Shelter response and vulnerability of displaced populations in the April 25, 2015 Nepal Earthquake

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SUMMARY

Approximately 8 million people have been affected by April 25th, 2015 earthquake in 39 districts (including Kathmandu Valley districts), in four of the five Regions of Nepal (Far Western region not affected). As of 05 May 2015, the Government of Nepal (2015) reported 7,557 deaths and 14,409 injured people. It is estimated that 2.8 million Nepalese are displaced. The Government of Nepal has identified 191,058 houses as being destroyed and another 175,162 damaged across 67 districts in total, and has predicted that the number of destroyed houses could reach 500,000 across the country. Subsequently, the UN has emphasized the need for shelter in the affected communities. More than 3.5 million people are estimated to be in need of food of which 1.4 million may require food assistance for the next three months (UN 2015). The focus of the response has shifted from search and rescue in the Kathmandu Valley to delivery of aid to remote villages in the most affected districts. Many remote villages have yet to receive any form of aid. The aim of this report is to analyze the current shelter response situation with a view on emerging factors critical to forming the shelter policy and vulnerability of displaced populations in Kathmandu and affected areas across Nepal.

AFFECTED DISTRICTS

Table 1 lists the most affected districts as identified by the Government of Nepal (WFP 2015). Over 5 million people live in these most affected districts. Based on Government figures, the districts listed in **Table 2** with a population of over 2.7 million appear to also be very badly affected, although they have not yet been officially labelled as 'most affected'.

Table 1: Most affected districts

District	Deaths	Injuries	Houses Destroyed	Houses Damaged	No. of Displaced (estimate)
Bhaktapur	304	1887	7000	2000	39.948*
Dhading	680	657	2000	3000	22.753*
Dolakha	69	272	5000	35000	16.331*
Gorkha	412	1034	44877	13438	237,677*
Kathmandu	1202	4634	27640	33215	243.262*
Lalitpur	173	1224	16344	5851	94.631*
Lamjung	5	31	2724	4548	28.986*
Makawanpur	34	0	363	497	4.199*
Nuwakot	904	1312	30000	15000	210.862*
Ramechhap	26	27	2534	2266	22.152*
Rasuwa	433	748	8000	1000	39.855*
Sindhuli	10	63	1042	1638	13.786*
Sindhupalchowk	2911	852	0	0	no quantities

*estimate based on total destroyed/damaged homes X avg. household size) All other quantities from Government of Nepal (2015) (http://eq.nitc.gov.np/)

Table 2: Further badly affected districts

District	Deaths	Injuries	Houses Destroyed	Houses Damaged	No. of Displaced (estimate)
Kavrepalanchowk	312	930	30000	18545	229,697*
Tanahu	1	18	3377	12927	67,309*
Shyanja	0	6	3119	9654	53,618*
Khotang	0	3	1580	1615	15,450*
Palpa	0	15	1060	1510	12,841*
Bhojpur	2	8	1056	1326	11,026*
Parbat	0	11	844	1617	10,100*
Gulmi	0	1	507	2423	12,644*
Baglung	0	0	428	1176	7,003*

*estimate based on total destroyed/damaged homes X avg. household size) All other quantities from Government of Nepal (2015) (http://eq.nitc.gov.np/)

SHELTER RESPONSE IN KATHMANDU

Pre-event Contingency Planning
In 2010, the International Organisation of Migration compiled a Report on camp site selection for potential Internally Displaced Persons (IDP) in Kathmandu Valley (IOM 2010) in which they laid out a potential scenario of sheltering 900,000 persons within Kathmandu Valley during a major earthquake with 60% of buildings destroyed and up to 40,000 dead. They identified 83 open spaces as potential sites for initial response assigned them specific uses (MoHA & IOM 2013). In January 2014, the Shelter Cluster Nepal updated its Contingency Plan for the Coordination of Shelter Preparedness and Response in Nepal (Shelter Cluster Nepal 2014) from 2009 using a similar earthquake scenario. They calculated an anticipated capacity of the Kathmandu Valley to hold 710,000 people.

The earthquake on April 25 was not the worst-case scenario postulated in the contingency plan, but serves as a major first event testing the response planning framework for the Government and partner agencies. The objective in this report is to draw on our research and tools from an ongoing collaboration by CEDIM and SAI in Nepal to shed scientific insights and understanding on the ongoing event and response.

Table 3: Comparison of M7.8 earthquake occurred April 25th 2015 with scenario event

	Contingency Plan Scenario Event (Shelter Cluster 2014)	**Gorkha Earthquake 25th April 2015** (UN OCHA Situation Report No. 10)
Fatalities	44,000	7,367 official (as of 4th May); 7,560 modeled median (Daniell et al. 2015)
Injured	103,000	14,355 official (as of 4th May)
Affected	1 to 1.5 million	over 5 million live in the most affected districts
Displaced	900,000	37,500 IDPs officially in Camps. Estimates based on building damages are around 1 million in the most affected districts and another 400,000 in affected districts
Shelter capacity and management	64 designated large shelter sites with a total capacity of 710,000 persons	58 camps in the Kathmandu Valley 17 are managed as 'Formal Camps'
Outmigration (KV, and outside)	Up to 625,000 people will attempt to leave Kathmandu Valley	300,000 are estimated
Physical Impact	Large amounts of debris, airport unusable	Airport temporarily shut-down for large cargo planes on Sunday 3rd May
Building damage	60% of buildings destroyed, another 20% of buildings damaged or inhabitable	Official count: 191,058 homes destroyed and 175,162 damaged. 90% buildings destroyed in Gorkha and Sindupalchowk District (most stone and mud houses)

In terms of evacuation behavior, it was anticipated that homeless people will use all kinds of shelter including repairing their homes, creating makeshift spontaneous shelters, moving to friends and family members outside the city or even the valley as well as move to planned and unplanned shelters. Considering the scale of the scenario earthquake, spontaneous shelters were considered almost unmanageable and would result in chaotic circumstances. **Table 3** compares the scenario earthquake event and its modelled consequences with the recent April Earthquake.

Designated Shelter Sites for this event

Personnel from the Shelter Cluster use the Displacement Tracking Matrix (DTM) Rapid Assessment tools to identify and conduct rapid profiling (needs assessment) of camps in the following areas: Sankhu, Jorpati, Gongabu, Dhapasi, Manamaiju in Kathmandu. The government is providing camp management in Halchowk, Sinamangal, Shankha Park in Kathmandu and Bhaktapur Durbar Square. The Shelter Cluster also carried out a structural/site evaluation at Balambu village in Kathmandu and will further investigate camps outside the valley. The government has so far identified 16 open spaces to be used as formal camps out of their initial pre-defined 83 ones around Kathmandu, plus 1 in Balambu VDC. These are:

- Kathmandu Metropolitan City - KMC (N=6):
  Shankha Park, Sano Gaucharan, Tudikhel/Ratna Park, Dashrath Stadium, Royal Nepal Golf Course (Sinamangal) [previous reports indicate also Civil Aviation 3 which is not used further][1], Tin Kune
- Kathmandu (N=2):
  Balambu, Halchowk/APF HQ (Nagarjung)
- Lalitpur Sub Metropolitan City - LSMC (N=5):
  Pulchowk Engineering College, Pulchowk Engineering College 1, St. Xavier School, Lagankhel Football Ground, Bagmati Corridor 1 [previous reports indicate also Jawalakhel Football Ground, Royal Nepal Academy of Science & Technology (RONAST) and Nepal Agricultural Research Council (NARC) which are not used anymore as of today]
- Kirtipur Municipality (N=1):
  Tribhuwan University
- Bhaktapur Municipality (N=3):
  Tinkune, Durbar Square, Kamal Binayak

Another 43 are "not used" (20 in Lalitpur and 23 in Kathmandu) according to the IOM database. Another 16 in Kathmandu are mentioned as "Spontaneous Settlement".
In all formal camps has been a central camp management authority established. Almost all the spontaneous shelter sites remain unmanaged.

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[1] There has been some confusion in previous datasets and reports on the different shelter sites around the airport: Those include (sometimes) the Sinamangal Civil Aviation 1 Airport Golf Courses, the Army Golf Club, the Halchowk (APF HQ) or Airport central Dojo, as well as Civil Aviation 2 (End of Airport).
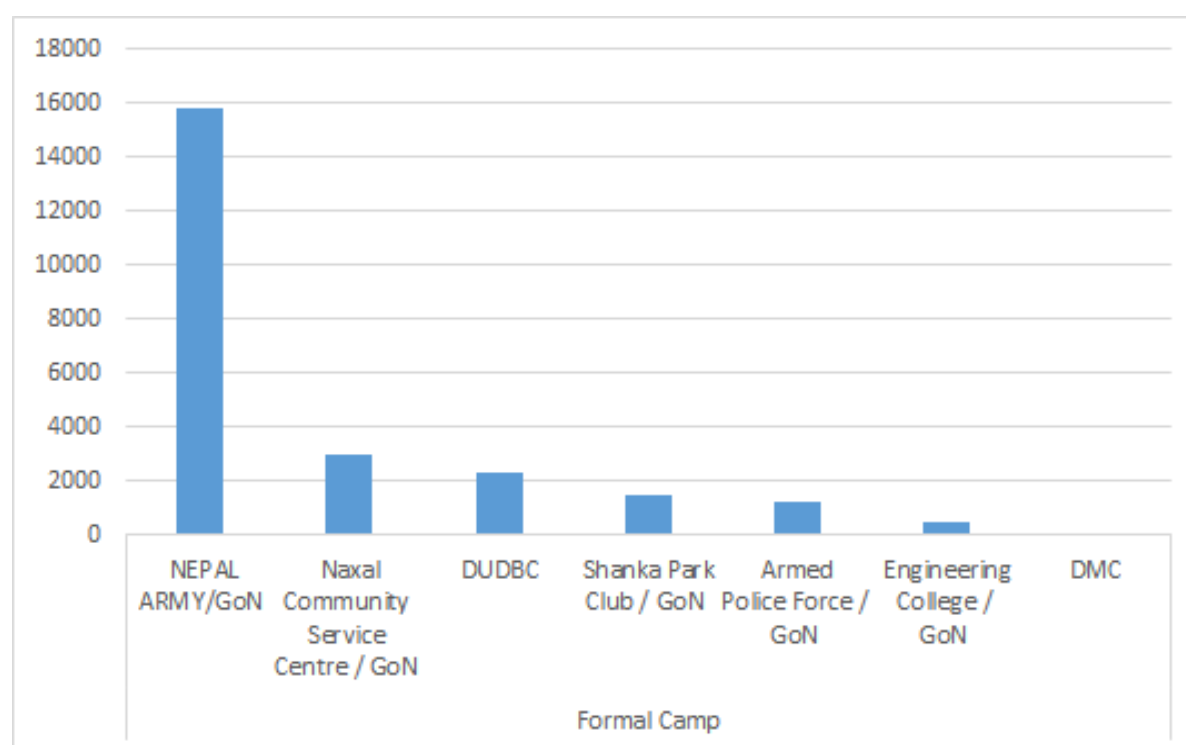
Figure 1: *Authorities responsible for formal camps management.*

The number of people in designated emergency sites is likely to increase as the rains of the monsoon season create for difficult conditions in the make-shift arrangements and the feeling of belonging and connection to neighborhoods as well as staying near familiar areas is replaced with the need for adequate shelter and provision of services.

The SPHERE shelter and settlement standard for covered living space provides a guideline for emergency managers to evaluate or plan for immediate, short-, and long-term shelter (SPHERE Project, 2011). It recommends an area in excess of 3.5 m² per person to meet requirements of typical household activities. The overall surface area per person, including communal space for cooking, roads and footpaths, educational facilities, administration etc., within temporary communal settlements should be 45 m².

The following analysis concentrates on the 'Formal Camps' that have been part of the previous investigation during the contingency planning.

