Nepal Earthquake 2015 Loss Assessment: on the Perspective of China

Weihua FANG

Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs & Ministry of Education

Beijing Normal University
1. Introduction

2. Direct Economic Loss

3. Building Loss

4. Infrastructure Loss

5. Heritage Loss

6. Suggestions
1. Introduction
Shaking Intensity

The Modified Mercalli Intensity (MMI) scale depicts shaking severity. The area nearest Katmandu experienced very strong to severe shaking.

Image courtesy of the US Geological Survey

USGS Estimated shaking Intensity from M 7.8 Earthquake
1) Team building
2) Preparation
3) Data collection
4) Field Survey in Nepal
5) Report Writing

Preparation Meeting before departure for field work in Nepal
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xiaoning Zhang</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs. Associated Director/Researcher</td>
</tr>
<tr>
<td>Yi Yuan</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs.</td>
</tr>
<tr>
<td></td>
<td>Department of Disaster Assessment and Emergency Management, Department Director / Researcher</td>
</tr>
<tr>
<td>Yan Guan</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs.</td>
</tr>
<tr>
<td></td>
<td>Department of International Cooperation. Department Director/Associate Researcher</td>
</tr>
<tr>
<td>Wei Wang</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs.</td>
</tr>
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<td></td>
<td>Department of Aerial Remote Sensing. Associated Director/Associate Researcher</td>
</tr>
<tr>
<td>Hongjian Zhou</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs.</td>
</tr>
<tr>
<td></td>
<td>Department of Disaster Assessment and Emergency Management. Associate Director/Associate Researcher</td>
</tr>
<tr>
<td>Do nghuaPan</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs.</td>
</tr>
<tr>
<td></td>
<td>Department of Disaster Assessment and Emergency Management. Associate Researcher</td>
</tr>
<tr>
<td>Yi Ding</td>
<td>National Disaster Reduction Center, Ministry of Civil Affairs.</td>
</tr>
<tr>
<td></td>
<td>Data Center Associate Researcher</td>
</tr>
<tr>
<td>Lianyou Liu</td>
<td>Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs &amp; Ministry of Education. Secretary of the Party Committee/Professor</td>
</tr>
<tr>
<td>Weihua Fang</td>
<td>Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs &amp; Ministry of Education. Professor</td>
</tr>
<tr>
<td>Wei Xu</td>
<td>Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs &amp; Ministry of Education. Associate Professor</td>
</tr>
<tr>
<td>Jidong Wu</td>
<td>Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs &amp; Ministry of Education. Associate Professor</td>
</tr>
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<td>Chinese Academy of Cultural Heritage, State Administration of Cultural Heritage. Assistant Chief Engineer/Senior Engineer</td>
</tr>
<tr>
<td>Liping Wang</td>
<td>China Relic Information Consultation Center, State Administration of Cultural Heritage. Assistant Chief Engineer/Senior Engineer</td>
</tr>
<tr>
<td>Yunfei Qiao</td>
<td>Chinese Academy of Cultural Heritage, State Administration of Cultural Heritage, Institute of Engineering Planning. Director/Senior Engineer</td>
</tr>
<tr>
<td>Demin Zeng</td>
<td>China Institute of Building Standard Design &amp; Research. Researcher</td>
</tr>
<tr>
<td>Tiehua Shi</td>
<td>China Academy of Building Research. Researcher</td>
</tr>
<tr>
<td>Li Yang</td>
<td>Building General Municipal Engineering Design &amp; Research Institute Co., Ltd., Senior Engineer</td>
</tr>
<tr>
<td>Qi Li</td>
<td>Building General Municipal Engineering Design &amp; Research Institute Co., Ltd., Senior Engineer</td>
</tr>
</tbody>
</table>

**Team Members**

- 18 members
- 7 Institutes
## Collection of Dataset
(hazard, statistics, remote sensing imagery, modeling parameters, etc.)

