

CAUTION

This scenario story describes what could happen to one fictional family in the Linwei and Huazhou Districts of Weinan if the 1568 earthquake occurred in the present day.

It is NOT a prediction of a specific disaster. It does NOT mean that an earthquake akin to the one described will happen in Weinan in the near future. No one knows when or where the next earthquake might occur, nor how large and damaging it might be. Rather, this fictional scenario story is an example to help people visualize specific consequences and learn what you can do now to lessen the impacts of any future possible earthquake. This description is intended only for use in planning and preparedness exercises and in raising awareness of local earthquake risk.

Some actions taken by the children in the story's village setting may not be advisable in other contexts. The authors, funders, publishers and other contributors to this report are not responsible for any interpretation and use beyond the purposes stated. It is important to note that the story described is not a worst-case scenario. For emergency planning purposes, officials may also wish to consider larger earthquakes, and earthquakes in different locations, different times of the day, and seasons of the year.



MAIN IMPLEMENTATION ORGANIZATIONS

China

- Institute of Geology, China Earthquake Administration (CEA)
- China Earthquake Disaster Prevention Center (CEDPC)
- The Hong Kong Polytechnic University, China

United Kingdom and United States

- Overseas Development Institute (ODI), UK
- Department of Earth Sciences, University of Oxford, UK
- Department of Architecture, University of Cambridge, UK
- GeoHazards International (GHI), USA

FUNDERS

- National Natural Science Foundation of China (NSFC), China
- Natural Environment Research Council (NERC), UK
- Economic and Social Research Council (ESRC), UK
- Newton Fund, UK



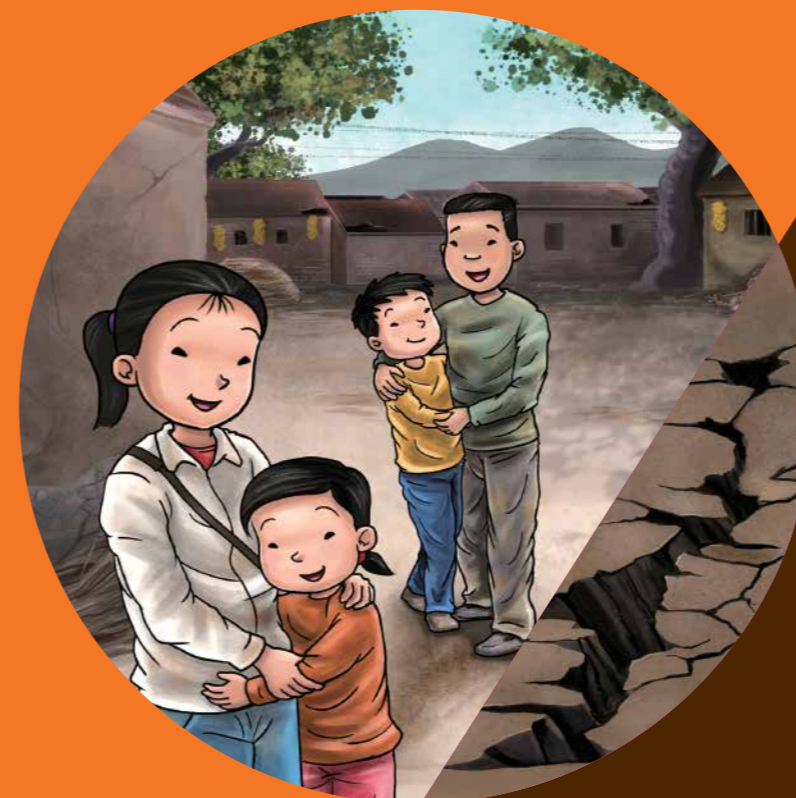
New Concept for Disaster Prevention, Mitigation and Relief in China in the New Era

This project aligns with China's new approach to disasters, which is to:

Prioritize prevention; combine prevention with preparedness and rescue; unify regular disaster reduction and extraordinary disaster relief; shift focus from post-disaster relief to prevention beforehand, from coping with single disaster to comprehensive disaster reduction, and from reducing losses to mitigating disaster risks; fully raise the comprehensive capability of the whole society to resist natural disasters.