According to the Kathmandu Valley Open Spaces report (Moha & IOM 2013) only nine of them were planned to be used as settlements/camps. Other uses include logistic hub, debris collection and distribution area. The Open Space Suitability Index (Anhorn & Khazai 2015) ranks the suitability of the selected sites within Kathmandu considering three weighted categories: implementation issues, environmental considerations, and basic utility supply and eight indicators. These are shown for the selected sites in **Figure 2**.
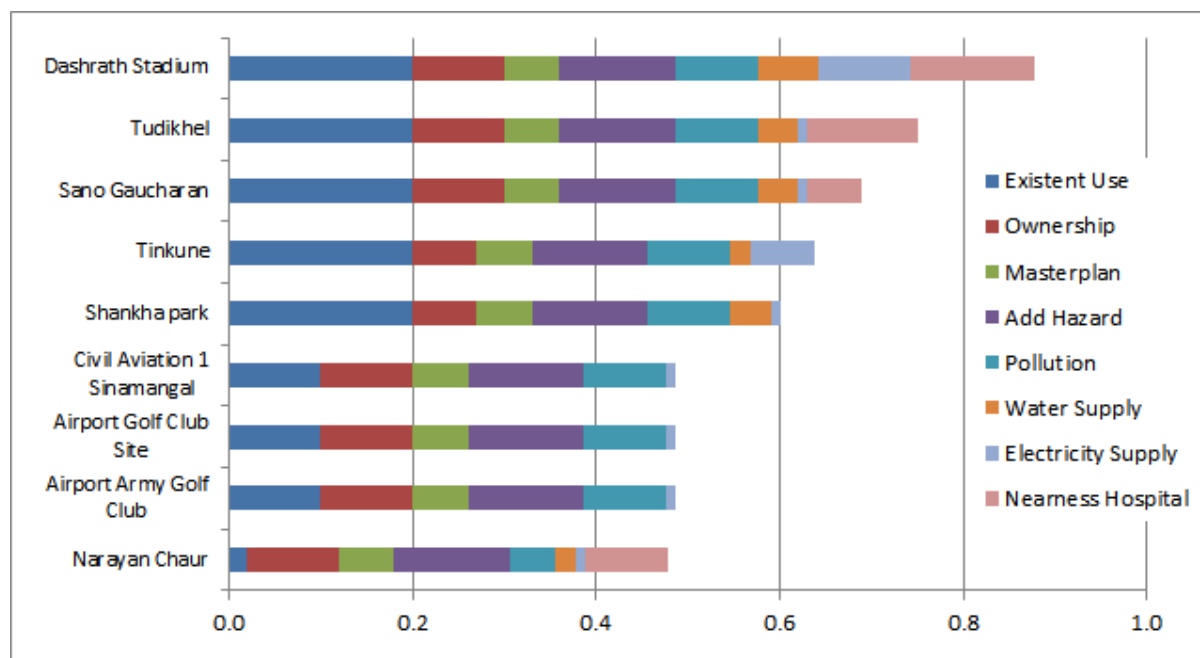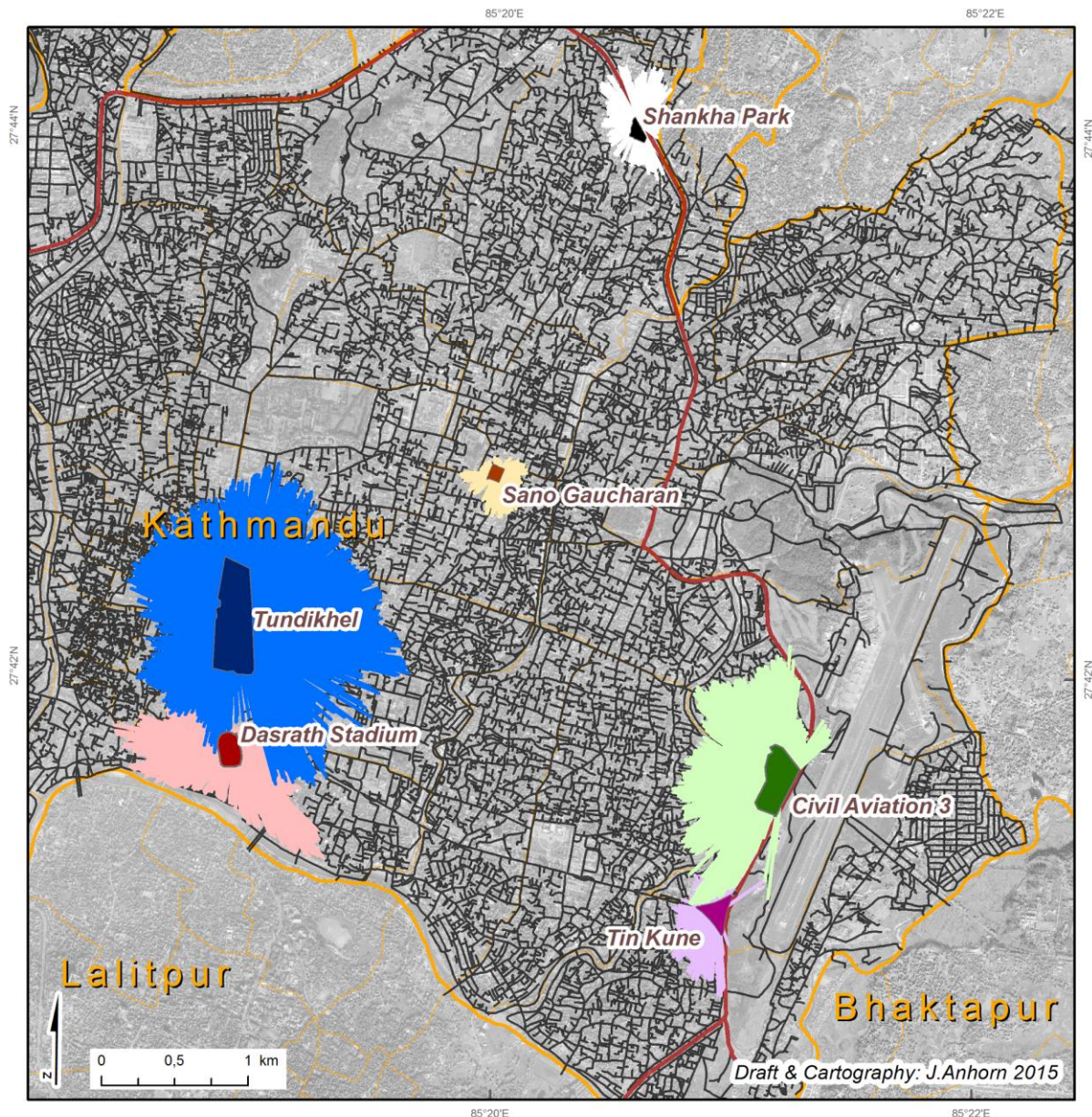
Figure 2: *Open Space Suitability ranking of selected formal camps within KMC using weighted indicators.*

Comparing these sites with the overall ranking of a larger database of open spaces compiled from NSET (2012) and IOM (2010) (N = 269) the Dashrath Stadium ranks 14th out of 269 and can be considered most suitable, while the lower four camps are within the last decile (least suitable). The weak performance of the later ones is due to their 'Existent Use', as well as 'Pollution'. Narayan Chaur has been flagged as a dumping site in previous investigations, adding to the risk of health and sanitation. One key issue in terms of available services seems to be water supply: according to the information in the reports, none of the sites has readily available water resources in large quantities. All the sites had at least one potential source mentioned, but would always require treatment or even installation of infrastructure like wells, which is considered unsuitable for the short time-frame of immediate shelter needs.

While suitability criteria of potential shelter sites are important, accessing them and finding enough room there is equally important. The map in **Figure 3** shows a subset of the final model highlighting the integration of a capacitated accessibility measure (CAM). The GIS measure assigns each demand point (building footprint of specific weight = persons in need of shelter) to the nearest designated open space. The capacity of each open space is calculated using SPHERE standards (here we used minimum standards of 3.5 sqm/person). In doing so, the result shows a specific serviceable area for each camp site. If (as for the worst-case earthquake scenario in Kathmandu) the available open spaces are insufficient to cope with the extreme shelter demand, analyzing all open spaces as an interdependent cluster, allows us to identify these areas of potential stress on shelter needs and therefore stress on the open spaces. In combination with the qualitative suitability measures, the tool provides a solid basis for decision makers to establish target states and monitor shelter performance.

Given the background of this earthquake event (especially the relative low number of collapsed and damaged buildings compared to the scenario event), the selection of only a

few high priority shelter places does make sense, but the spatio-temporal dynamics behind peoples decision to take shelter in designated areas or setting up spontaneous camps need to be integrated especially if services and aid distribution aims to reach the most vulnerable equally.

Figure 3: *Modeled capacitated accessibility for the designated open spaces in KMC using minimum SPHERE standards (3.5sqm/person) and network analysis to derive maximum serviceable area considering all building inhabitants sheltering.*

Services available

According to the UN, drinking water has been delivered to all official shelter sites. While sanitation remains a great challenge, toilets have been positioned at some places (which are already being abandoned).

In Kathmandu and Lalitpur most grocery shops have opened their doors again, and mobile phone networks and internet are functional. Power throughout the city is limited with most households and offices relying on additional generator power or in-house storage systems. Nevertheless this is not a very extraordinary situation, as usually during these months load shedding is about 6 to 8 hours per day, depending on weekdays and the neighbourhood. The national power production relies on minimum water flow, which is naturally not guaranteed pre-monsoon.

Kathmandu Durbar Square
Public shelter area with government provided water service and phone recharge station.

(c) V.Flörchinger, 30.4.2015

Jawalakhel Football Ground (LSMC)
officially closed (as of April 29th)

(c) V.Flörchinger, 27.04.2015

(c) V.Flörchinger, 04.05.2015

Tudikhel Camp
Water gets distributed by the government, but is insufficient. 20 toilets have already been established, 50 are planned and under construction. During the first three days there were more people, but some have already moved back into their houses. There is no deep-tube well as recommended/planned in the 2012 IOM study.

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In-place Sheltering

Residents are seeking refuge in outdoor camps throughout Kathmandu, and a temporary shelter landscape has emerged. In-place sheltering is favored by many residents as they prefer to stay close to their homes, food reserves, livelihoods and social ties. Despite the heavy rains, many people whose homes were undamaged still prefer to shelter outdoors due to fear of aftershocks.

Public shelter is often considered a last resort. One study found that in Taiwan only 20% of evacuees would choose to go to a public shelter (although this number would rise to 38% in case of bad weather) while the remaining households would prefer to camp or to stay with family or friends (Chien et al. 2002). Following the 2003 Bam earthquake 3100 of the 9006 intermediate shelter units constructed remained vacant due to the reluctance of the people of Bam to relocate to compounds that were judged too remote from their livelihoods, family and friends. Furthermore many feared that they might lose their homes if they relocated to shelter camps on the outskirts of the city (Khazai and Hausler 2005). The role of family and friends is also shown in a study that showed that Haitians who were in Port-au-Prince at the time of the earthquake mostly stayed in similar areas to where they were before the earthquake or returned to communities that they visited on the previous holidays (Lu et al. 2012).

With the emergence of numerous spontaneous makeshift shelter camps in the neighborhoods of affected persons in Kathmandu, we are seeing a similar trend as in these past events. The many smaller IDP camps in the Kathmandu Valley represent a stark contrast to the planned shelter sites in the IOM emergency shelter strategy which remain sparsely populated at this point (IOM & MoHA 2012). As of 1st May there were more than 1,200 spontaneous shelter sites mapped through analysis of high-resolution pre- and post-disaster satellite imagery. The Humanitarian OpenStreetMap Team (HOT) team prepared a mapping task to identify IDP camps in Kathmandu and the surrounding areas based on two images: pre-EQ imagery from 2014-11-29 and post-EQ imagery 2015-04-27. On Tuesday night, the whole covered area had been mapped and up to around 65% has been validated. The database that has been collected is a valuable source of information. With more and more post-event imagery being accessible, the focus on mapping IDP camps will be broadened and will enable the in-depth analysis of shelter-dynamics.