<table>
<thead>
<tr>
<th>Category</th>
<th>Data name</th>
<th>Data content</th>
<th>Time</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental geographic</td>
<td>Administrative division</td>
<td>Development area, Prefecture, City, County, City Point, Administrative area code</td>
<td>2014</td>
<td>HDX</td>
</tr>
<tr>
<td></td>
<td>Natural environment</td>
<td>Terrain elevation, Hydrographic net, etc.</td>
<td>—</td>
<td>HDX</td>
</tr>
<tr>
<td></td>
<td>Traffic data</td>
<td>Airport, Road</td>
<td>2015</td>
<td>HDX</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>Nepal Statistical Yearbook</td>
<td>Nepalese Population, GDP, etc.</td>
<td>2013</td>
<td>Central Bureau of Statistics (CBS)</td>
</tr>
<tr>
<td></td>
<td>Nepalese population census data</td>
<td>Nepalese administrative units, Households, etc.</td>
<td>2011</td>
<td>Central Bureau of Statistics (CBS)</td>
</tr>
<tr>
<td></td>
<td>Nepalese county level statistics data</td>
<td>Nepalese county level socio-economic statistics data, population, households, number of enterprises, etc.</td>
<td>2014/2015</td>
<td>Central Bureau of Statistics (CBS)</td>
</tr>
<tr>
<td>Thematic elements</td>
<td>Housing data</td>
<td>House number, House structure type</td>
<td>2011</td>
<td>Nepalese statistics departments</td>
</tr>
<tr>
<td></td>
<td>Cultural heritage maps</td>
<td>Heritage place plans, individual building dimensions, Heritage composition maps</td>
<td>2015</td>
<td>Nepal archaeological bureau</td>
</tr>
<tr>
<td>Remote sensing data</td>
<td>Satellite remote sensing data</td>
<td>High-resolution satellite images</td>
<td>November 13, 2014</td>
<td>Google Earth</td>
</tr>
<tr>
<td></td>
<td>before disaster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Satellite remote sensing data</td>
<td>High-resolution satellite images</td>
<td>May 14, 2015</td>
<td>Google Earth</td>
</tr>
<tr>
<td></td>
<td>before disaster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UAV remote sensing data after</td>
<td>UAV remote sensing data</td>
<td>In May 2015</td>
<td>Domestic sharing mechanism</td>
</tr>
<tr>
<td></td>
<td>the disaster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casualty loss</td>
<td>Loss data</td>
<td>Death and missing population, Damaged buildings, Relocated population</td>
<td>2015</td>
<td>Nepal Ministry of the interior</td>
</tr>
</tbody>
</table>
Field work:  -- 3 cities (Kathmandu, Lalitpur and Bhaktapur)  
-- detailed survey at 29 locations in the above 3 cities
Meeting with National Planning Commission of Nepal (June 6)

Meeting with Mayor of Lalitpur (June 11)

Survey in temporal shelter (June 11)

Meeting with Economic and Commercial Counselor (June 12)
Introduction

Field survey at Kathmandu, June 9

Field survey at School, Kathmandu, June 10

Changu Narayan Temple, May 10

Lalitpur, June 11

Economic Loss

Building Loss

Infrastructure Loss

Heritage Loss

Suggestions
Scope of Assessment

1. Nepal
   - Total Direct Economic Loss

2. Three Cities (Kathmandu, Lalitpur Bhaktapur)
   - Building
   - Infrastructure
   - Heritage
Data and Methods for Assessment

1) Hazard maps: China Earthquake Administration, USGS
2) Field Survey: data by Assessment Team in Nepal
3) Satellite Imagery: obtained by NDRCC, China, and UN-Charter
5) Loss Statistics: casualty, and building damages by Nepal Gov. (by June 20)
6) Others: Rapid loss assessment results by other international organizations
2. Direct Economic Loss
**Direct economic loss**

Loss caused by physical damage induced by earthquakes, such as physical damages of buildings, infrastructure, equipment and other fixed assets while the cultural value of buildings, the value of non-moving cultural relics, land resources and other natural resources are not considered.

**Loss rate of fixed asset**

Direct Economic Loss = Fixed Asset Stock × Fixed Asset loss rate

**Fixed Asset Stock:** the total number of buildings, infrastructures, equipment and other fixed asset from historical investment. It is the upper limit of direct economic loss caused by a disaster. The calculation fixed asset stock is mainly based on historical fixed asset, rice index, depreciation rate, GDP and other indicators.