HOME COMING

Janise Rodgers, Guiwu Su, Timothy Sim, Philip England, John Young, Wenhua Qi and others



A story about how a strong earthquake affects a family with "left-behind" children

Version for Government Officials

This scenario describes how a repeat of the historical 1568 Shaanxi Northeast Xi'an earthquake could impact the life of a family with "left-behind" children in a rural village in Weinan if it occurred in the present day.

This hypothetical scenario will help you to understand the specific consequences of a damaging earthquake, in the hope of stimulating discussions among various local relevant agencies to foster consensus, and encourage action to strengthen local top-down earthquake disaster risk reduction pathways.

HOME COMING

A story about how a strong earthquake affects a family with "left-behind" children (Version for Government Officials)

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earthquake affects a family
with “left-behind” children

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NOTE FOR READERS

This document is intended for use by local officials in Weinan, who already know their community well. For readers not local to the area, including international readers, this note provides basic background about Weinan.

Weinan is located to the east of Xi'an in Shaanxi Province, in the Wei River valley. *Please see the map on page 12.* The two municipal districts of the study area, Linwei and Huazhou, contain the two main urban areas in Weinan prefecture (the prefecture is a larger administrative area with additional districts), as well as large rural areas located in the valley, in the yellow-soil (loess) plateau and in the Qinling mountains to the south. As of 2017, these two districts had a total population of over 1.3 million and a Gross Domestic Product of 46.6 billion RMB.

Linwei district adjoins eastern Xi'an, which is one of the most historically and culturally important areas of the country with numerous heritage sites. Weinan was devastated by the deadliest earthquake in recorded history, the 1556 Huaxian earthquake (approximately M8), and today Weinan remains at risk from the numerous active earthquake faults in the Wei River valley.

Editorial committee

Leading authors

- Janise Rodgers GeoHazards International (GHI), USA
- Guiwu Su Institute of Geology, China Earthquake Administration (CEA)
- Timothy Sim The Hong Kong Polytechnic University (PolyU), China
- Philip England Department of Earth Sciences, University of Oxford, UK
- John Young Overseas Development Institute (ODI), UK
- Wenhua Qi Institute of Geology, China Earthquake Administration (CEA)

Authors

Contributors from the same organization are listed in alphabetical order of their last names

- Xiaoli Li Institute of Geology, China Earthquake Administration (CEA)
- Zhiqiang Li
- Yaohui Liu
- Min Qi
- Lei Sun
- Jie Gao China Earthquake Disaster Prevention Center
- Dongming Wang
- Wei Shi
- Chunlan Guo The Hong Kong Polytechnic University (PolyU), China
- Junlei Yu
- Xijie Feng Shaanxi Earthquake Agency, China
- Ji Ma
- Kun Chen Institute of Geophysics, China Earthquake Administration (CEA)
- Yue Cao Overseas Development Institute (ODI), UK
- Barry Parsons Department of Earth Sciences, University of Oxford, UK
- Emily So Department of Architecture, University of Cambridge, UK
- Arrietta Chakos Urban Resilience Strategies, USA
- Craig Davis Los Angeles Department of Water and Power, USA (Retired)
- Alexander Densmore Department of Geography, Durham University, UK
- David Milledge School of Engineering, Newcastle University, UK

-
- **Illustrator:** Siu Kuen Lai Lotersy Arts and Printing Co., Hong Kong, China
 - **Book Designer:** Sandy Lui Lui & Co Design, Hong Kong, China

Background information

This earthquake scenario narrative is a product of an international collaboration (PAGER-O: Pan-participatory Assessment and Governance of Earthquake Risks in the Ordos Area) funded by the National Natural Science Foundation of China (NSFC) and by the Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC) of the UK. This programme aimed to combine the strengths of physical and social sciences to increase resilience and reduce risks from multi-hazards in earthquake-prone regions in China.

The PAGER-O project focused on the Ordos area with the specific goal of bridging the gaps between science and policy and between top-down and bottom-up approaches to disaster risk reduction (DRR) to improve resilience to earthquakes. The project used a highly collaborative, participatory approach to develop an earthquake scenario for Weinan City, which brought together a trans-disciplinary team of international and Chinese physical science, social science, policy and engineering researchers and local stakeholders to co-identify earthquake risk, co-explore pathways to earthquake resilience, and motivate co-operative action for reducing earthquake risk.