Several groups have provided live-feeds to the data and visualized the ongoing mapping efforts[2]. Others have started to develop services around the database, useful for post-disaster management including routing services for aid distribution.

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[2] For example the GFZ OSM visualization nepal2015.obm.gfz-potsdam.de, the IOM Displacement Tracking Matrix (DTM) for the Nepal Earthquake https://ditaanggraeni.cartodb.com/viz/63214dde-f00f-11e4-abe5-0e018d66dc29/embed_map, the SAI Spontaneous Camp and Shelter Analysis Platform, and the GDACS Live Map - Earthquake, Nepal https://unosatgis.cern.ch/live/EQ20150425NPL/

The shelter capacity of these small self-organized camps provide using SPHERE standards are enormous. **Figure 4** provides an overview about the capacity distribution per VDC. The International Organization of Migration is currently collecting data on socio-economic portfolios of inhabitants, as well as services and supplies needed in such small camps.
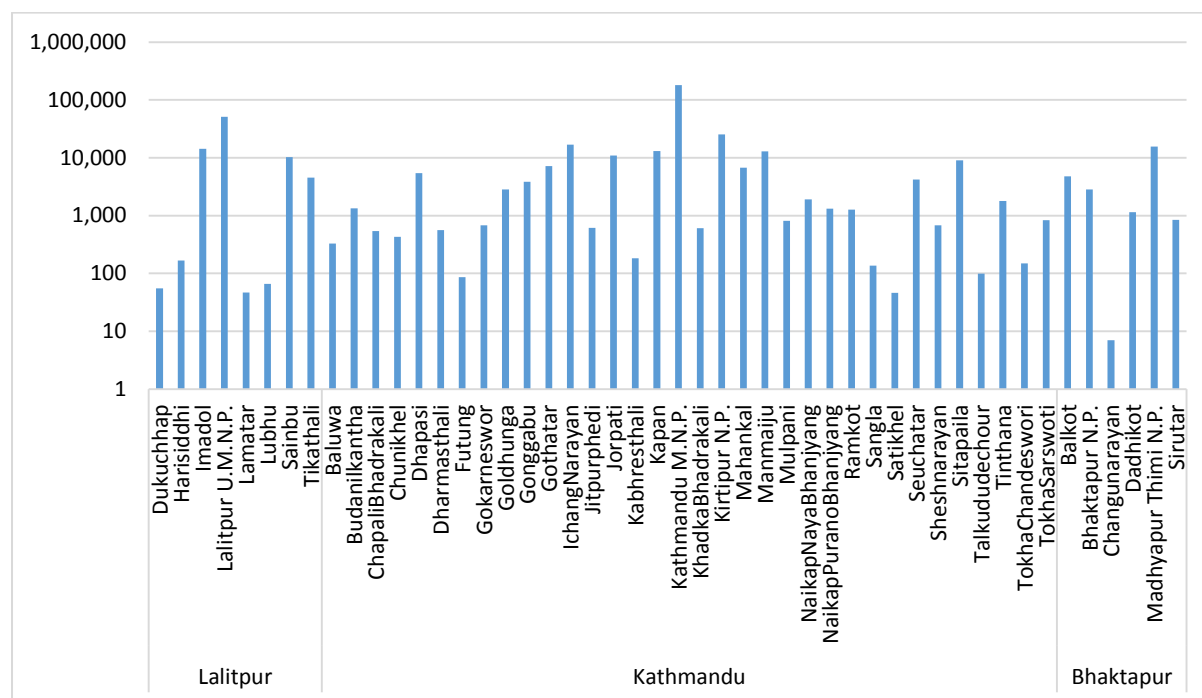

Figure 4: Overview on the capacity distribution per VDC

It is already visible and further expected that more and more people are pulling back from the makeshift shelters back to their houses, despite the valid danger of further damages and collapses during potential aftershocks. The contribution in terms of shelter capacity they provide is visible from the map below (**Figure 5**).
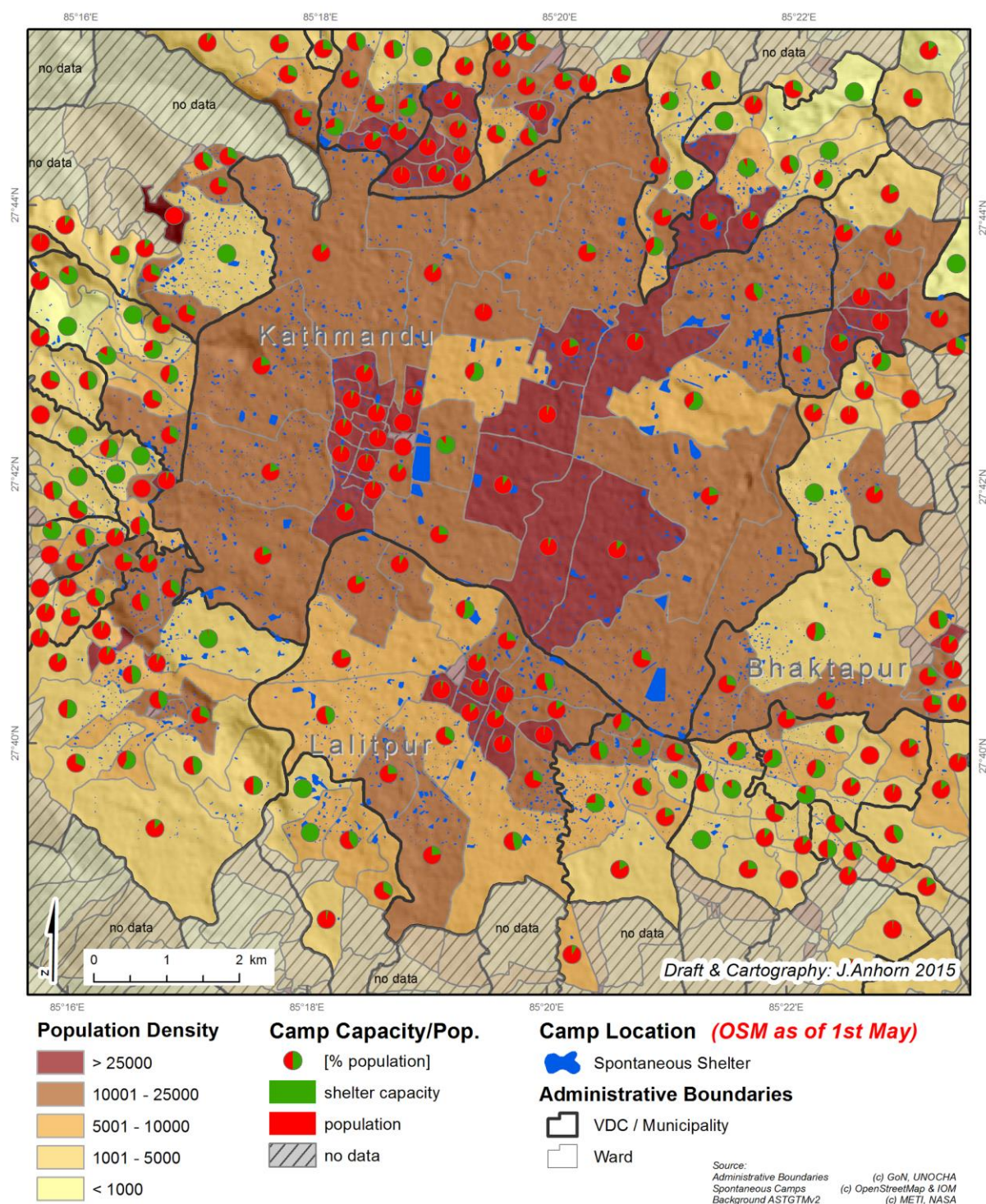
Figure 5: *Spontaneous camps around Kathmandu (as of 1st May) and shelter capacity using 10 sqm/person with respect to Ward population.*

Exodus from the Valley

There is currently a massive migration of Kathmandu residents to the villages of their family. The numbers have already topped 100,000 and are estimated to reach 300,000 (Guardian 2015). An important question is: how will they get there if roads are blocked due to landslides? Furthermore, there have been reports of protests and Bandhas (road closures)

which would cause further delays to travellers (and delivery of aid). Due to these factors, it could take days for some to reach their home villages. It is unknown if plans are in place to accommodate for food and water for those in transit and whether or not the typical road side restaurants along Nepal's highway are open.

According to UN OCHAs Situation report from 29th April, Local schools and organizations have started mobilizing buses to help earthquake victims to travel out of Kathmandu to Itahari in the east and Butwal in the west. Some 300,000 people are believed to have left Kathmandu (Guardian 2015). Long queues have built up near the main bus station (see photo below).

There are some unverified reports of protests and scuffles at the main bus station in Kathmandu due to emotional stress and frustration over the slow onset of aid coming onto the city and people wanting to leave to their rural hometowns (Phillips 2015).

Queues at the main bus station

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School busses have been deployed to cope with the large number of people leaving Kathmandu.

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VULNERABILITY OF DISPLACED POPULATIONS

Regionally there are differences in vulnerability of populations in Nepal displaced by the recent earthquake both in terms of their physical as well as social vulnerabilities. Disasters can cause long term displacement of populations or even in some cases permanent migration. Lack of employment opportunities and permanent disruptions to livelihoods can drive people away from undamaged homes. Economic changes after a disaster can cause both in and out migration among different groups (Cutter et al. 2011). Utilizing evidence from past research and with an eye towards the next weeks in the response activities in Nepal, we have produced in this section an analysis of key factors contributing to vulnerability of displaced populations and attempted to identify the most vulnerable districts within the affected areas.

Transportation infrastructure network
The direct impact of the earthquake and its secondary effects such as landslides and avalanches have crippled the transportation networks across central Nepal. The delivery of aid and relief services to the affected areas is further complicated by the landlocked nature of Nepal with extremely challenging geography and inadequate road infrastructure. Damage to the road infrastructure, debris, and logistics continue to hamper the relief operations and remote settlements at high altitudes remain isolated. Displaced people at sites where road connectivity is either insufficient and/or cut off by landslides are more vulnerable. Heavy rain has added to the hardship of thousands of people, and water, food and power are scarce, raising fears of waterborne diseases.

As presented in **Figure 6**, roads and aviation are the major modes of transportation in Nepal. The presence of railways is negligible, and freight transit services are unreliable – the average pre-earthquake transit time from India varies from 3 to 8 days (World Bank 2015). Nepal uses India's eastern port of Kolkata as its gateway to the sea.
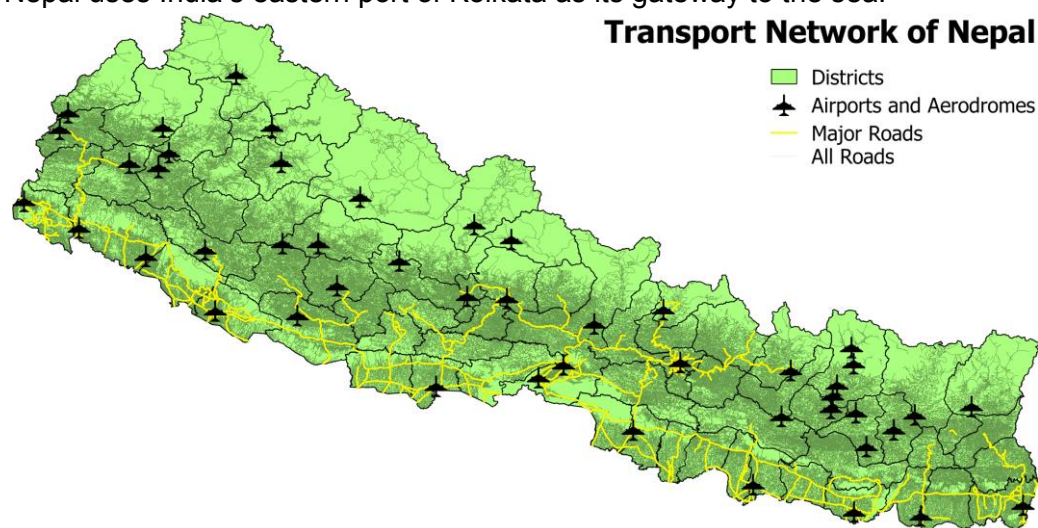

Figure 6: Map of Nepalese transport network with road network including major roads, airports and aerodromes.