**Loss Rate of Fixed Asset:** classified into high, medium and low 3 types. The calculation of 3 types of loss rate is mainly based on the estimated “complete damage rate” and “partial damage rate “of private buildings in affected area.
## Direct Economic Loss of Nepal and 3 Cities

( unit: 0.1bn )

<table>
<thead>
<tr>
<th>Unit</th>
<th>GDP</th>
<th>Assets</th>
<th>Damage Ratio (%)</th>
<th>Direct Economic Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td>Nepal</td>
<td>198.82</td>
<td>731.66</td>
<td>6.5</td>
<td>7.3</td>
</tr>
<tr>
<td>-Kathmandu</td>
<td>31.33</td>
<td>115.28</td>
<td>6.9</td>
<td>7.8</td>
</tr>
<tr>
<td>-Lalitpur</td>
<td>2.73</td>
<td>10.05</td>
<td>18.8</td>
<td>21.2</td>
</tr>
<tr>
<td>-Bhaktapur</td>
<td>5.76</td>
<td>21.19</td>
<td>10.8</td>
<td>12.2</td>
</tr>
<tr>
<td>-Sum of 3 cities</td>
<td>39.82</td>
<td>146.53</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>
Comparison with PDNA of Nepal Earthquake 2015
3. Building Loss
Field Survey

1. Relatively old residential buildings: 1-2 stories, Masonry or wooden. Majority of them are severe damaged or collapsed; a few old residential buildings are brick or masonry structure, damage state severer than moderate are nearly 50%, a few are severe damaged or collapsed.
Field Survey

2. Multi-story residential or commercial buildings
Relatively new, masonry or frame structure, majority of which are 3-5 stories. The damage degree is relatively slight, damage state severer than medium are less than 30%, very few are collapsed.

3. High-rise residential buildings:
reinforced concrete frame or shear wall structure, brick filled wall, the damage state is under medium from appearance, no severe damage.
### Population and building statistics (Data source: Nepal statistics depart.)

<table>
<thead>
<tr>
<th>Area</th>
<th>Population</th>
<th>Building</th>
<th>Building structure type%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Frame</td>
</tr>
<tr>
<td>Kathmandu</td>
<td>1,744,240</td>
<td>436,344</td>
<td>20</td>
</tr>
<tr>
<td>Bhaktapur</td>
<td>304,651</td>
<td>68,636</td>
<td>10</td>
</tr>
<tr>
<td>Lalitpur</td>
<td>468,132</td>
<td>109,797</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>2,517,023</td>
<td>614,777</td>
<td>—</td>
</tr>
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</table>
## Shaking/Intensity Maps

### Damage Ratio of three cities /%

<table>
<thead>
<tr>
<th>Building type</th>
<th>Slight</th>
<th>Moderate</th>
<th>Severe</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathmandu Wooden</td>
<td>20%</td>
<td>40%</td>
<td>25%</td>
<td>15%</td>
</tr>
<tr>
<td>Masonry / Concrete</td>
<td>72%</td>
<td>20%</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td>Frame</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lalitpur Wooden</td>
<td>30%</td>
<td>30%</td>
<td>28%</td>
<td>12%</td>
</tr>
<tr>
<td>Masonry / Concrete</td>
<td>65%</td>
<td>20%</td>
<td>12%</td>
<td>3%</td>
</tr>
<tr>
<td>Frame</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Bhaktapur Wooden</td>
<td>15%</td>
<td>35%</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>Masonry / Concrete</td>
<td>55%</td>
<td>20%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>Frame</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
## Residential damage in 3 cities

