DMA) of 2005 specifies five major forms of funding for disaster management, namely the National Disaster Response Fund (NDRF), the State Disaster Response Fund (SDRF), the National Disaster Mitigation Fund, the State Disaster Mitigation fund and the District Disaster Mitigation Fund. Of these only the NDRF and SDRF are formalized with earmarked funding. The DMA further stipulates that the SDRF "shall be used only for meeting the expenditure for providing immediate relief to victims" of 12 notified hazards— cyclone, drought, earthquake, fire, flood, tsunami, hailstorm, landslide, avalanche, cloud burst and pest attack (DMA 2005; Disaster Management Division of the Ministry of Home Affairs 2010). In case of special category states like Uttarakhand, the GoI contributes 90% of the allocated budget while requiring the state to cover 10%. Other funds for rehabilitation, recovery and mitigation projects need to be established by notifications from different levels of government as and when required. Thus, following the 2013 flash floods the Department of Economic Affairs (DEA), Government of India (GoI) sought funding from the World Bank for recovery projects in this region.

Subsequently, The World Bank and the Asian Development Bank (ADB), fielded a Joint Rapid Damage and Needs Assessment (JRDNA) Mission that visited the State from July 29 to August 07, 2013. In collaboration with the Government of Uttarakhand (GoUk), the JRDNA Mission undertook a multi-sectoral assessment of the damages and laid the groundwork for an immediate recovery and reconstruction needs framework. This resulted in approval from The World Bank on 25th October 2013 for the *Uttarakhand Disaster Recovery Project*, with development objectives to restore housing, rural connectivity and build resilience of communities in Uttarakhand and increase the technical capacity of the State's entities to respond promptly and effectively to an eligible crisis or emergency ([20]; The Project Management Unit, First progress Report 2015). This project will close on June 30th, 2019.

Although the Uttarakhand Disaster Recovery Project is noteworthy, it was sanctioned within four months of the disaster, possibly leaving little time to connect with the local people to gauge their needs and preferences for mitigation planning. Arlikatti and Andrew [3] noted that oftentimes post disaster recovery projects are spearheaded by government agencies rather hastily to meet the urgent demands of disaster survivors. This results in an over reliance on a homogenous strategy that follows the "Build Back Better" approach with a greater thrust towards structural mitigation measures like building a sea wall or dike, adopting stringent building codes and better construction materials for building stronger homes or relocating away from the risk area. In such a context the micro realities of survivors needs are often ignored or bypassed. Their expectations for non-structural mitigation measures like disaster education, awareness generation and training or revival of local/indigenous early warning systems, and investments in post-disaster trauma counselling for psychological recovery are often not accommodated.

Alternatively, post disaster recovery may be left entirely to market forces such that those with homeowners or renters insurance are able to rebuild and bounce back while the resource strapped or marginalized are left devastated for years. The process of building back better and instituting mitigation strategies have also been known to ignore survivors' livelihood needs and preferences thus subjecting them to even more hardships. It is well recognized that absence of pre-planning for disaster recovery leads to inadequate post disaster efforts and an increase in community vulnerability to future events [1,4].

Post disaster recovery activities may also fail wherever an integration of community stakeholders is absent. Chang et al. (2010) reviewed disaster recovery programs in China, Indonesia and Australia initiated either by the government, non-governmental organizations (NGO)/donors or market forces (private contractors). They found that government driven reconstruction efforts faltered in the absence of long term recovery planning, NGO driven efforts failed due to their unfamiliarity with the local environment, while market driven recovery efforts failed due to lack of coordination with other stakeholders like local construction firms and recipient communities.

Similarly in their detailed review of the 2001 Gujrat Earthquake rebuilding efforts in India, Barenstein and Iyengar [5] underscored the need for community participation in reconstruction efforts right from the outset. They compared satisfaction levels between individuals that built their own homes with fiscal and technical help from the government and NGOs i.e. Subsidiary Housing Approach (SHA), Owner Driven Reconstruction (ODR) and the Participatory Housing Approach (PGA), to those who moved into contractor built homes in situ (CODIS) or were ex-nihilio or relocated (CODEN) and concluded that recipients of SHA, ODR and PHA were not only the most satisfied in that order compared to recipients of contractor built agency houses but their housing designs were more sustainable as they utilized local materials and methods of construction. On the other hand, a substantial number of agency built houses were left unoccupied since their locations and styles were far from local livelihoods and needs.

Andrew et al. [2] assessed the 2004 Indian Ocean Tsunami reconstruction efforts in Tamil Nadu, India and found similar patterns. NGO driven relocation and reconstruction activities did not take into account the indigenous housing needs such as location of toilet outside a home or the use of locally available eco-friendly building materials traditionally used. Consequently owner driven reconstructions were more acceptable and satisfactory compared to donor funded relocation schemes. Furthermore, lack of government monitoring and controls led to demolishing of undamaged houses to build newer ones by contractors hired by NGOs and poor construction techniques [4]. The government's solution of building back by providing new NGO sponsored houses in newly acquired lands away from the coastline inevitably led to wastage of resources and disruption of fishing livelihoods.

An analogy for disaster induced displacement and relocation can be drawn from instances of development induced displacement. Asthana [1] elucidated the significant economic and socio-cultural disruption that such relocation brings in the lives of the displaced communities, especially women. Experiences of women displaced from their original villages due to the Tehri Dam project in Uttarakhand, India, highlighted a heightened sense of insecurity faced in the new physical and social space assigned to them. The government 'built' houses and 'unfamiliar' residential patterns, cultural and linguistic differences as well as hostilities both perceived and real, in these resettlement areas were a far cry from the security of their original settings. Due to distance from their social networks and kinship groups, women also experienced loss of their support systems, making them more dependent on the male members of the household.