Several organizations have published reports of blocked or damaged road infrastructure, for instance Kathmandulivinglabs.org which gathered 55 reports as of 1st May 2015 (Kathmandu Living Labs, 2015). For instance, in Sindhupalchok district the major road H03 near Bahrabise village is reported to be blocked (see **Figure 7**), making it difficult for rescue teams to access the area north of it, possibly affecting more than 30,000 people. Other reports state that the major road F21 close to Betrawati village (Nuwakot district) and also further north in Rasuwa district is blocked or damaged (see **Figure 7**), making Rasuwa district with more than 40,000 inhabitants hardly accessible (Nepalese Central Bureau of Statistics, 2012). A full picture of all road closures is not yet available.
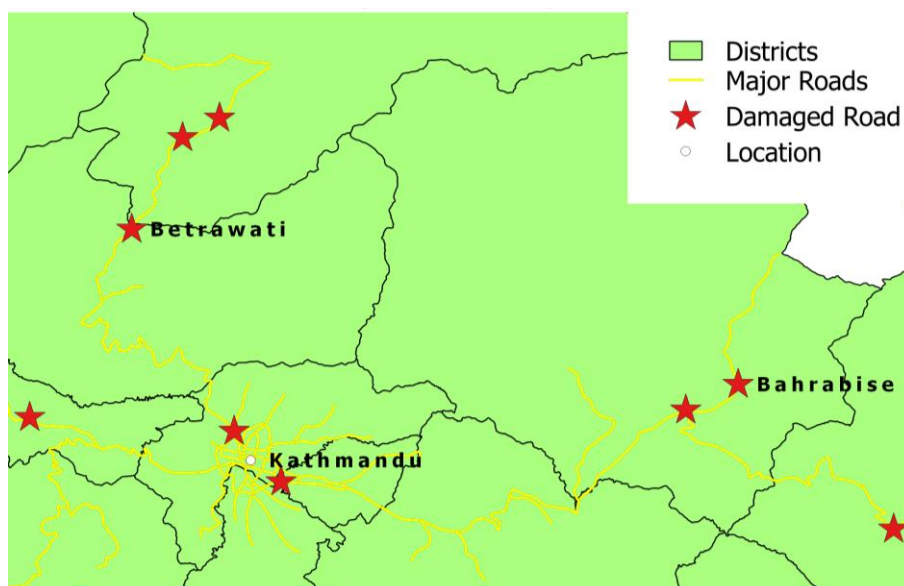

Figure 7: Map of reported damages to major roads. (Source of reports: Kathmandu Living Labs, 2015)

Road infrastructure vulnerability

Lack of adequate and accessible roads and other transport infrastructure in Nepal is a key factor contributing to the vulnerability of inaccessible populations. A dense road network implies network redundancy and therefore reduces the risk of inaccessibility of areas or whole regions in case of a blocked or damaged road. In districts where only a few roads are available, the risk of inaccessible areas is increased, making the people living there more vulnerable.

Road density is a common indicator for the development level of the road network in a country (Xie & Levinson 2006). As a comparison, Germany has an average of 180 km of roads per 100 km^2 land area, and the mean value of road density for OECD countries is about 44 km/100 km^2 (OECD 2013). In contrast, Nepal´s road density is about 20 km/100 km^2. Moreover, there are huge differences in road density between Nepalese districts. As presented in **Figure 8**, the range of road density differs from 2 km/100 km^2 in Manang district to 48 km/100 km^2 in Bhaktapur district. Within the most severely affected districts Rasuwa has a road density of less than 10 km/100 km^2. Thus, even if only a few roads in these districts are blocked or damaged, possibilities to access the population living there will quickly be limited.
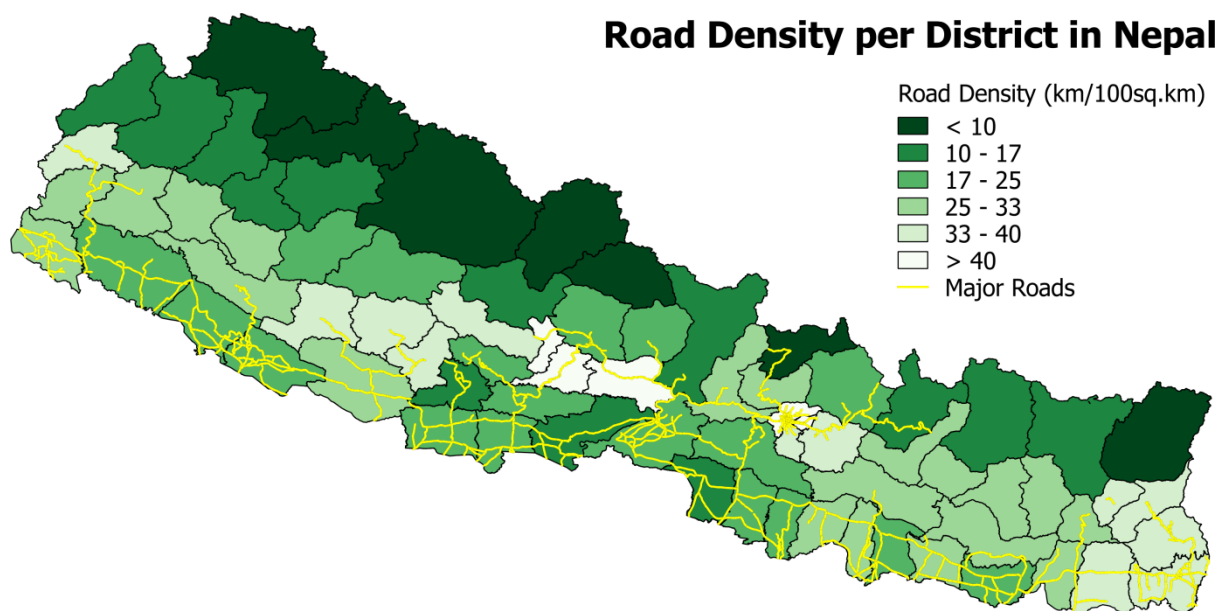
Figure 8: Road density (in km/100 km^2) per district in Nepal

Isolation vulnerability of populations at high elevations

After the earthquake of 25 April 2015, many villages remain isolated and can only be reached by foot with some areas taking up to four to five days to reach. In those villages that have been reached, the immediate needs are great including the need for search and rescue, food items, blankets and tarps, and medical treatment. The lack of access of some areas will be a key factor in the rise of the death tolls. Furthermore, lack of communication and coordination is also emerging as a factor in the delay of relief services. Residents in Barkobot village in Sindhupalchok district have reported that they had had no aid despite being just an hour and a half on good roads from Kathmandu. But helicopters have begun ferrying wounded from Gorkha close to the epicentre of the earthquake (Humanity Road Situation Report #8). Settlements at high elevations are at a greater risk of isolation and more vulnerable to adverse weather and temperatures. At higher elevations, such as regions above 3500 meters, nighttime temperatures are frequently in the range between 0 and 5C.
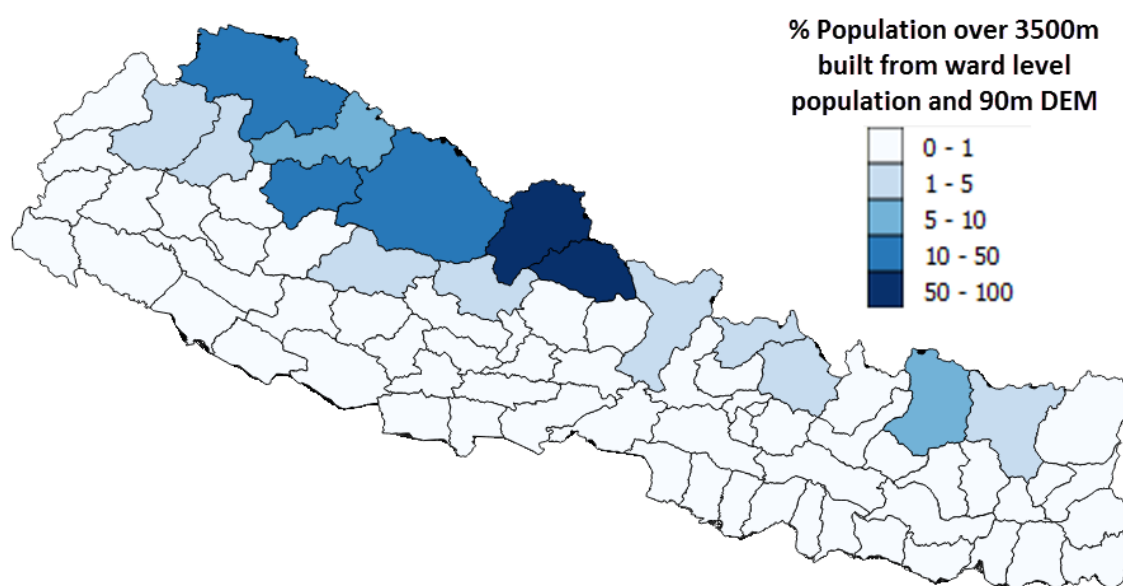

Figure 9: Populations living at elevations greater than 3500m and at risk of isolation.

Vulnerability to landslides

Globally, Nepal is the country with the highest relative relief on earth. The earthquake impacted both the mountain districts of the far north, incorporating the remote mountain massifs of the High Himalaya (only 7.3% of the population) and the hill districts, of the Middle Himalaya where the terrain consists of alpine-height mountains and valleys (represents 44.2% of the national total). There is considerable variation in the temporal occurrence of landslides in Nepal, with an apparent underlying cyclicity with time. The majority of fatal landslides in Nepal are triggered by monsoon rainfall from June to September associated with the south-west Asian monsoon (Petley et al. 2007).
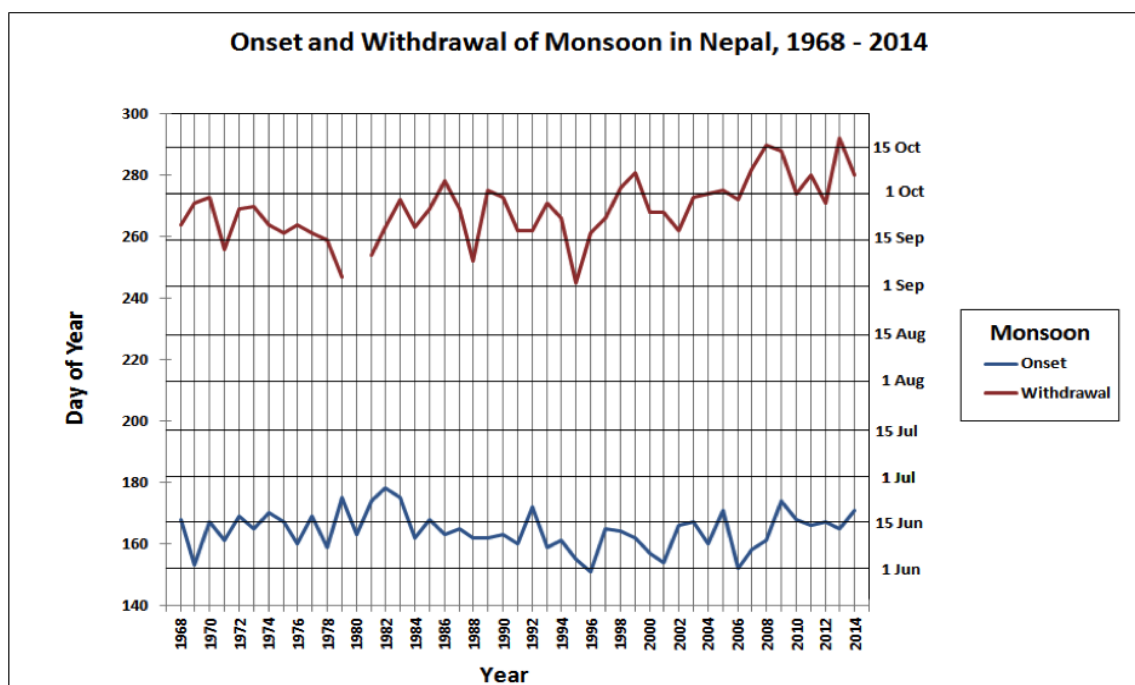
Figure 10: *Yearly onset and withdrawal of monsoon in Nepal 1968-2014. Data: Government of Nepal, Department of Hydrology and Meteorology, Babarmahal, Kathmandu, Nepal.*

There is a great yearly variability in when the summer monsoon arrives in Nepal. On average, the onset of the monsoon is June 10th for Eastern Nepal, and June 12th for the area of Kathmandu. During the last 46 years, the monsoon started in May only once (31 May 1996). The latest beginning of the monsoon was in 1982 (27 June); so there is time gap of roughly 4 weeks between the two extremes. On average, the monsoon lasts for about 4 months, the retreat is on 26 September. In 2013 the withdrawal of the monsoon was the record delay since 1968 (19 October). The summer monsoon is responsible for about 80% of the yearly precipitation. In the peak months, July and August, some stations get several hundred millimeters of rain. For instance, Pokhara records an impressive amount of 940 mm in July. The onset of the monsoon rainfall is related to the occurrence and the migration of a monsoon depression north of the Bay of Bengal (Ueno et al. 2008).