The main implementation organizations of the PAGER-O project include:

China

- Institute of Geology, China Earthquake Administration (CEA)
- China Earthquake Disaster Prevention Center (CEDPC)
- The Hong Kong Polytechnic University, China

United Kingdom and United States

- Overseas Development Institute (ODI), UK
- Department of Earth Sciences, University of Oxford, UK
- Department of Architecture, University of Cambridge, UK
- GeoHazards International (GHI), USA

The principal investigators (PIs) of the project are:

China

- Guiwu Su from Institute of Geology, China Earthquake Administration (CEA)

United Kingdom

- John Young from Overseas Development Institute
- Philip England from Department of Earth Sciences, University of Oxford

PI Guiwu Su provided overall project leadership and guidance, as did PIs John Young and Philip England. The scenario's narrative story was written by Janise Rodgers with assistance from numerous team members including Guiwu Su, Timothy Sim, Wenhua Qi, Chunlan Guo, Junlei Yu, Arrietta Chakos and Philip England, translated into Chinese by Guiwu Su and the CEA team, and illustrated by Siu Kuen Lai. It is based on active fault investigations by Xijie Feng and Ji Ma; ground shaking estimates by Kun Chen and Barry Parsons; loss estimation calculations for rural buildings by Li Zhiqiang's team at CEA, for urban buildings by Wang Dongming's team of CEDPC, and for landslides by David Milledge and Alexander Densmore; qualitative observations of infrastructure vulnerability led by Craig Davis and Wenhua Qi; and social science research by Guiwu Su and the CEA team, and Timothy Sim and the PolyU team. John Young and Yue Cao provided policy and process guidance, while Emily So provided casualty estimation expertise. Janise Rodgers and Arrietta Chakos provided expertise on creating and using earthquake scenarios. The ideation and discussion of the overall structure of the narrative was led by Janise Rodgers, Guiwu Su and Timothy Sim, while the detailed style of the book was designed by Sandy Lui.

Brief introduction of the contents

The scenario is supported by a dozen technical papers in academic journals that document the basis for the hypothetical but plausible earthquake, on which the scenario is built, and which explain the basis for calculations of vulnerabilities and risks to the city of Weinan and its surrounding areas, if such an earthquake was to occur. This technical analysis is accompanied by two audience-specific narratives of what the impacts might be on the Weinan area in the event of such, aiming to facilitate bridging the gap between sciences and policies to reduce earthquake risk. The two audience-specific narratives both have the English and the Chinese versions. The first audience is government officials, while the second is the general public. The aim of the two different narratives is to facilitate bridging the top-down and the bottom-up approaches to improving earthquake safety, preparedness, and resilience.

The narrative presented here is for government officials use. It includes the following three aspects:

First, a fictional story describes a local, rural family with "left-behind" children, and their experiences in the scenario earthquake and its aftermath. The storylines of this story were carefully constructed to highlight the main earthquake risk problems that Weinan faces.

Second, all the main results of the scenario are presented systematically and succinctly; detailed scientific information can be found in the technical papers mentioned above.

The third aspect is the provision of some basic knowledge on earthquake disasters and some background information on top-down earthquake disaster risk reduction policies. *(Note: This aspect exists in the Chinese version for government officials only.)*

The last two aspects were woven around the storylines both to help local government officials to easily understand the technical results of the scenario and in the hope of stimulating discussions among various local relevant agencies to foster consensus, and encourage action to strengthen local top-down earthquake disaster risk reduction pathways.

Acknowledgments

The PAGER-O project involved the contributions of a large number of other local organizations, researchers and stakeholders working to reduce disaster risk. In particular, the authors sincerely thank the following organizations for their substantial help and participation during the progress of the work:

- Various divisions of Shaanxi Earthquake Agency
- Weinan Earthquake Administration
- Earthquake Administration Office of Huazhou district of Weinan
- Weinan Education Administration
- Other numerous Weinan agencies in the Leading Group on Protecting Against and Mitigating Earthquake Disasters of Weinan
- Shaanxi Key Laboratory of Disasters Monitoring & Mechanism Simulation based at Baoji University of Arts and Sciences
- School of Architecture and Civil Engineering of Xi'an University of Science and Technology
- Gender Development Solution of Shaanxi Province
- Environmental Education Center of Beijing Normal University

Sincere thanks go to many others, too numerous to name. Many Shaanxi or Beijing-based consultants gave constructive comments and advice either on the development of the earthquake scenario, or on its communication products, or on application or replication directions of this kind of scenario approach. Special thanks go to over 15 thousand local primary or high school students, their teachers and parents, and the general public for their cooperative responses to questionnaires, surveys, and interviews about earthquake disaster awareness, preparedness and resilience. Thanks go to the CCTB Translation Service in assisting the translation of "New Concept for Disaster Prevention, Mitigation and Relief in China in the New Era".