What this means is that post-disaster recovery and development projects initiated by governments oftentimes fail to meet the needs of disaster survivors in both developed and developing countries. As such the empirical research described in this article independently carried out within 3-1/2 months following the disaster, using a comprehensive instrument developed by the authors contributes meaningfully to theory and practice of disaster mitigation.

The instrument quantitatively measures the mitigation actions that flash flood survivors from villages in the lowlands, midlands and uplands en-route to Kedarnath Dham in Uttarakhand intend to take to protect themselves and their families from future threats. These include their varying preferences to relocate to safer grounds, building back better, seeking information about flash floods, watching for environmental cues and creating emergency plans at the village level. The broader intent of this research is to also comment on whether the sectoral projects related to reconstruction of resilient housing and public buildings, tourism, urban water supply, roads and bridges and civil aviation for emergency assistance that are underway in the State, meet the survivors' needs, and to highlight new ones for consideration.

First however, a brief review of popular mitigation strategies initiated in mountain communities to protect residents against landslides, flash flooding, and flooding threats is discussed. These guided the survey questions related to mitigation strategies. This is followed by the research questions and a description of the convenience sampling strategy for data collection, followed by a section on analyzes and findings. Finally, the results and discussions section provides a more nuanced interpretation of the findings with the conclusions providing specific recommendations.

2. Mitigation for flash flooding in mountain communities

Montz and Gruntfest [15] noted that one of the greatest difficulties in addressing flash flood problems is defining them. Agreed upon characteristics of flash floods are that they occur suddenly, with little lead time for warning; they are fast-moving and generally violent, resulting in a high threat to life and severe damage to property and infrastructure; they are generally small in scale with regard to area of impact; they are frequently associated with other events, such as riverine floods on larger streams and mudslides; and they are rare (pg. 16). Consequentially, losses from flash floods are expected to increase in high risk areas such as mountainous regions of the world due to haphazard development and human activities.

Flash flood mitigation in remote mountain communities is oftentimes compounded by the interplay of geographical, socio-demographic and political factors. Gardner and Dekens [9] identified three specific challenges for disaster resilience in mountains. Firstly, mountain ecology is comparatively dynamic both geographically and hydrologically and characterized by larger bio-diversity because of different altitudes. Secondly, the traditional, organic or unplanned settlement patterns in mountain regions are categorized by smaller pockets of communities often separated by geographical features. Thirdly, because of distinct natural resources there is always a political tension between highland and lowland communities.

Other scholars have noted challenges stemming from an erosion of a self-resilient culture and kinship networks in mountain communities of Central Asia [11,17]. They have found that traditional knowledge transfer of indigenous sustainable development and construction practices through oral histories have lost their importance (Rautela 2007). This is primarily because of the demographic shifts taking place in these regions. High rates of poverty and unemployment have forced male members to give up mountain-based livelihoods and seek employment elsewhere in the region or in urban areas. This outmigration has resulted in an increase in female headed households caring for their young and elderly. Forced to balance work on the family farm and serve as care-givers, has left women with little time, physical capacity or monetary resources to work on strengthening their homes to protect against anticipated hazards [11].

Schad et al. [19] study of flood mitigation policies in mountain communities of Vietnam found that farmers often ignored adoption of mitigation techniques like soil conservation because of the top-down approach of government initiatives in implementing disaster management policies and the economic constraints it put on them. The authors emphasized that a more community based approach for implementing zoning and land use policies needed to be adopted with farmers receiving education and training to increase their buy in to adopting these techniques. This was also reflected by Dixit [8] who found that government initiated disaster mitigation in the Himalayan and Gangetic regions emphasized only structural mitigation measures and failed to focus on social needs.

While access to hazard information and risk perception have been identified as important factors for adopting disaster mitigation policies, Lin et al. [14] through their study of flood and landslide victims in Taiwan suggested that increased risk perception alone does not necessarily lead to adoption of mitigation techniques. Vulnerable populations often feel helpless/powerless, and assume that nothing can be done to protect them from hazards. This psychological factor inhibits adoption of mitigation techniques (p. 312). Utilizing indigenous materials for reconstruction, self-rescue strategies for remote villages and appropriate warning sources have also been discussed as sound mitigation strategies. Remote rural mountain communities that are likely to be cutoff following a disaster need to be self-reliant and have their own evacuation and rescue operations plans, depending upon their geography.

Halvorson and Parker Hamilton [10] in their study of post disaster reconstruction efforts after the Kashmir earthquake 2005 further emphasized that not only is knowledge of indigenous construction practices required, but the government must also disseminate the information to the communities efficiently. Even where local communities approve the reconstruction plans proposed by the government, they are likely to face difficulties in constructing their homes themselves because of a lack of technical know how about construction materials and design. Thus, Santi et al. (2011) concluded that developing countries should pay special attention to socio-cultural characteristics while designing mitigation policies and introduce indigenous construction practices into their policies (p. 397).

2.1. Research questions

The review of literature above underscores the importance of receiving inputs from disaster survivors in disaster mitigation efforts. Keeping this in mind the present research examines responses of 316 flash flood survivors from 17 villages situated in the Himalayas in North India to answer the following related questions:

RQ1: What types of mitigation measures do flash flood survivors intend to take to protect themselves and their families against future threats?

a. Structural mitigation - Relocate permanently to another location; build stronger homes or raise the home.
b. Nonstructural mitigation - Emergency Planning - Participate in discussions with neighbors and village leaders; work to create a village emergency plan/ have a family emergency plan.
c. Nonstructural mitigation - Raising Self-Awareness and hazard knowledge - watch for environmental cues; look for additional information on flash floods.

RQ2: Are the intentions to take structural and nonstructural mitigation measures correlated?