The pre monsoon months are not dry and westerly disturbances that travel across the Himalayan mountains are responsible for occasional precipitation. In April showers and thunderstorms release an average of 61mm of rain in Kathmandu. This mostly convective rain activity is erratic and hard to predict.

Temperature

In the earthquake affected regions of Nepal average temperatures in April are moderate. In Kathmandu area, which is located at about 1300 meters above sea level, mean temperature in May is 22.2°C, Pokhara at 800 meters has an May average of 24.2°C. The diurnal range at Kathmandu in May is between 16 and 29 °C, respectively 18 and 30 °C at Pokhara [Government of Nepal, Department of Hydrology and Meteorology, http://www.dhm.gov.np/climate]. At higher elevations, such as regions above 3500 meters, nighttime temperatures are frequently in the range between 0 and 5C, e.g. in Jumla.
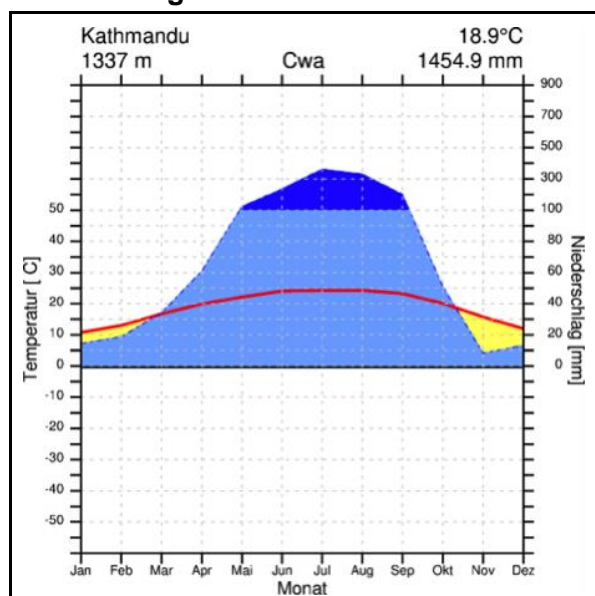
Climate diagrams:

Figure 11a: Climate diagram for Kathmandu, Nepal (reference period: 1981-2010).
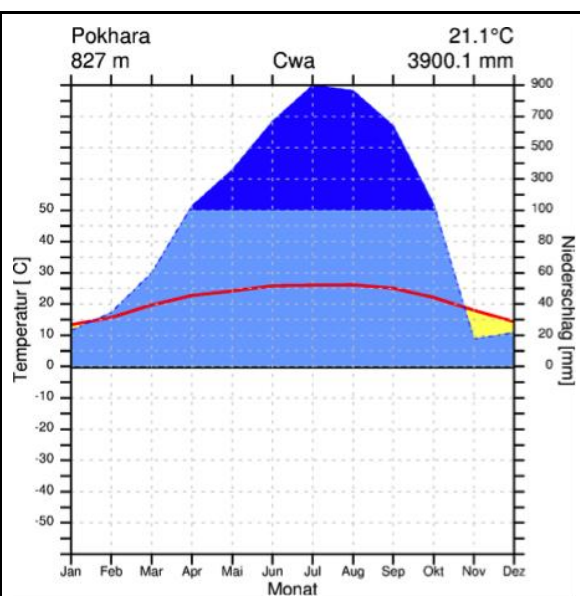Data source: www.dhm.gov.np/climate/

Figure 11b: Climate diagram for Pokhara, Nepal (reference period: 1981-2010).
Data source: www.dhm.gov.np/climate/

Table 4: Long term averages, temperature and precipitation (1981-2010) at Kathmandu and Pokhara.   (Source: http://www.dhm.gov.np/climate)

Kathmandu Airport, 1337 m 27.7 N 85.37 E				
	Tmean	Tmax	Tmin	Precip
	°C	°C	°C	mm
Jan	10.8	19.1	2.4	14.4
Feb	13.0	21.4	4.5	18.7
Mar	16.7	25.3	8.2	34.2
Apr	19.9	28.2	11.7	61.0
May	22.2	28.7	15.7	123.6
Jun	24.1	29.1	19.1	236.3
Jul	24.3	28.4	20.2	363.4
Aug	24.3	28.7	20.0	330.8
Sep	23.3	28.1	18.5	199.8
Oct	20.1	26.8	13.4	51.2
Nov	15.7	23.6	7.8	8.3
Dez	12.0	20.2	3.7	13.2
Year	18.9	25.6	12.1	1454.9

Pokhara Airport, 804 m 28.22 N 84.00 E				
	Tmean	Tmax	Tmin	Precip
	°C	°C	°C	mm
Jan	13.4	19.7	7.1	23.1
Feb	15.7	22.2	9.2	34.6
Mar	19.7	26.7	12.8	60.0
Apr	22.7	29.8	15.7	127.6
May	24.2	30.1	18.4	359.2
Jun	25.8	30.6	20.9	669.0
Jul	26.0	30.0	22.0	940.3
Aug	26.1	30.2	22.0	866.3
Sep	25.1	29.3	20.8	640.8
Oct	22.1	27.5	16.7	139.7
Nov	18.0	24.1	11.9	17.8
Dez	14.4	20.7	8.0	21.7
Year	21.1	26.7	15.5	3900.1

Forecast

Since the earliest onset of the summer monsoon in Nepal was 31 May (in the year 1996) there seems no immediate threat due to widespread heavy rainfall for the next 14 to 21 days. The satellite images from IMD, Delhi, show the typical convective cloud development in a diurnal cycle and tight to mountain ranges. The images are updated every 30 minutes and can be found at http://www.imd.gov.in/section/satmet/img/3Dnesec_vis.jpg and http://www.imd.gov.in/section/satmet/img/3Dnesec_rgb.jpg.Thunderstorms might be accompanied by downpours and can trigger landslides wherever they occur and meet destabilized slopes.
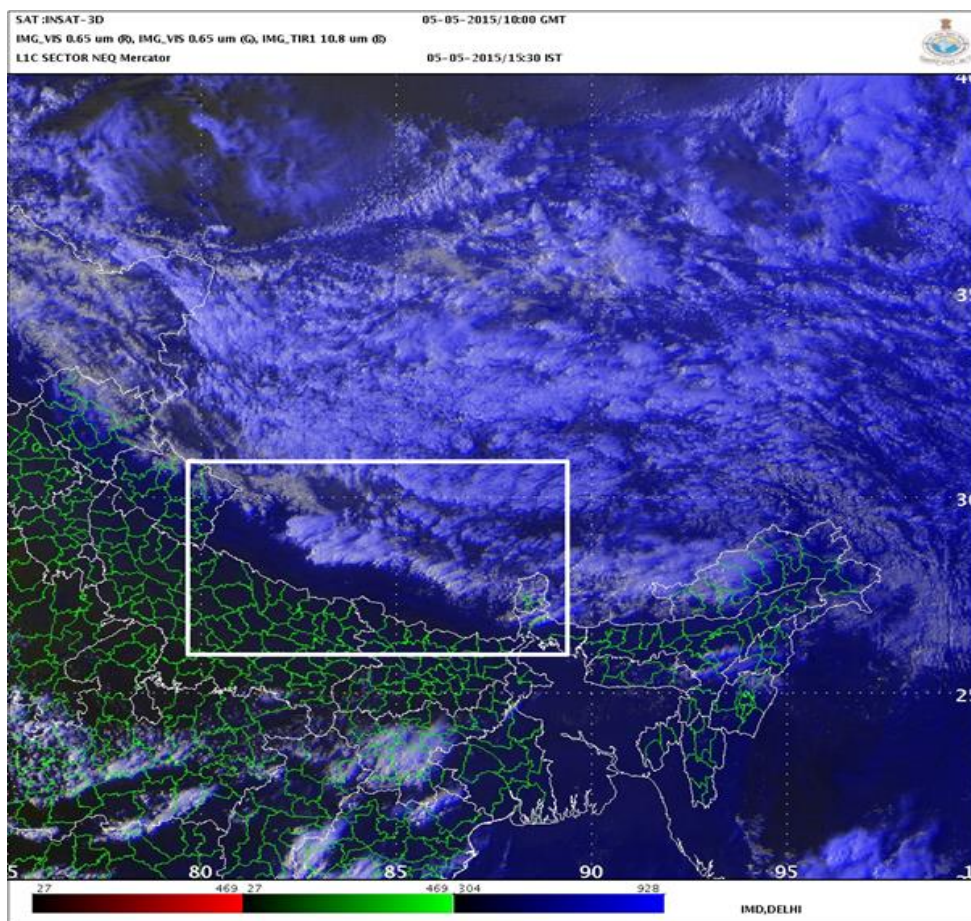

Figure 12: Satellite Image, 05 May 2015, 10 UTC. Image source: http://www.imd.gov.in
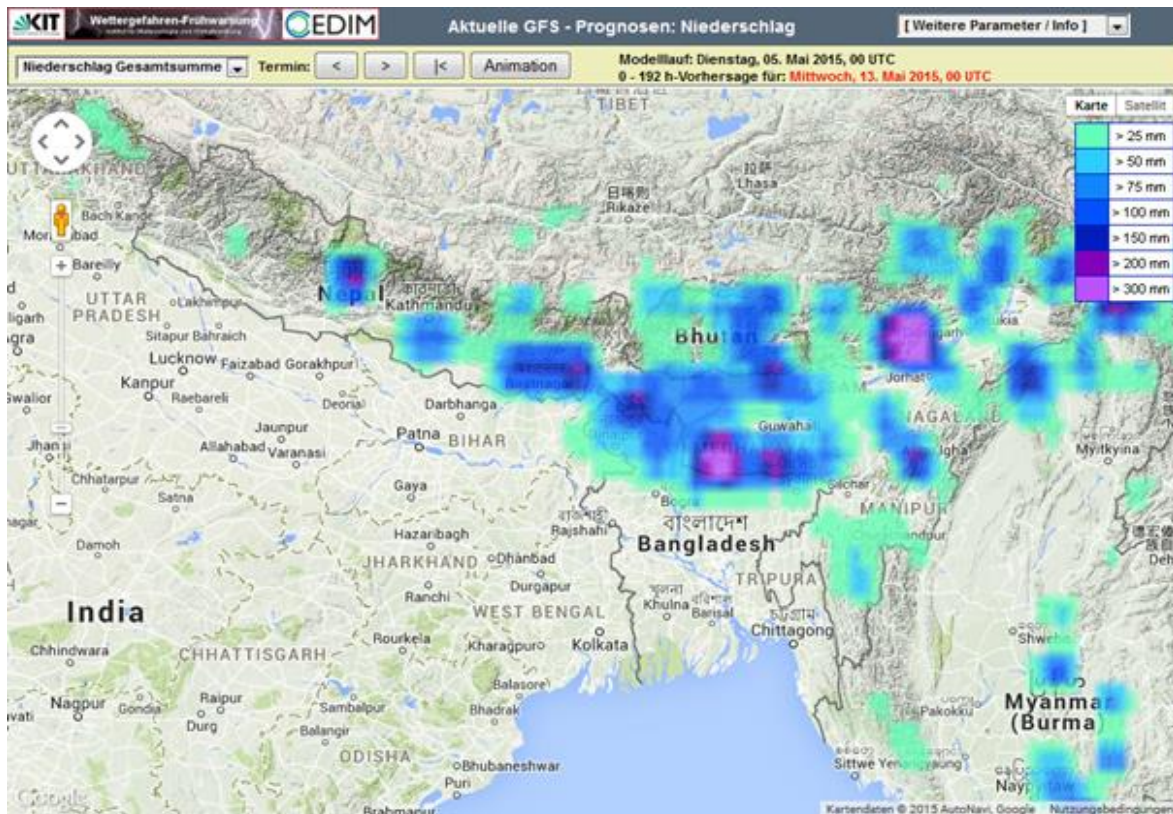
Figure 13: Rain forecast for the next 192 hours (until 13 May 2015), cumulative rain

During the next 192 hours (starting 05 May 2015) the monsoon seems to be not on the way. Close to the Himalayan mountains convective activity has to be expected which display in isolated thunderstorms. These thunderstorms can be heavy and trigger landslides where they occur.