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Homecoming – A story about how a strong earthquake affects a family with "left-behind" children (Version for Government Officials)

Janise Rodgers, Guiwu Su, Timothy Sim, Philip England, John Young, Wenhua Qi and others

Contact: Guiwu Su • Tel: 010-62009075 • Email: suguiwu@ies.ac.cn

• Address: Yard No.1, Hua Yan Li, Chaoyang District, Beijing, China, Postal code: 100029

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Introduction

1568

Scenario Earthquake

1 5 6 8

Gaoling (Northeast Xi'an)

Approximately M7

What is an Earthquake Scenario?

A scenario tells the story of a plausible earthquake and how it would likely affect people, the community, and the places we live. This story describes what could happen to one family in the Linwei and Huazhou Districts of Weinan if the 1568 approximately magnitude 7 (M7) Gaoling (Northeast Xi'an) earthquake occurred in the present day. The consequences are based on standard methods that engineers and scientists use to estimate the shaking, damage and impacts on people that a given earthquake may cause.

It is not a prediction of a specific disaster. It does not mean that an earthquake like the one described will happen in Weinan in the near future.

No one knows when or where the next earthquake might occur, nor how large and damaging it might be. Rather, this scenario is an example to help you visualize specific consequences, decide how you might respond, and learn what you can do now to lessen the impacts of any future earthquake.

This scenario begins with a hypothetical earthquake at 14:02 on a Saturday in April.

Ask yourself:

Where will I be?

Where are my children, my spouse, my parents?

Has my family and community prepared for an earthquake?

Do we know what to do during heavy shaking, to stay safe?

What must I do first? Who will need me?

2018

Simulated Scenario Impacts

Present days

Linwei and Huazhou Districts, Weinan

Rural family

Introduction

Weinan: Historic Devastation and Current Risk

On January 23, 1556, the Wei River Valley experienced the deadliest earthquake in recorded world history, the approximately magnitude 8 Huaxian Earthquake. According to historical records, 830,000 people lost their lives. Inscriptions at historic monuments throughout the valley such as Nanshan Temple for Deity's Protection from Earthquake (南神山庙地震祭碑) record the earthquake's effects. The devastation so altered the interwoven strands of life in local communities that villages (e.g., *Banjieshan* (半截山)) changed their names after the earthquake. The 1556 Huaxian earthquake was not the first earthquake to strike the Wei River Valley, nor will it be the last.

The effects of this earthquake and others for which records are available have been painstakingly compiled and published by the Shaanxi Earthquake Agency and local bureaus, and the China Earthquake Administration^①. Geologists have studied the evidence for past earthquakes, written in the layers of rock and soil at the margins of the valley^②. Records written by people and by the earth itself tell us that the Wei River Valley has experienced many earthquakes. The tectonic forces that caused those earthquakes continue to stretch the valley, meaning that future earthquakes are inevitable.

In the scenario that follows, we examine what could happen if one of the historical damaging earthquakes in the Wei River Valley, the 1568 approximately magnitude 7 Shaanxi Gaoling (Northeast Xi'an) earthquake, were to strike present-day Weinan.

Although the 1556 Huaxian earthquake, of approximately magnitude 8, caused massive devastation, earthquakes of magnitude 7, which happen much more frequently, can cause serious damage and heavy loss of life (Fig. 1). We have chosen a scenario based on such an earthquake because it is more relevant to the timescales of importance for developing policies on disaster mitigation and urban planning. We must emphasize, however, that we cannot predict the location, time, or magnitude of the next damaging earthquake. The next earthquake may be larger or smaller, and occur in a different place and time. Our scenario is just an example to help people to visualize the consequences of such an earthquake, and to learn how to respond and prepare for a possible damaging earthquake — whether it be near Weinan, or elsewhere in the Wei River Valley.