RQ3: Are intentions to relocate correlated with risk perception and respondent's village location *(lowland/ midland/ upland)?*

RQ4: What are the policy implications of these findings at the village (Panchayat level), state and national level, with the aim to foster resilience building?

3. Methodology

3.1. Study area

Following the June 17th, 2013 flash flood disaster in the State of

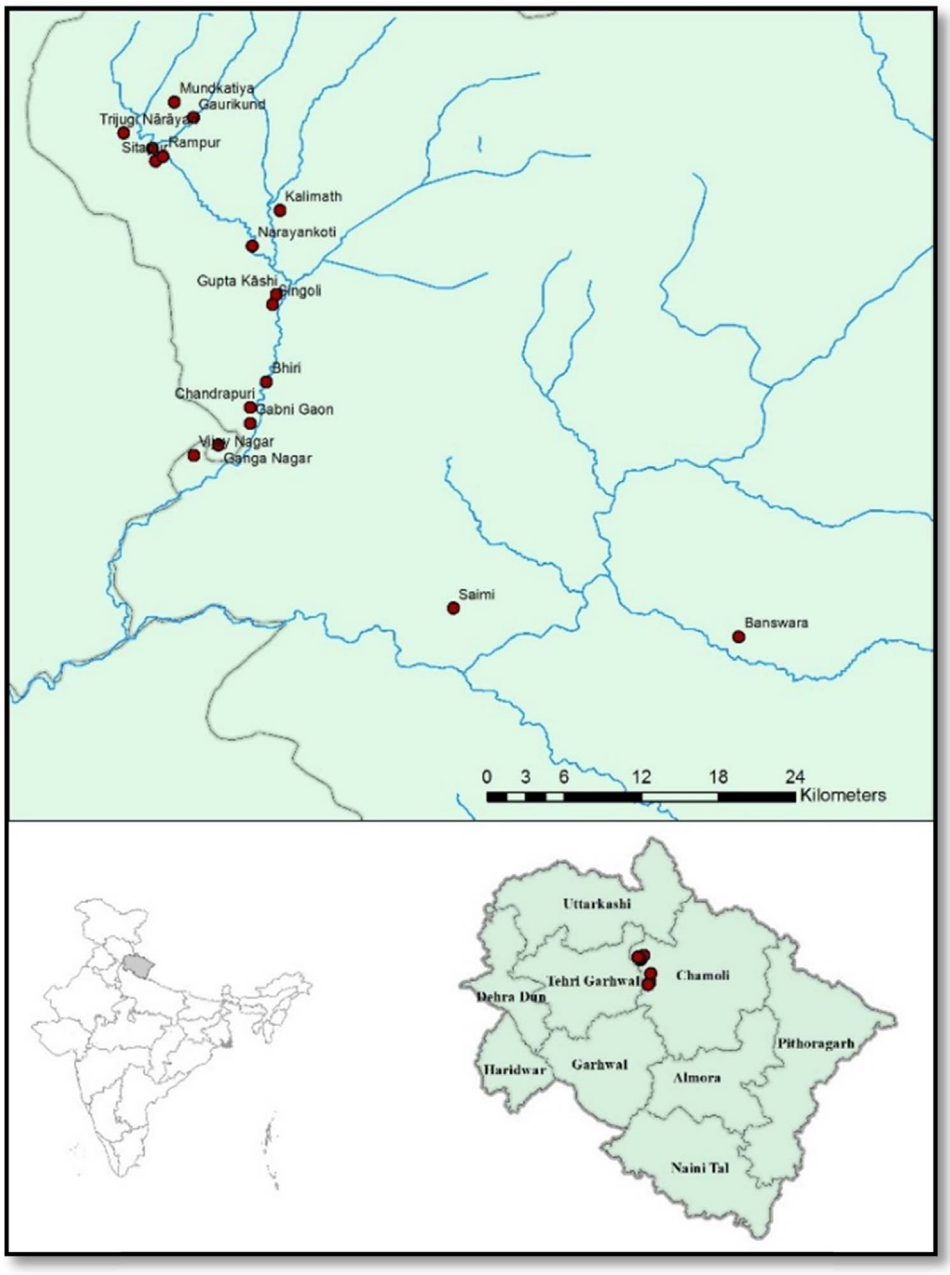

Fig. 1. Location map of villages in the sample with reference to the State of Uttarakhand and India

Uttarakhand, North India, the US research team drafted a questionnaire. This was shared with the Indian researcher who reviewed and edited it to reflect local spellings, words and expressions and translated it into Hindi. Pre testing of the survey instrument and training of the Indian team by the lead investigator from the USA was undertaken to ensure cultural appropriateness. 316 flash flood survivors were identified and interviewed face-to-face using a semi-structured interview schedule from October 16th- Nov 1st 2013 by a six member research team in the local language (Hindi). Interviews took place in 17 villages, at survivors' homes, government and nonprofit sponsored temporary shelters, at highway stops, local shops and banks of the Mandakini river en-route to the Kedarnath temple in Rudraprayag district. Fig. 1 provides the location of the respondents villages in the State of Uttarakhand and India.

3.2. Data collection

A convenience sampling strategy was adopted to identify respondents as the study was conducted four months after the disaster and many of the roads were impassable due to continuing landslides and widespread infrastructure damage and ongoing recovery activities. A list of flash flood affected villages from lowlands, midlands and uplands en-route to Kedarnath temple was drawn and village leaders or local liaisons identified. They further helped locate potential participants who had been directly impacted by the disaster ——experienced death or injury and damage or destruction to homes and farmlands from the floods. These participants further suggested others from their kinship network. A 50 questions survey instrument was used to collect data but only those related to risk perception, hazard experience, home damage, socio-demographic characteristics and intended mitigation measures are analyzed in this paper.