Landslides triggered by the earthquake
New landslides triggered by the earthquake were interpreted using image signatures and mapped by CERN using UNOSAT maps as well as the National Remote Sensing Centre, ISRO of the Department of Space, Government of India from high resolution multi-spectral images taken before and after the earthquake. These inventories do not contain the full landslide extent and will be updated as more information and cloud-free imagery becomes available. Several large deep seated landslides were triggered in the earthquake damming lakes.
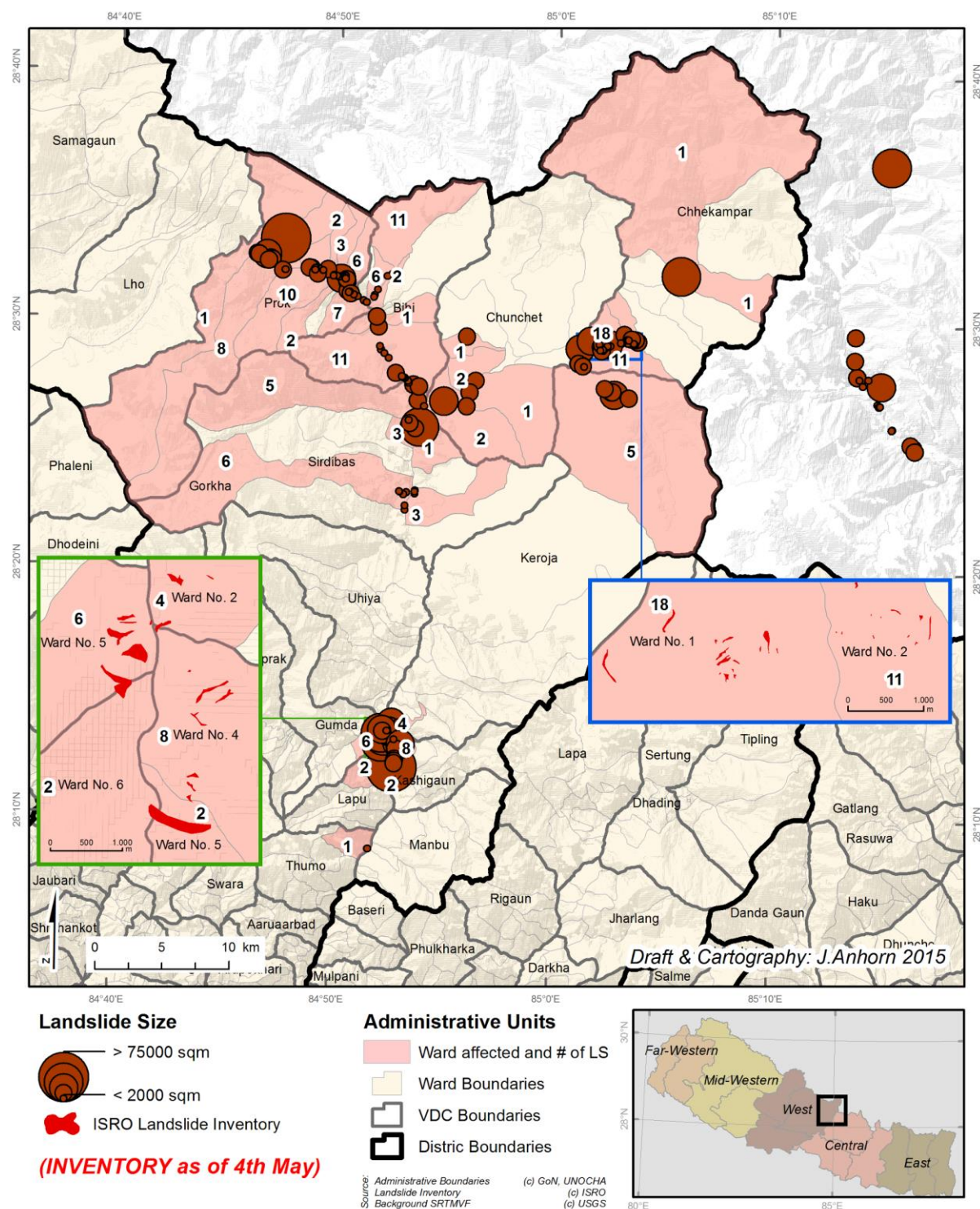
Figure 14: *Landslide distribution and affected Wards in Gorkha according to ISRO Landslide Inventory (as of 4th May 2015).*
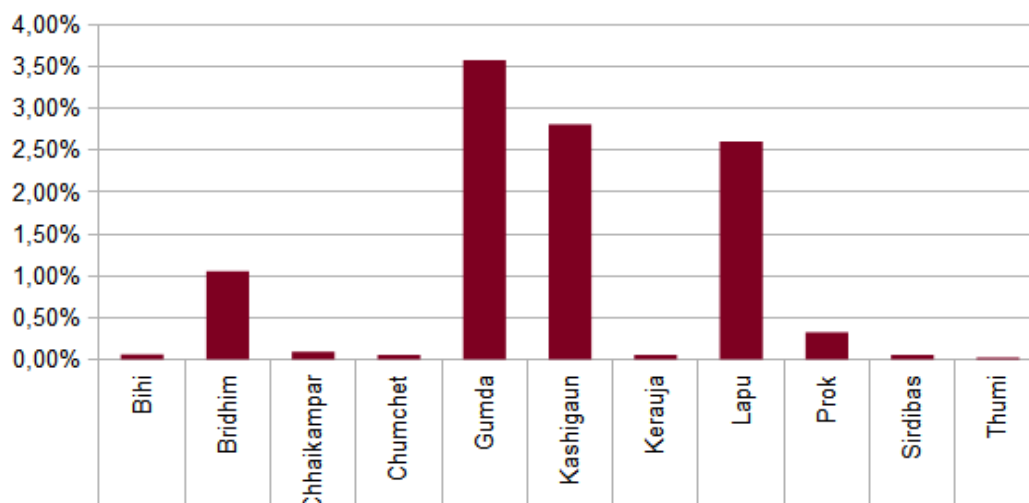
Figure 15: Landslide size compared to the land area of affected wards per VDC.

Preliminary Landslide Vulnerability Index

A preliminary landslide vulnerability index was produced with a view towards the vulnerability of displaced populations to landslides triggered by the earthquake disrupting roads and settlement, as well as the impending threat of rainfall-induced landslides in the coming weeks and months in slopes left unstable by the earthquake. The preliminary landslide risk index is aggregated at the district level and is composed of the following three measures:

- Number of fatal landslides by district
- Annual precipitation variability
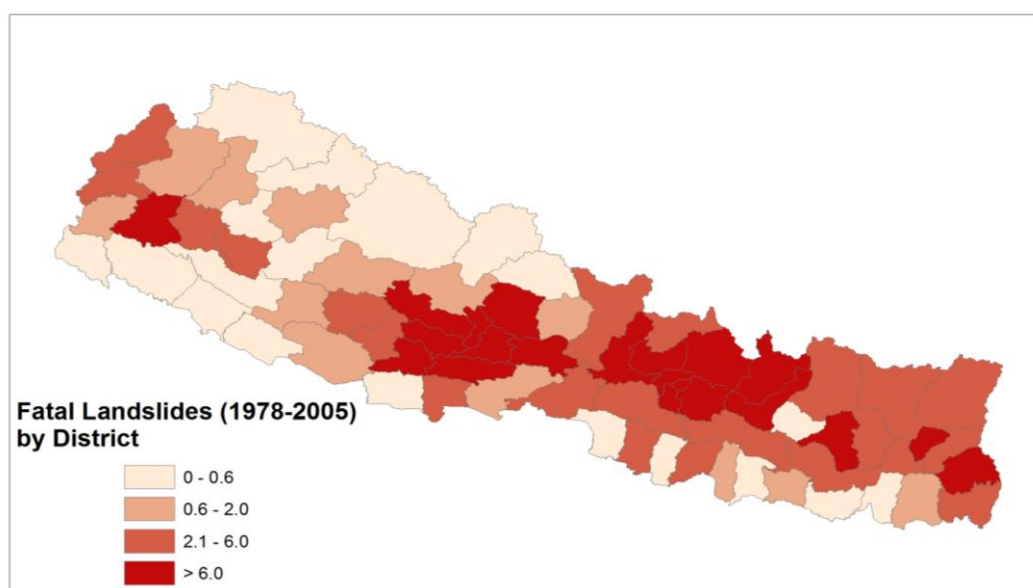- Percent population at risk of landsliding

Figure 16: The distribution of fatal landslides by district for Nepal. The data are sourced from Petley et al (2007) based on recorded number of fatal landslides per 100 km² for the period 1978–2005.
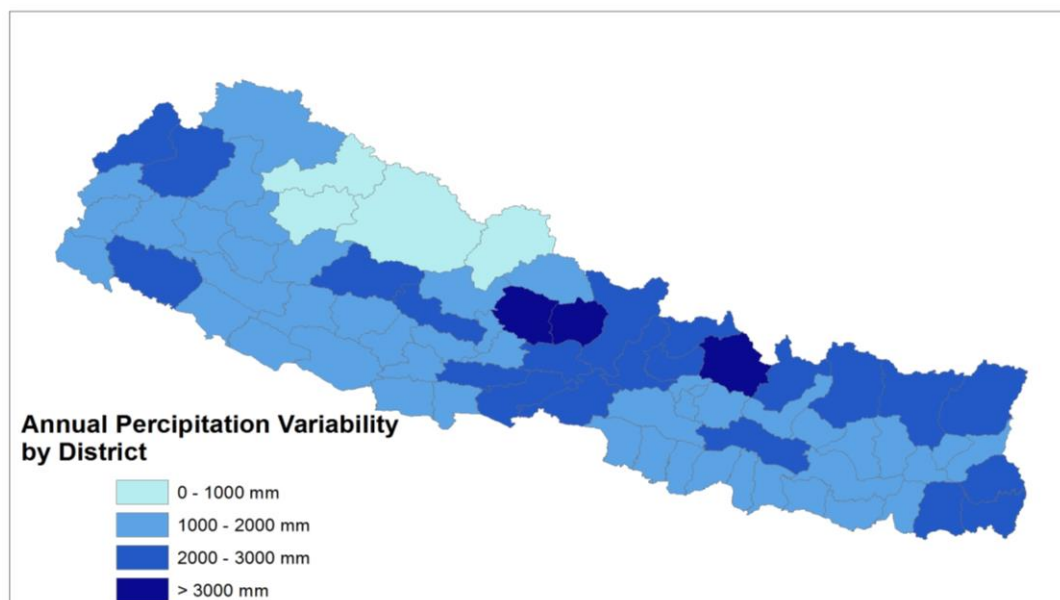
Figure 17: *Annual precipitation variability (data from Chalise et al. 1996).*