The study area of this scenario includes two municipal districts of Weinan City, Linwei District and Huazhou District (Fig. 2). We estimated building damage quantitatively based on the relevant requirements of China's national standard "*The Code for earthquake disaster evaluation and its information management system* (GB/T 19428-2014). The project team collected building data for a total building area of 71.52 million m², using both field investigations and remote sensing interpretation.

We quantitatively modeled earthquake-induced landslides using remote sensing and statistical methods. We estimated liquefaction and impacts on various lifelines qualitatively based on various online open material, remote sensing images and limited field investigations.

We must emphasize that this scenario is not a prediction, but rather a tool to help you visualize possible earthquake impacts, and then plan and prepare for them. The damage and consequences we describe need not happen.

Collectively, we can prevent much damage in future earthquakes by acting now to strengthen or replace weak buildings and older, seismically deficient infrastructure, to avoid or mitigate risks from landslide-prone areas, problematic soils, and earthquake faults, to enhance people's earthquake safety awareness, and to increase comprehensive resilience of families, communities, schools, enterprises, and more and at levels from the village, townships to the county.

By each doing our part, we can all contribute to a safer, stronger, more resilient Weinan.

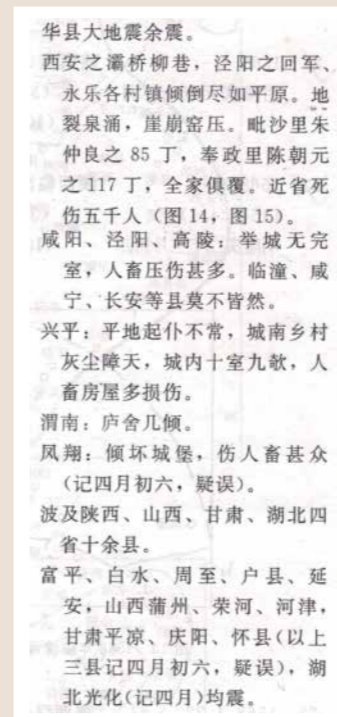


FIG. 1 Historical literature description of the consequences of 1568 Earthquake. This text is translated on page 13.

^① *The Great 1556 Huaxian Earthquake*, by the Shaanxi Earthquake Agency, 2010; *Earthquake Annals of Shaanxi Province*, 2016, by the Shaanxi Earthquake Agency; and the *Catalog of Chinese Historical Strong Earthquakes*, by the China Earthquake Administration, 1995.
^② Ma Ji, Feng Xijie, Li Gaoyang, et al. 2016. *The coseismic vertical displacements of surface rupture zone of the 1556 Huaxian earthquake*. *Seismology and Geology*, 38(1): 22-30.