3.3. Data analysis and findings

The survey responses were coded, cleaned and analyzed in STATA. To assess the structural and non-structural mitigation measures, respondents' were asked if they would look for additional information about flash floods, have a family emergency plan, participate in

discussions with neighbors and village leaders, work to create a village emergency plan, move during the monsoon season, relocate permanently to another location, build stronger homes/ raise the home, watch for environmental cues, or other. Responses on a 3-point Likert type Scale ranged from *(Not at all = 1 to Very great extent = 3)*. Subsequently a descriptive analysis was conducted.

To assess risk perception, respondents were asked seven questions—during the flood, how likely they thought the flood would severely damage or destroy their home; injure or kill them and their families; disrupt their jobs and prevent them from working; disrupt electrical, telephone and other basic services; destroy or severely damage homes in their village; injure or kill people in their family or village if they did not evacuate. They were also asked if anyone in their household was killed or injured by the flood/landslide, or if any family members were still missing. Responses on a 3-point Likert type Scale ranged from *(Not at all = 1 to Very great extent = 3)*. An aggregate risk perception measure was then computed.

To better understand the correlation between the most intrusive structural mitigation measure (i.e. relocation) and non-structural mitigation measures (i.e. emergency planning and disaster awareness) a contingency table/ cross-tabulation analysis was performed. Respondents' also reported on their socio-demographic characteristics including age, gender, marital status, household size and ages of family members (lower than 18, 18–65, greater than 65), member/s with special needs requiring assistance, caste, religion, highest level of education, household income, home ownership and tenure in the village and the frequencies computed (*see* Table 1.)

4. Results and discussions

4.1. Protective action - Relocate temporarily, permanently and/ build stronger homes (RQ1.a)

The respondent's intentions to relocate temporarily during the monsoons was mixed with 43% wanting to relocate to a great extent, 16% to some extent and 41% not at all willing to relocate temporarily during the monsoons. These findings are interesting and warrant further examination to understand whether relocation choice during the monsoons is related to resident's livelihoods coinciding with the pilgrimage season, seasonality in farming or increased perceptions of risk when it rains. On the choice to relocate permanently, the respondents were split in half with 48% interested to a great extent, 20% to some extent and 32% not at all. Residents favoring permanent relocation may have experienced the death or injury of family members and friends, or lost their homes, farmlands and orchards. Such personal losses not surprisingly would translate into higher perceptions of risk, making relocation a more palatable choice (Fig. 2).

On the other hand residents opposed to relocation may be concerned with the dilution of community ties, a dismantling of community cohesion and solidarity, and a breakdown of the informal social security systems. For example, Asthana [1], noted that during the Tehri Dam construction in Uttarakhand, villagers forced to relocate revolted by threatening the government with "Jal Samadhi" (i.e. self-immolation in the river that was to submerge their village and dwellings). The families were not only unhappy about the forced relocation but were also protesting the submergence of their ancient temples and the famous 60-foot-high "Ghanta Ghar" or Clock Tower. This landmark symbolized their sense of identity, culture and history. Although the government 'transplanted' all the temples from the old town to the new township, and also created a replica of the Clock Tower there, the people could not relate to it as buildings rarely matched the originals and were also not culturally relevant.

Finally, about 37% respondents wanted to build stronger homes, while 48% respondents did not express any intention to build back better. Currently, 2499 Owner Driven Construction of Houses (ODCH) are underway for those who experienced complete damage to their homes, with funding from the World Bank. Technical knowhow is being provided by government agencies but the construction of stronger disaster resilient homes is spearheaded by the recipients. However, it appears that many villagers believe their traditional homes and village locations are adequate in keeping them safe. Such nuanced differences amongst respondents, needs further investigation.

Table 1
Characteristics of respondents (N = 316).

Income[a]	Percent	Marital status	Percent
< Rs. 5000	50.9	Married	74.7
5000–10,000	23.1	Single	12.0
11,000–25,000	13.3	Widowed	13.0
26,000–40,000	6.3		
41,000–55,000	2.8	Tenure (years)	
> 55,000	3.5	0–10	22.8
		11–20	19.9
Female gender	41.5	21–30	18.4
		31–40	13.0
Education		41–50	9.4
Illiterate	25.9	> 50	16.5
Less than 9th grade	26.3		
Pass SSC	15.8	Caste	
Pass HSC	9.5	Upper	60.4
Some college/voc. school	2.2	Backward	6.3
Bachelor degree	13.6	Scheduled	33.2
Grad/prof degree	6.3		
		Past hazard information	
Homeowner	88.0	Flood meeting	1.9
		Landslide meeting	3.2
Member with special needs	16.8	Flood brochure	1.6
		Landslide brochure	2.8
Hindu religion	99.4		
		Past flood experience	
Age	Md = 40.0 (SD = 15.54)	Flooded in 10 years	1.9
		Flood evacuation	1.0
Number of household members			
Less than 18	M = 2.04 (SD = 1.71)	Recent flood experience	
18–65	M = 4.03 (SD = 2.34)	Caught in flood	5.4
Greater than 65	M = 0.35 (SD = 0.64)	Member injured/ killed	11.4
		Member missing	3.8
		House damaged	4.0

[a] 2013 exchange rate of dollar to Indian Rupee was - 1.00 USD = Rs. 60.725.