<table>
<thead>
<tr>
<th>City</th>
<th>Building type</th>
<th>Slight</th>
<th>Moderate</th>
<th>Severe</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathmandu</td>
<td>Wooden</td>
<td>4355</td>
<td>8711</td>
<td>5444</td>
<td>3267</td>
</tr>
<tr>
<td></td>
<td>Masonry / Concrete</td>
<td>235194</td>
<td>65332</td>
<td>19599</td>
<td>6533</td>
</tr>
<tr>
<td></td>
<td>Frame</td>
<td>87109</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Sum</td>
<td>326658</td>
<td>74042</td>
<td>25044</td>
<td>9800</td>
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<tr>
<td>Lalitpur</td>
<td>Wooden</td>
<td>3285</td>
<td>3285</td>
<td>3066</td>
<td>1314</td>
</tr>
<tr>
<td></td>
<td>Masonry / Concrete</td>
<td>53384</td>
<td>16426</td>
<td>9855</td>
<td>2464</td>
</tr>
<tr>
<td></td>
<td>Frame</td>
<td>16426</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Sum</td>
<td>73095</td>
<td>19711</td>
<td>12922</td>
<td>3778</td>
</tr>
<tr>
<td>Bhaktapur</td>
<td>Wooden</td>
<td>514</td>
<td>1200</td>
<td>1028</td>
<td>686</td>
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<tr>
<td></td>
<td>Masonry / Concrete</td>
<td>32050</td>
<td>11655</td>
<td>8741</td>
<td>5827</td>
</tr>
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<td></td>
<td>Frame</td>
<td>6856</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Sum</td>
<td>39420</td>
<td>12854</td>
<td>9769</td>
<td>6513</td>
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<tr>
<td>Totals of 3 cities</td>
<td></td>
<td>439173</td>
<td>106608</td>
<td>47735</td>
<td>20091</td>
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</table>
### Public Building Loss (field survey results)

<table>
<thead>
<tr>
<th>School</th>
<th>Location</th>
<th>Students</th>
<th>Building type</th>
<th>Damage Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gramsewa Higher Secondary School</td>
<td>Dharmasthali, Kathmandu</td>
<td>600</td>
<td>Frame</td>
<td>Slight</td>
</tr>
<tr>
<td>Sanskrit</td>
<td>Kathmandu city</td>
<td>300</td>
<td>Masonry / Concrete</td>
<td>Severe</td>
</tr>
<tr>
<td>Unnamed</td>
<td>Kathmandu city</td>
<td>100</td>
<td>Manufactured; Brick &amp; Wooden</td>
<td>Slight or Severe</td>
</tr>
<tr>
<td>Municipal public school</td>
<td>Kathmandu city</td>
<td>200</td>
<td>Teaching: Concrete &amp; Steel (3 stories)</td>
<td>Teaching: Slight</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Office: Brick &amp; Wooden (1 story)</td>
<td>Office: Severe</td>
</tr>
<tr>
<td>Shree Geetamata</td>
<td>Kathmandu city</td>
<td>300</td>
<td>Masonry / Concrete (4 stories)</td>
<td>Severe</td>
</tr>
</tbody>
</table>

* Severe damage ratio: Schools (20%), Hospital (5%), Government Building (15%)
4. Infrastructures
The water sources of residents in Kathmandu, Patan and Budgang mainly are well water, river (spring) water and tap water, which are mainly distributed water supplies. The water security rate is low.
Each independent water supply system is small and the water supply network coverage is low.

Except for the initial supply panic, although Kathmandu's water security is low, the impact of the earthquake is generally small.
There are no systematic drainage facilities and municipal wastewater treatments in Kathmandu, Patan, Bhadgaon and other places.

Rainwater passes through the road runoff into the gutter or open ditch on either side of the road, and eventually pooled into the Bagati River.

During the field investigation, no drainage facilities were found to be significantly damaged after the earthquake.
**Road system.** Some cross river Bridges, in the bridge body and the land connection positions, because of uneven settlement, cracks were found along the transverse section. Bridge decks and roads of other Bridges did not show abnormal changes.

**Power supply and communication systems.** According to the field surveys, within two months after the earthquake, the electricity supply and communication in the city were basically restored to their original level.

**The fuel gas system** Three cities adopt gas cylinder air supplies, During the investigation, a larger LPG transfer station was observed and its operation was normal. There should be no obvious damage.
5. Heritage
Surveyed 7 world heritage sites in 3 cities in Kathmandu Valley, including 130 individual buildings, covered area 83397m², total area 180ha.

Surveyed and recorded seismic damage and conservation status, laws, regulations and technical standards about heritage protection.

Severity Types:

Main heritage building status: collapse and conserved status.