A preliminary landslide susceptibility expresses percent population in each district at risk of earthquake induced landslides using the ground motion in terms of peak ground acceleration (PGA) experienced in the April 25 M7.6 event and slope angles of the terrain from a 30-m Digital Elevation Model. The population was quantified from ward level population data as of April 2015. The landslide susceptibility model is based on a simplified infinite slope stability model and looks at where modeled PGA values could be exceeded by critical acceleration required for slope instability. Critical acceleration is computed as a simple ratio of the friction angle of surficial materials and the slope angle, given by: tan (φ:internal friction angle of surficial soils; assume φ=25 degrees) / tan (slope angle; obtained from 30m DEM).
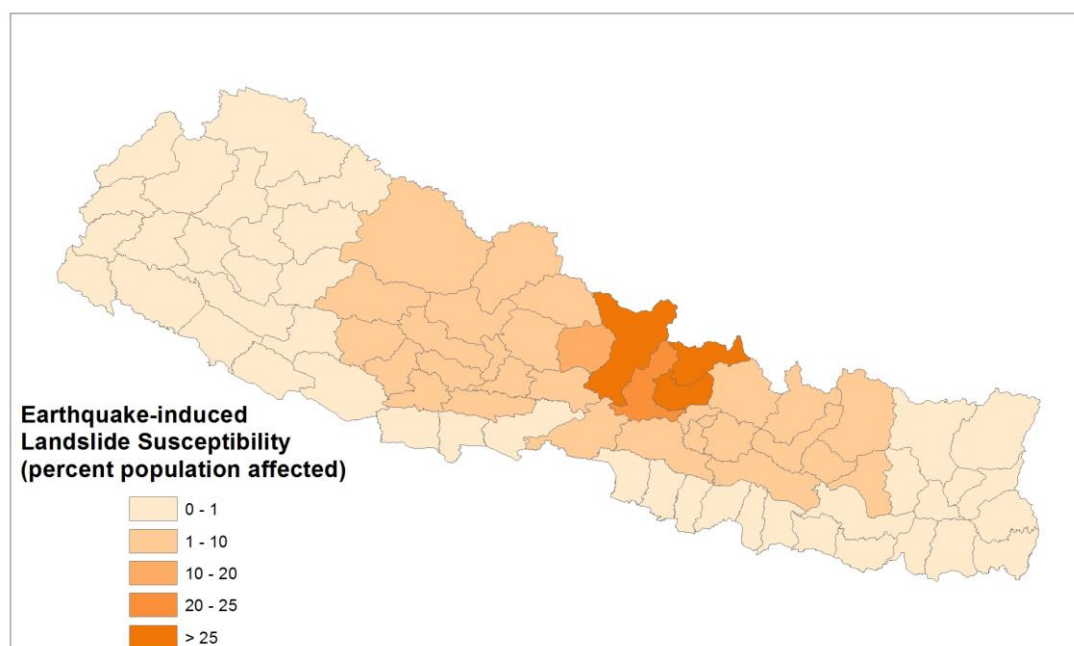

Figure 18: Earthquake-induced landslide susceptibility of districts.

A preliminary landslide risk index is obtained for the most affected districts by combining the earthquake-induced landslide susceptibility (60% weight), annual precipitation variability (20% weight), and historic fatal landslides (20% weight). The index points to districts where populations may be at a higher risk to landslides in slopes that have failed or weakened but did not fail in the earthquake and may be more prone to landsliding when the monsoon rains arrive. The current index provides a preliminary comparison of the relative vulnerability between districts due to landslide risk. As more of the landslides from the event are mapped, validated Peak Ground Acceleration (PGA) values and more information on the strength of the surficial material becomes available, landslide risk can be modeled better.
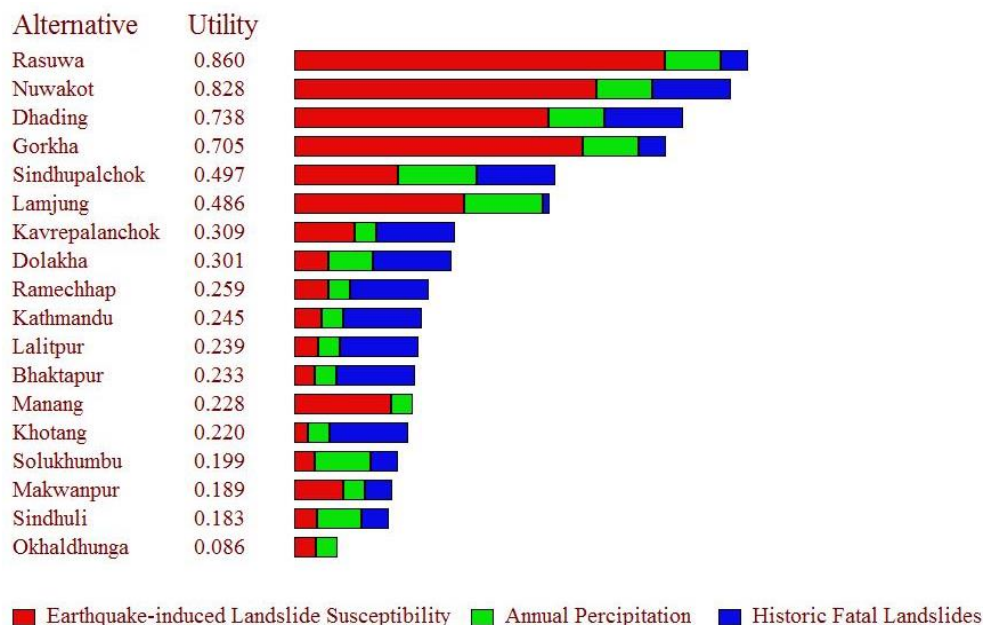
Alternative	Utility
Rasuwa	0.860
Nuwakot	0.828
Dhading	0.738
Gorkha	0.705
Sindhupalchok	0.497
Lamjung	0.486
Kavrepalanchok	0.309
Dolakha	0.301
Ramechhap	0.259
Kathmandu	0.245
Lalitpur	0.239
Bhaktapur	0.233
Manang	0.228
Khotang	0.220
Solukhumbu	0.199
Makwanpur	0.189
Sindhuli	0.183
Okhaldhunga	0.086

■ Earthquake-induced Landslide Susceptibility ■ Annual Percipitation ■ Historic Fatal Landslides

Figure 19 Preliminary landslide risk index for most affected districts.

Social Vulnerability to Displacement
The resourcefulness of survivors in the rural communities cut off from relief to provide and organize their own shelter, food and water from salvaged materials and existing resources is a determining factor in coping with the immediate impacts of the earthquake. Duplication of what the local communities can provide themselves will increase not only dependence but also the cost of post-disaster relief as well as potentially lead to wasted aid. Using the 2011 District level census data we have produced a displacement vulnerability map based on two types of vulnerability:

- Vulnerability to being isolated or trapped by the event;
- Vulnerability to associated difficulties with displacement.

Vulnerability to being isolated: This is a category of vulnerable people who may be unable to seek alternate shelter because of physical restrictions. These could include elderly, persons with disabilities, households without transportation or other factors limiting their mobility to choices for seeking alternatives elsewhere (Chang et al. 2009). Research particularly points to a tendency for elderly to prefer to stay close to home (Chien et al. 2002), delay or not evacuate (Heath et al. 2001) or return home after a short evacuation (Groen & Polivka 2006). Households with elderly members were less likely than other households to be living

in camps rather than staying at home after the Haitian earthquake (Kirsch et al. 2012). This "isolated" or "immobile" population is an important characteristic to consider when considering vulnerability to displacement (Black 2013).

Vulnerability to difficulties associated with displacement: Although the characteristics differ across events, there are often groups that are disproportionately exposed to additional difficulties associated with displacement. A household that is displaced, but is able to stay in the same neighborhood, in comfortable surroundings and with strong social ties is quite different from a household that is forced to rely on shelters which may be less safe, comfortable or may cause disruptions in access to employment, schooling and other necessities. Despite the variation in preferences and availability of shelter options, there are groups that consistently remain in disadvantaged conditions. Large households can be difficult to place in housing leading to extended displacement (Levine et al. 2007). After the 2005 Kashmir earthquake female headed households, larger families, and elderly were more likely to be in smaller unofficial camps that received less aid (Chan & Kim 2010). Poverty and level of education are also important indicators. After the 2004 tsunami, households in camps were found to have lower education than households that stayed with other community members (Rofi et al. 2006). Often the poor are more likely to go to public shelters (Khazai et al. 2014), or stay with friends or family as their options are limited (Peacock et al. 2007).

Looking at these two dimensions of vulnerability of displaced populations as well as factors related to geography and infrastructure, we have developed a Displaced Population Vulnerability Index at the district level for Nepal.

1) Households without car or motorcycles (Census 2011)
2) Percent population with disabilities (Census 2011)
3) Percent population with large families (Census 2011)
4) Percent children (0-5 years) and elderly (65 and above) in a district (Census 2011)
5) Percent illiterate population (Census 2011)

Figure 20 shows a map of the index in the most affected districts while **Figure 21** shows the relative contribution of each of the components to the index.
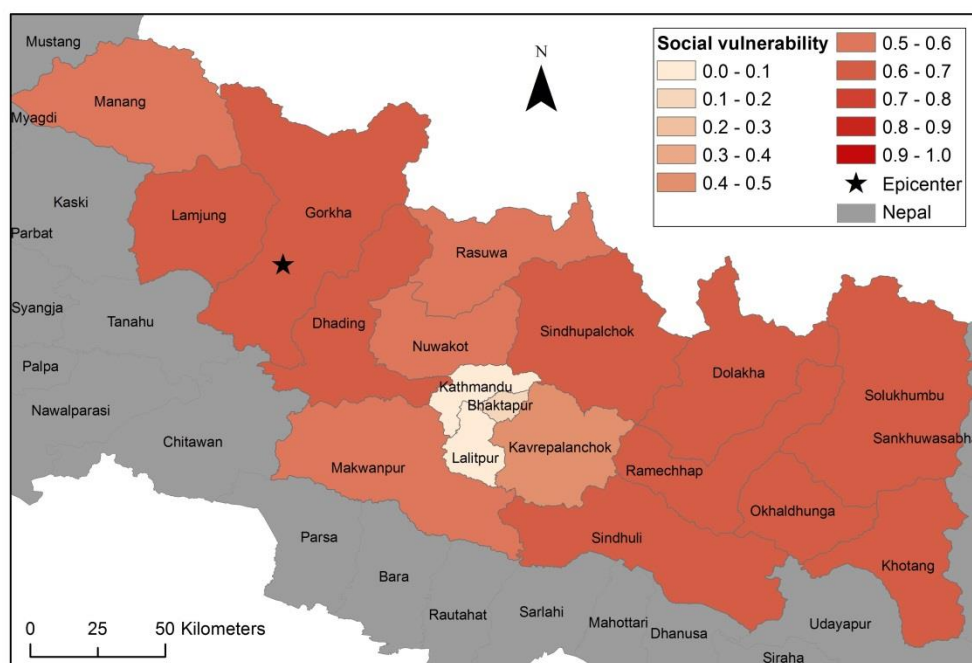
Figure 20: Vulnerability of Displaced Populations in terms of both vulnerability of being isolated and associated difficulties with displacement.
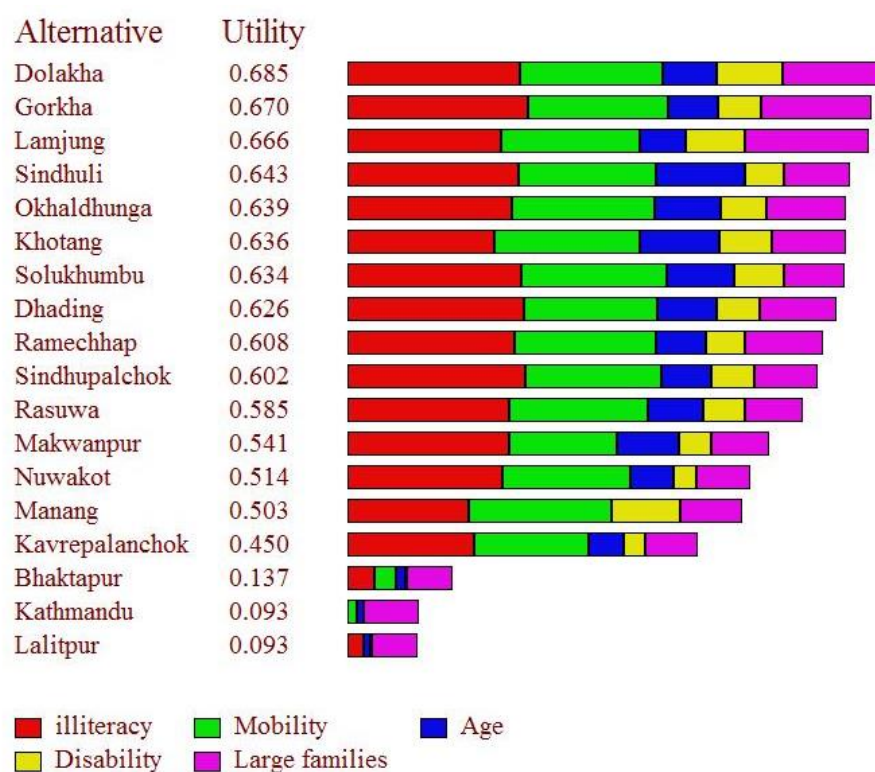