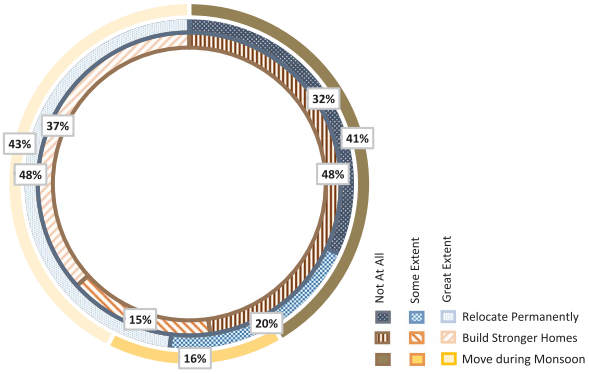

Fig. 2. Intent to adopt structural mitigation - Relocate/ Build stronger.

4.2. Emergency planning at household and village level (RQ.1b)

Respondents' intentions to adopt non-structural mitigation measures such as being involved in emergency planning was gauged. About

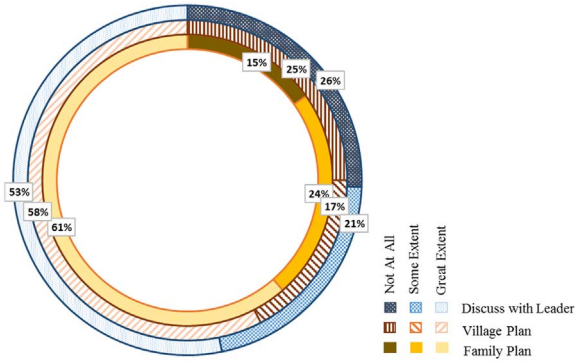

Fig. 3. Intent to adopt non-structural mitigation – Emergency planning.

53% of the respondents expressed that to a great extent they intended to discuss with neighbors and village leaders about planning for flash floods, about 58% were interested in creating a village emergency plan and about 85% were interested to some extent or great extent in creating a family emergency plan (see Fig. 3). However, about a quarter of the respondents were not willing to participate in any discussions with village leaders or work on creating a village emergency plan. It is important to understand why this group did not think it worthwhile to work with village leaders or create a village level plan. It could be because of lack of trust in these leaders due to social segregation along lines of caste which is evidenced in these villages i.e. Brahmins or the upper caste who are predominantly the leaders or wealthier villagers and the scheduled or backward caste who are the farmers or those who work in the tourism sector as hotel staff or own mules to carry tourists.

4.3. Self-awareness and hazard knowledge (RQ. 1c)

About 69% of the respondents' reported they would look for additional information about flash flooding and 63% intended to watch for environmental cues, to protect themselves and their family from future flash flood risks (see Fig. 4). Scarcity of essential commodities was a common observation made by most of the agencies involved in search, rescue, and relief operations following the flash flood. Unavailability of essential food and non-food items led to the black marketing of commodities in the affected areas, while damage to infrastructure resulted in delays in aid relief reaching these villages. These observations and the research findings above suggest that planning guidelines on stockpiling essential perishable items (food, grains, medicines, powdered milk, baby food) and nonperishable items (footwear, blankets, batteries, natural gas cylinders, generators), need to be provided and storage sites selected at the panchayat/ village levels to ensure self-sufficiency immediately following a disaster.

Most post disaster recovery strategies by the government of India have focused heavily on structural measures like building stronger infrastructure or homes. As Dixit [8] noted, structural measures need to be accompanied with collaboration across various stakeholders regionally and nationally in improving homes, identifying safer shelter sites, health of communities and protection of livelihoods. Moreover scientific development in the field of hazard management should be conveyed to these communities in an appropriate easy to understand language and terms. Some other challenges including dealing with inadequate warning systems for cloudbursts and flash flooding and the propagation of myths and blame shifting by the media (p. 174) also need attention.

There is urgent need to work on enhancing hazard awareness programs in the Himalayan mountain region. Although topics related to disaster management have already been introduced in school curricula till the Xth grade (K-10) in India as a national policy, there is need to expand it among community members with special needs like the uneducated, elderly, female heads of households, people with disabilities etc.

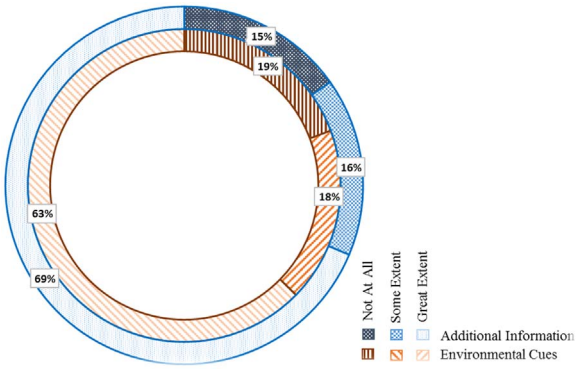

Fig. 4. Intent to adopt non-structural mitigation – Self-Awareness/Hazard knowledge.

4.4. Relationship between structural and nonstructural mitigation (RQ.2)

Taking the analysis a step further, the relationships between intentions to take structural and nonstructural mitigation strategies was computed and is described in the contingency table below (*see* Table 2). This provides insights into the types of interventions (relocation, rehabilitation, and hazard education policies) that a particular group in the community might need.

Specifically looking at the two extremes of responses namely, "extremely likely to relocate" to "not at all likely to relocate" suggests, that of the 37% respondents (116 of 316) who are extremely likely to relocate, a majority also intend getting involved in emergency planning activities and raising self-awareness and knowledge. 92% were intent on discussing about flash floods with neighbors and village leaders, 84% interested in working on creating a family emergency plan, 83% on creating a village emergency plan, 88% on watching for environmental cues and 86% seeking more information on flash floods. On the other hand, of the 49% respondents who were not at all likely to relocate, only 28% were intent on discussing about flash floods with neighbors and village leaders, 42% interested in working on creating a family emergency plan, 40% on creating a village emergency plan, 29% on watching for environmental cues and 36% seeking more information on flash floods. Of special concern to policy makers is the low level of interest among these respondents to take any sort of mitigation measures including relocating, emergency planning and raising self-awareness and hazard knowledge. Why this is so, needs further exploration.