Sum-up the number and volume of each site:

Building status:

A: Structural cracking, deformation, security risks

B: Structural cracking, severe deformation, severe security risks

C: Main building collapse
<table>
<thead>
<tr>
<th>Heritage</th>
<th>Profile</th>
<th>Damage/Loss Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>加德满都皇宫广场</td>
<td>地处加德满都古城中心，皇宫广场集中了尼泊尔马拉王朝的古建筑，多建于为16世纪至19世纪，总共有43组（座）寺庙和宫殿，主要古建筑包括独木庙（Kasthamandap）、库玛莉神院（KumariBahal）、旧皇宫（Hanuman Dhoka）和塔莱珠神庙（TalejuBhawan）等。</td>
<td>加德满都皇宫广场文物建筑受损十分严重，共有天黑神庙、纳拉杨毗湿奴庙、玛珠庙、Kamdev神庙、独木庙、纳拉扬神庙、Panch Muki Hanuman 神庙等七处神庙完全坍塌，皇宫城墙及塔庙遭受不同程度的局部坍塌、开裂、变形破坏。</td>
</tr>
<tr>
<td>帕坦皇宫广场</td>
<td>帕坦是尼泊尔最古老的城市，帕坦皇宫广场包括帕坦皇宫及其附近的寺庙群，被誉为“尼泊尔建筑艺术的杰出典范”。</td>
<td>广场文物建筑受损严重，共有贾嘉纳拉扬神庙、哈里·尚卡尔神庙等两处神庙完全坍塌，部分塔庙遭受不同程度开裂、变形破坏。</td>
</tr>
<tr>
<td>巴德岗皇宫广场</td>
<td>广场修建于马拉王朝鼎盛时期，被誉为“中世纪尼泊尔艺术的精华和宝库”，特别是其中的金门和五十五窗宫，是世界罕见的艺术珍品。</td>
<td>广场文物建筑受损严重，共有西大门、Rameshvara神庙、国王雕像柱、瓦斯塔拉迦神庙和法希得噶神庙等五处主要建筑完全坍塌，部分塔庙遭受不同程度开裂、变形破坏。</td>
</tr>
<tr>
<td>斯瓦布纳特</td>
<td>意为“自体放光”，该寺修建于2500年前，是尼泊尔最古老的佛教寺庙，因为寺庙里猴子众多，所以得名猴庙。</td>
<td>佛塔震损较小，周边喇嘛庙坍塌、开裂变形十分严重。</td>
</tr>
<tr>
<td>昌古纳拉扬寺</td>
<td>该寺庙主供毗湿奴，受到印度教徒的尊敬，被认为是尼泊尔最古老的印度教神庙。</td>
<td>主体佛寺局部开裂变形，总体保存较好，但附属建筑损失严重。</td>
</tr>
<tr>
<td>帕舒帕蒂纳特</td>
<td>意为“一切生物的保护者和主”，帕舒帕蒂纳特庙占地面积2.6平方公里，是塔式建筑。</td>
<td>Bishworoop塔顶部局部坍塌，墙体开裂受损严重；部分小型佛塔坍塌，其他文物建筑受损较小，保存较好。</td>
</tr>
<tr>
<td>布达哈佛塔</td>
<td>又名保纳特佛塔，相传建于公元5世纪，是李察维王朝的希瓦·蒂瓦国王所建，塔中央安放释迦牟尼弟子摩柯迦叶的舍利。该塔是尼泊尔最高大的佛塔。16世纪时，该塔由西藏宁玛派喇嘛修复，19世纪中叶到20世纪中叶，该塔一直由中国西藏的喇嘛掌管。</td>
<td>上部塔体出现开裂变形，总体保存较好，当地正在组织抢险加固，其他文物建筑受损较小，保存较好。</td>
</tr>
</tbody>
</table>
Earthquake: significant magnitude and massive destruction potential

Structure:
Problematic
Weak Adhesion and joint of brick and masonry structure
Disrepair

Patan Durbar Square/ Jagannarayan Mandir
Bhaktapur Durbar Square / karma Cetus Temple
Changu Narayan Temple / Laxmi Narayan
6. Suggestions
Suggestions to Chinese government

1) Localization: in complied with local cultural, geophysical, and socio-economic conditions
2) Priority areas: define reconstruction priority areas: shall consider both short-term and long-term goals
3) Project types: both structure project, and technical assistance project, in order to enhance local capacity

Suggested Priority Reconstruction Projects

1) Heritage
2) Municipal infrastructure
3) Public buildings (school, hospital, government buildings)
4) Residential building
The end.

Thank you!