Figure 21: Social vulnerability index for displaced population with the relative contribution of each of the variables.

The **Figure 22** shows a relative ranking of the vulnerability of displaced populations in the most affected districts based on the main criteria discussed above. These include two physical vulnerability criteria: 1) vulnerability to landslide threats based on susceptibility of slopes that are unstable (either failed or weakened) in the earthquake, past fatal landslides and annual precipitation variability to account for potential for landslides in monsoon rains and 2) lack of road accessibility as a function of road density and percent population in settlements above 3500m. The ranking also shows two social vulnerability criteria of displaced populations in terms of factors that lead to increased immobility and isolation as well as factors that account for difficulties associated with displacement based on inherent vulnerability conditions (poverty, education, large families, etc.). The breakdown of the causes shows that there is a large variation in the vulnerability to landslides and the lack of road accessibility.
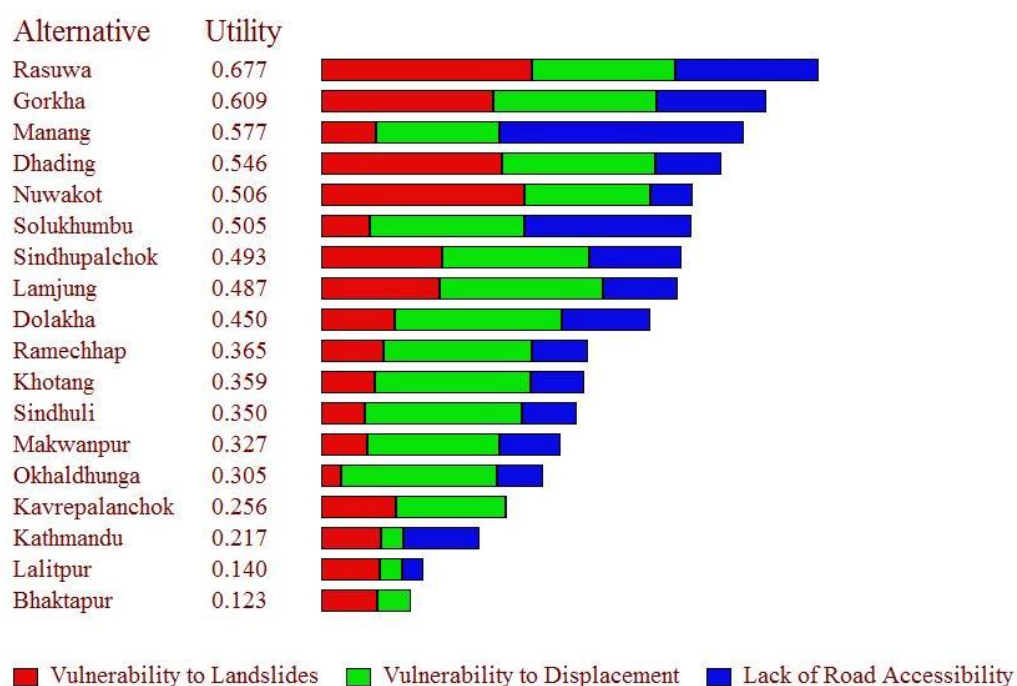
Alternative	Utility		
Rasuwa	0.677		
Gorkha	0.609		
Manang	0.577		
Dhading	0.546		
Nuwakot	0.506		
Solukhumbu	0.505		
Sindhupalchok	0.493		
Lamjung	0.487		
Dolakha	0.450		
Ramechhap	0.365		
Khotang	0.359		
Sindhuli	0.350		
Makwanpur	0.327		
Okhaldhunga	0.305		
Kavrepalanchok	0.256		
Kathmandu	0.217		
Lalitpur	0.140		
Bhaktapur	0.123		

■ Vulnerability to Landslides   ■ Vulnerability to Displacement   ■ Lack of Road Accessibility

Figure 22: Relative ranking of the vulnerability of displaced populations in the most affected districts.

Mapping these indicators of vulnerability, we can see that the districts close to the epicenter and to the North and West of Kathmandu have relatively high displacement vulnerability (**Figure 23**). These areas have relatively high vulnerability to landslides and lack of road accessibility. This underscores the need to direct aid to those severely affected villages outside Kathmandu that may have additional vulnerability. Initial reports indicate that aid has not reached some rural areas yet (Zutt 2015).
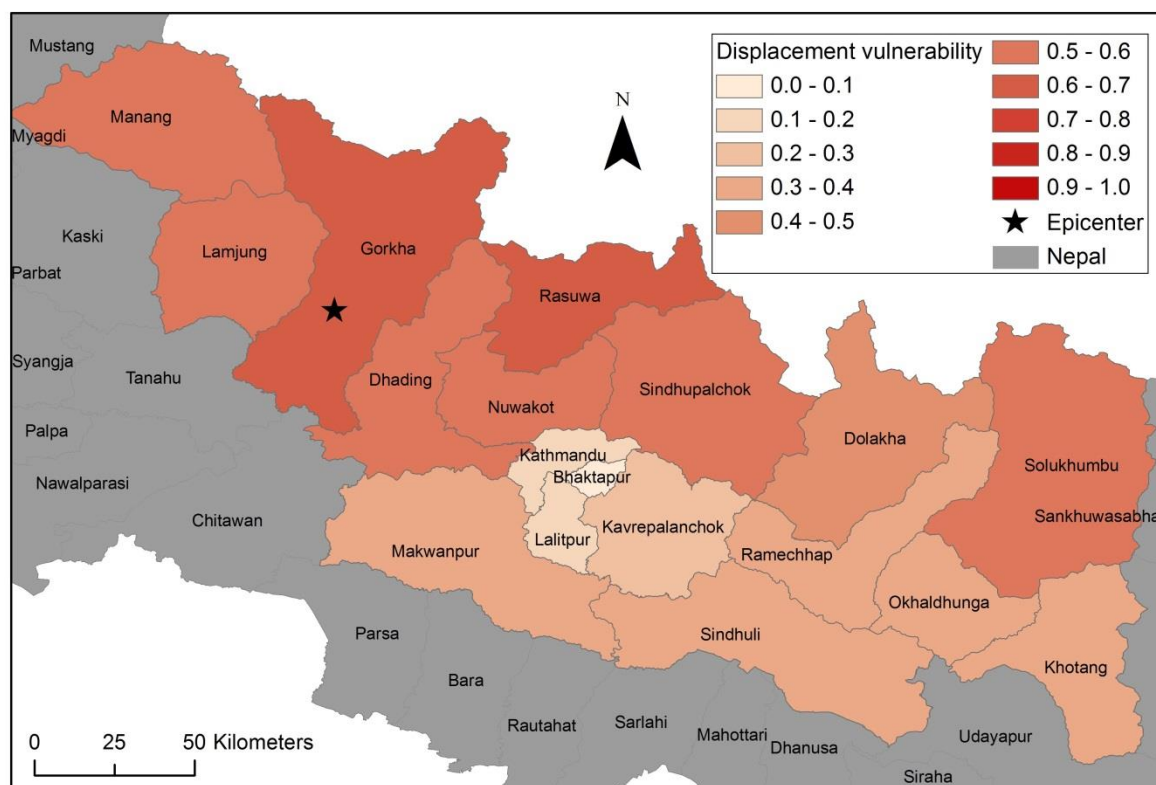
Figure 23: A map of the displacement vulnerability in the most affected districts

A scatter diagram in **Figure 24** shows a comparison of the overall vulnerability of displaced populations with the recorded casualties in districts with districts that were most affected. It should be noted that the fatality counts are not final and this is based on an interim count from May 4th 2015 and is subject to change.
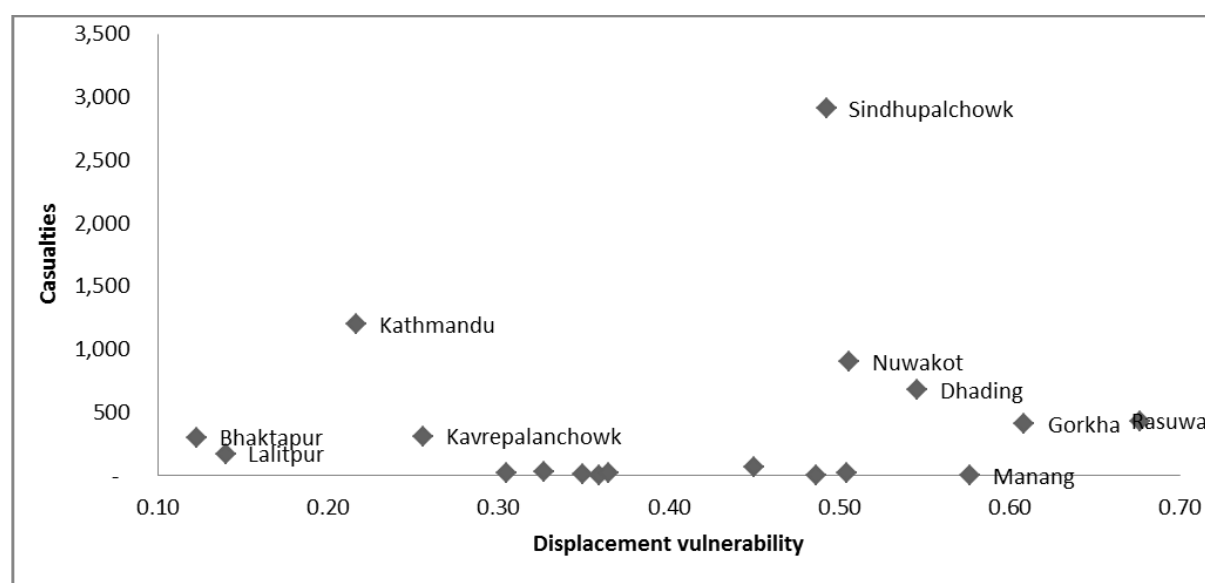

Figure 24: Scatter diagram of the displacement vulnerability compared to the current recorded casualties by district.

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