Table 2
Relationship between structural and non-structural mitigation strategies.

Non-structural mitigation	Structural mitigation: Relocate permanently		
	Not at all 151 (48%)	Some extent 49 (16%)	Very great extent 116 (37%)
Emergency planning			
Discuss with Neighbors and Leaders	43 (28%)	24 (49%)	107 (92%)
Family Emergency Plan	64 (42%)	18 (37%)	98 (84%)
Village Emergency Plan	61 (40%)	22 (45%)	96 (83%)
Self-awareness and hazard knowledge			
Watch for Environmental Cues	44 (29%)	10 (20%)	102 (88%)
Look for Additional Information	55 (36%)	18 (37%)	100 (86%)

Table 3
Village altitude versus distance from river in meters (source of risk).

Settlement	Altitude	Distance from river	Risk level
Guptkashi	1319	2000	1 - Negligible risk
Saimi	1200	1000	1 - Negligible risk
Naryankoti	1400	1500	1 - Negligible risk
Chandrapuri	650	50	2 - Low risk
Singholi	660	50	2 - Low risk
Gavni	675	50	2 - Low risk
Ganga Nagar	680	150	2 - Low risk
Vijay Nagar	640	150	2 - Low risk
Banswara	650	100	2 - Low risk
Bhiri	740	200	2 - Low risk
Kalimath	1463	50	3 - Medium risk
Sonprayag	1839	100	4 - High risk
Rampur	1800	200	4 - High risk
Mundkutiya	1860	200	4 - High risk
Gaurikund	1982	100	4 - High risk
Triyuginaryan	1829	150	4 - High risk
Sitapur	1830	200	4 - High risk

4.5. Correlates of risk perception and village location with intent to relocate (RQ.3)

A one-way ANOVA was conducted to test the differences in means for respondents' risk perception and relocation choices with respect to the geographic location of the 17 villages. It is hypothesized that respondents living in high risk locations i.e. villages at higher altitudes and closer to the source of the flash flood will also have a higher risk perception score and thus greater intentions to relocate. The risk for each village was based on the village altitude above Mean Sea Level and distance from the river.

Assessments of flood risks generally use objective topographical data such as the Digital Elevation Model (DEMs) and hydraulic models to predict vulnerability to flooding (Apel et al., 2009). Although not-subjectively measured, this study uses the concepts of altitude and distance from the river as a method to assess the risk. It should be noted that although the approach is primitive, it uses the anecdotal evidence of areas that were subjected to the flooding with little notice and reported high casualty, to categories the villages/hamlets into four risk categories:

as seen in Table 3:

1. Negligible Risk
   Although located at mid-altitude the river is far away; n = 26 villages *(Coded 1)*
2. Low Risk (Lowland)
   Located at a low altitude or the plains so maximum lead time for flash flood warning, but close to the river, and thus prone to flooding; n = 144 villages *(Coded 2)*
3. Medium Risk (Midland)
   Located at mid-altitude, hence a little more lead time to receive flash flood warning, but close to the river, and thus prone to flooding; n = 96 villages *(Coded 3)*
4. High Risk (Highland)
   Located closest to the Himalayan peaks which was where the flash flood originated; n = 23 villages *(Coded 4)*

A one-way ANOVA was conducted to determine if respondents' risk perception varied between the four groups by village altitude above Mean Sea Level (MSL) and distance from the river (the source of flash flood threat). There was a statistically significant difference between groups (F (3285) = 3.00, p = 0.031). A subsequent, Tukey post-hoc test revealed that risk perception was statistically lower in the 'Low Risk-Lowland' group compared to the 'High Risk-Highland' group (−2.089 ± 0.789, p = 0.042) (Table 4).

Similarly, a one-way ANOVA test was also conducted to determine if respondents' intent to relocate varied between the groups by village altitude and distance from the river. The analysis revealed a statistically significant difference between groups (F (3285) = 3.43, p = 0.018). A subsequent Tukey post-hoc test indicates that the choice to permanently relocate differed between the Low Risk-Lowland and the Medium Risk-Midland groups. The choice to permanently relocate was statistically higher in the 'Low Risk' group vs. the 'Medium Risk' group (0.344 ± 0.119, p = 0.022). This is likely because of the topography of these locations (Table 5).

Table 4
One-way ANOVA - Risk perception with Tukey's test.

Source	*df*	*SS*	*MS*	*F*	*P*
Between groups	3	110.94	36.98	3	0.031
Within groups	285	3514.23	12.33		
Total	288	3625.17	12.58		

Risk Perception	Contrast	Std. error	t	P	95% conf. interval	
Highland vs Lowland	−2.09	0.789	−2.65	0.042	−4.127	−0.052

Table 5
One-way ANOVA - Intent to relocate with Tukey's test.

Source	*df*	*SS*	*MS*	*F*	*P*
Between groups	3	8.392	2.797	3.43	0.017
Within groups	285	232.494	0.816		
Total	288	240.886	0.836		

Relocation	Contrast	Std. error	t	P	95% conf. interval	
Lowland vs Midland	0.344	0.119	2.89	0.022	0.0362	0.651

Despite the existence of the Uttarakhand Flood Plain Zoning Act, 2012, to protect flood zones, hundreds of new buildings had encroached upon the floodplains in the lowlands and in many instances on the riverbed itself. Thus although villages in the lowlands were further away from the origin of the flash flood, some of the illegal constructions in the river beds were flooded. In many instances the river swollen with debris changed its course and overtopped its banks, washing away or damaging homes, and flooding farmlands and orchards and totally disrupting livelihoods *(from research team observations and informal conversations with villagers)*.

The results from both the ANOVAs revealed that risk perception was higher in 'High Risk- High land' areas while the choice to relocate permanently was higher in 'Low Risk' group versus the 'Medium Risk' group. This indicates that risk perception alone does not dictate intentions to relocate. People with high risk perception may still choose not to relocate. This finding suggests that relocation is not a preferred option for the highly scattered village communities in Uttarakhand. This is primarily because the livelihoods of people in the remote areas of Central Himalayas is dependent on the ecology of the local context. Not only is there a lack of habitational land in the Himalayan landscape but livelihoods are tied to their location. Also, the three most prevalent hazards in the region namely earthquakes, landslides and floods impact the whole region, and are unpredictable phenomena providing limited relief even with relocation.

4.6. Limitations

As with all studies, this one also has its limitations. First, the research team had to employ a convenience sampling strategy due to inaccessibility from damaged roads and infrastructure, persistent threats of landslides, downed powerlines and raging waters. Future

studies could adopt a random sampling strategy during normal times to ensure that people in remote villages are also sampled and the findings are more generalizable to the region. Second, the questions to measure risk perception only asked about the impact from the flash flood and no other threats like those perceived from dam building projects for hydropower, diseases, poverty, unemployment, climate change or rapid urbanization in this fragile region. Also, historically this mountainous region has not been affected by flash flooding of this magnitude and hence the perceptions and preferences could have been influenced by this one off event. Future studies should examine a wider range of threats to prioritize or demonstrate interconnectedness between these threats. It would be worthwhile to attempt a longitudinal study to measure changes to risk perceptions, and examine the effects of government mitigation and rebuilding efforts. Finally, people's preference to relocate was only correlated with the objective measure of risk from the flash flood, which is rather limited. It is important to include a broader range of subjective measures like livelihood choices and seasonal relocation/ migration choices during the rainy or harvest seasons to develop a more nuanced understanding of risks and relocation choices in the Central Himalayas.

Despite these limitations this research makes a valuable contribution by highlighting that intent to adopt structural mitigation (relocate or build stronger) and/or nonstructural mitigation (emergency planning and increasing hazard knowledge) measures are not mutually exclusive or solely dependent on risk perception. Further, a majority of the flash flood survivors are eager to increase their self-awareness and hazard knowledge and work on emergency planning with village leaders, friends and family which are critical to any hazard education interventions.

5. Conclusion and recommendations

The findings of this study give a glimpse into how the 2013 flash flood disaster in Uttarakhand, North India serves as a window of opportunity for mitigation initiatives. It revealed that a majority of 316 disaster survivors surveyed are aware of their fragile environment and want to be better prepared for the future. It encourages support for offering mixed mitigation measures that include structural initiatives like building back stronger, relocating temporarily during monsoons or relocating permanently; with nonstructural ones like facilitating emergency planning and training at the village and household levels and increasing hazard knowledge. Thus, in summary it reiterates the importance of integrating local knowledge and expectations of citizens living in remote mountain communities for building physical, economic and psycho-social resiliencies.

Although the state of Uttarakhand has a Disaster Management Action Plan, a report by NIDM [16] titled "Uttarakhand Disaster 2013" noted that the process of risk mapping and warning the public is very top-down. Furthermore, key decision makers were not familiar with 'why things went wrong' and what was actually lacking in the disaster management action plans. Officials at the district, block and local level administration offices were unaware of the contents of the plan and their roles and responsibilities during the pre-event planning, preparedness, warning and response stages. Moreover these plans had not be updated in a long time.

The result of such a hierarchical structure was that communities at risk did not receive timely information about the flash flood hazard, increasing the losses to life and property. A lack of understanding of the disaster management plan also resulted in sub-optimal coordination among lead and support organizations in disaster management, further affecting the timeliness of disaster response and recovery. Finally, although the Indian Meteorological Department (IMT) provided warnings of 'heavy to very heavy rain', this information was not translated into an expectation of flash flooding or landslides. Specifically, the inability to predict area specific precipitation was evidenced. Thus recommendations for policy makers at various levels of governance are:

1. Investing in revising and updating the plans at all levels of government starting from the state to district level to the village level is vital. Furthermore, a functional operational structure that clearly defines goals, roles and responsibilities should be created and tested through disaster exercises and drills.
2. Reviewing the existing forecasting and warning system is necessary. In general Advanced Doppler Radar Systems and Automated Rain Gauge Stations may be deployed in vulnerable and remote regions. Accuracy of hydro-meteorological data collection and sharing of weather information with decision makers, media and the public should be targeted for improvement.
3. Involving villagers in the design and implementation of early warning criteria tailored to their villages would be worthwhile given their familiarity with environmental cues to watch out for and a better understanding of the terrain and local practices. Such self-reliance is important when road connectivity and power lines are down.
4. Implementing the provisions of "Uttarakhand Flood Plain Zoning Act, 2012" is vital, through strict regulating mechanisms to prevent future encroachments. Further, legal framework needs to be developed to avoid construction on unstable or steep slopes and ensure land use planning is based on Hazard, Risk and Vulnerability studies.
5. Sharing of Disaster Mitigation Plans [18] and the Tourism Masterplan between responsible agencies should be initiated to ensure that economic development is not at the cost of safety. Both these planning documents should be complementary and backed up by hazard mapping and assessments to achieve sustainable development.
6. Building up hazard knowledge and awareness among the residents of this region can be achieved by involving them in risk area and shelter mapping and making these available to them locally.
7. In all these efforts the government and the media should be cognizant of informal social networks and use these to improve disaster warnings and risk communication. Information disseminated should be in the local language and major dialects of the region without technical jargon and be user friendly.
8. Educational materials including videos should emphasize on the visual cues that people need to be aware of for flash floods. Some individuals may need to be reminded of past disaster events and associated damages to encourage them to take protective actions.

Although community based disaster management/mitigation has caught the attention of the government and civil society, the notion is more in rhetoric than in reality. Village task force teams need to be constituted in high risk category villages to serve as the nodal body in direct contact with the state disaster management agency (SDMA). Depending on the need the village task force can focus on creating an early warning communications plan, enlisting response volunteers, offering hazard awareness training etc. A network of multiple village task forces can also help in improving coordination and information sharing among different communities including ones that are remote and cut off from rest of the region during a disaster. Involvement of local and credible non-governmental organizations and panchayats (local grassroots governance structures) can act as viable mediators between the village level teams/task forces and the state.

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References

[1] V. Asthana, Forced displacement: a gendered analysis of the tehri dam project, Econ. Political Wkly. XLVII (2012) (nos. 47 & 48).

[2] S.A. Andrew, S. Arlikatti, L.C. Long, J.M. Kendra, The effect of housing assistance arrangements on household recovery: an empirical test of donor-assisted and owner-driven approaches, J. Hous. Built Environ. 28 (1) (2013) 17–34.

[3] S. Arlikatti, S.A. Andrew, Chapter 12: disaster housing recovery in rural India: lessons from 12 Years of post-tsunami housing efforts, in: Alka Sapat, Ann-Margaret Esnard (Eds.), Coming Home after Disaster: Multiple Dimensions of Housing Recovery, Taylor and Francis Group, CRC Press, 2017, pp. 175–190.

[4] S. Arlikatti, S. Andrew, Housing design and long-term recovery processes in the aftermath of the 2004 Indian Ocean tsunami, Nat. Hazards Rev. 13 (1) (2012) 34–44, http://dx.doi.org/10.1061/(ASCE)NH.1527-6996.0000062.

[5] J.D. Barenstein, S. Iyengar, India: from a culture of housing to a philosophy of reconstruction, Build. Back Better (2010) 163.

[6] Census of India, Census of India, Provisional Population Totals: Uttarakhand: Census, 2011. Accessed 5 August ⟨http://www.censusindia.gov.in/2011-prov-results/prov_data_products_utt.html⟩.

[7] P.K. Das, The Himalayan tsunami"–Cloudburst, flash flood & death toll: a geographical postmortem, IOSR J. Environ. Sci. Toxicol. Food Technol. 7 (2013) 33–45.

[8] A. Dixit, Floods and Vulnerability: Need to Rethink Flood Management. In Flood Problem and Management in South Asia, Springer, Netherlands, 2003, pp. 155–179.

[9] J.S. Gardner, J. Dekens, Mountain hazards and the resilience of social–ecological systems: lessons learned in India and Canada, Nat. Hazards 41 (2) (2007) 317–336.

[10] S.J. Halvorson, J. Parker Hamilton, In the aftermath of the Qa'yamat: 1 the Kashmir earthquake disaster in northern Pakistan, Disasters 34 (1) (2010) 184–204.

[11] S.J. Halvorson, J.P. Hamilton, Vulnerability and the erosion of seismic culture in mountainous Central Asia, Mt. Res. Dev. 27 (4) (2007) 322–330.

[12] Hindustan Times. By Anupam Trivedi, Updated: June 29, 2013 18:54 IST. Rebuilding *Uttarakhand: Brand State, follow master plan*. ⟨http://www.hindustantimes.com/india/rebuilding-uttarakhand-brand-state-follow-master-plan/story-INITfxSQPFUzRlZPYBDGmK.html⟩.Downloaded on February 18th, 2017.

[13] Indian Express. By Express News Service | Lucknow | Updated: July 22, 2015 5:11 am. Rebuilding Kedarpuri: Uttarakhand's master plan aims to protect shrine from calamities. ⟨http://indianexpress.com/article/india/india-others/rebuilding-kedarpuri-uttarakhands-master-plan-aims-to-protect-shrine-from-calamities/⟩. Downloaded on February 18th, 2017.

[14] S. Lin, D. Shaw, M.C. Ho, Why are flood and landslide victims less willing to take mitigation measures than the public? Nat. Hazards 44 (2) (2008) 305–314.

[15] B.E. Montz, E. Gruntfest, Flash flood mitigation: recommendations for research and applications, Glob. Environ. Chang. Part B: Environ. Hazards 4 (1) (2002) 15–22.

[16] National Institute of Disaster Management. Uttarakhand Disaster 2013. Ministry of Home Affairs, Government of India. Retrieved online from ⟨http://nidm.gov.in/PDF/pubs/ukd-p1.pdf⟩.

[17] P. Rautela, Traditional practices of the people of Uttarakhand Himalaya in India and relevance of these in disaster risk reduction in present times, Int. J. Disaster Risk Reduct. 13 (2015) 281–290.

[18] State Disaster Management Action Plan for the State of Uttarakhand. Accessed 1 October. ⟨http://dmmc.uk.gov.in/files/pdf/complete_sdmap.pdf⟩.

[19] I. Schad, P. Schmitter, C. Saint-Macary, A. Neef, M. Lamers, L. Nguyen, V. Hoffmann, Why do people not learn from flood disasters? Evidence from Vietnam's northwestern mountains, Nat. Hazards 62 (2) (2012) 221–241.

[20] The World Bank (n.d.) India - Uttarakhand Disaster Recovery Project: P146653 - Implementation Status Results Report: Sequence 08 (English), July 18, 2017. Accessed 10th August at ⟨http://documents.worldbank.org/curated/en/492481500397847444/pdf/ISR-Disclosable-P146653-07-18-2017-1500397836717.pdf⟩.