Introduction

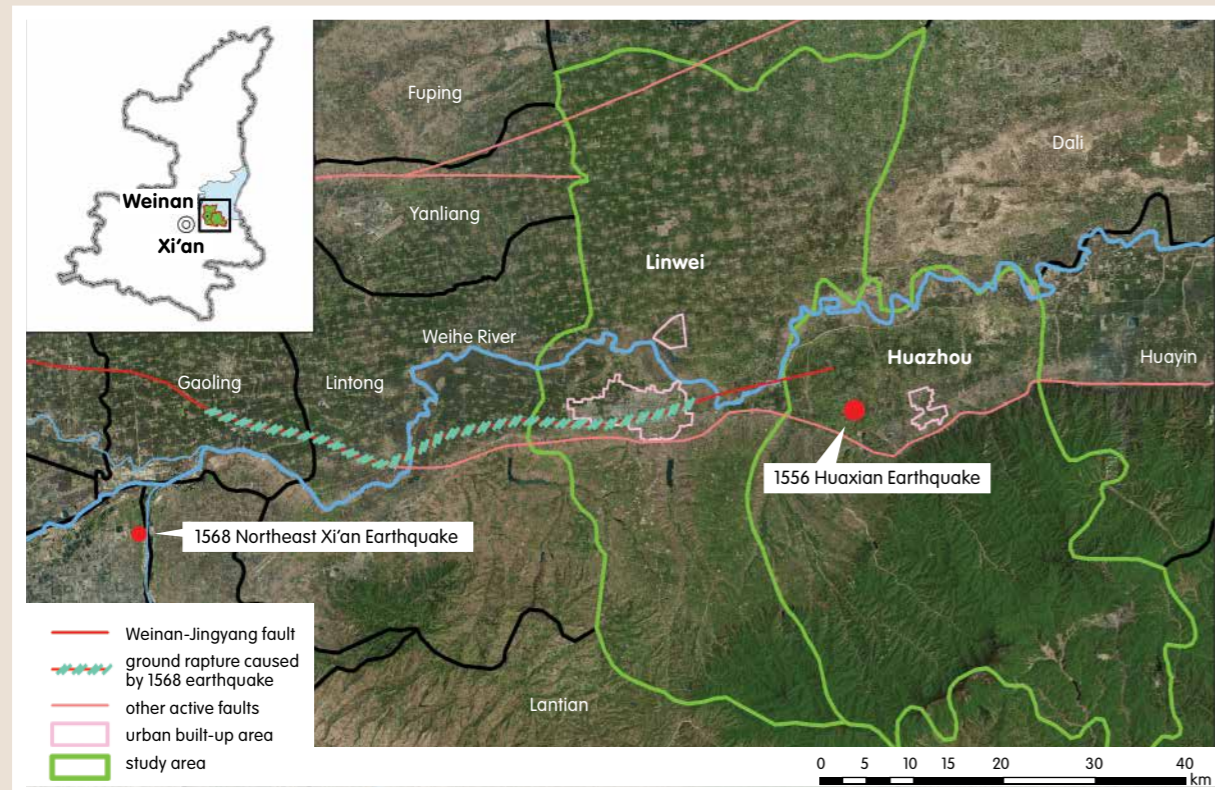


FIG. 2 The study area for this scenario: Linwei and Huazhou districts of Weinan. Red circles indicate epicenters of historical earthquakes, as estimated from historical records.

The Real 1568 Shaanxi Gaoling (Northeast Xi'an) Earthquake

Occurring 12 years after the devastating 1556 Huaxian earthquake, the 1568 Shaanxi Gaoling earthquake (formerly known as the 1568 Northeast Xi'an earthquake) was regarded as an aftershock. The following descriptions of the 1568 earthquake's impacts were translated from *The Catalog of Chinese Historical Strong Earthquakes, 1995*.

In Baqiao and Liuxiang areas of Xi'an, and Huijun and Yongle areas of Jingyang, houses were all razed to the ground. All 85 people in Zhu Zhongliang's house in Pisha Village, and all 117 people in Chen Chaoyuan's house in Fengzheng Village were crushed to death. The ground cracked, fountains of water gushed out, hills slid and collapsed, and buried cave-dwellings.

In Xianyang, Jingyang and Gaoling cities, no houses were left intact, leaving many people and livestock injured or dead. Similar consequences also occurred in Lintong, Xianning and Chang'an counties.

In Xingping, flat ground was made to rise and fall here and there. In its southern part, a thick dust cloud blocked the sunlight. Nine of 10 houses tilted, and many people and livestock were injured or killed.

In Weinan, there were houses that nearly collapsed.

In Fengxiang, the city wall was damaged and even collapsed, with many people and livestock injured. (Note: the record says this happened on April 6th, which might be wrong.)

The earthquake was also (strongly) felt by over 10 distant counties of Shaanxi, Shanxi, Gansu, and Hubei provinces. These included Fuping, Baishui, Zhouzhi, Huxian, and Yan'an counties of Shaanxi province; Puzhou, Ronghe, and Hejin counties of Shanxi province; Pingliang, Qingyang, and Huaixian counties of Gansu province (note: the record says this happened on April 6th in these three counties, which might be wrong); and Guanghua county of Hubei province (note: the record says this happened in April).

Introduction

Characteristics of the Study Area

TABLE 1 Overall social and economic status of the study area (2017)

District	Population 10,000 persons	Urban Population 10,000 persons	Rural Population 10,000 persons	Urbanization rate / %	Area km ²	Urban built-up area km ²	GDP bil. yuan RMB	Per Capita GDP yuan RMB
Linwei	96.43	46.05	50.38	47.75	1,263.76	79.30	37.05	38,421
Huazhou	33.83	7.46	26.37	22.06	1,132.46	14.05	9.50	28,081
Total	130.26	53.51	76.75	—	2,396.22	93.35	46.55	—

FIG. 3 Typical buildings in the study area and locations most commonly found

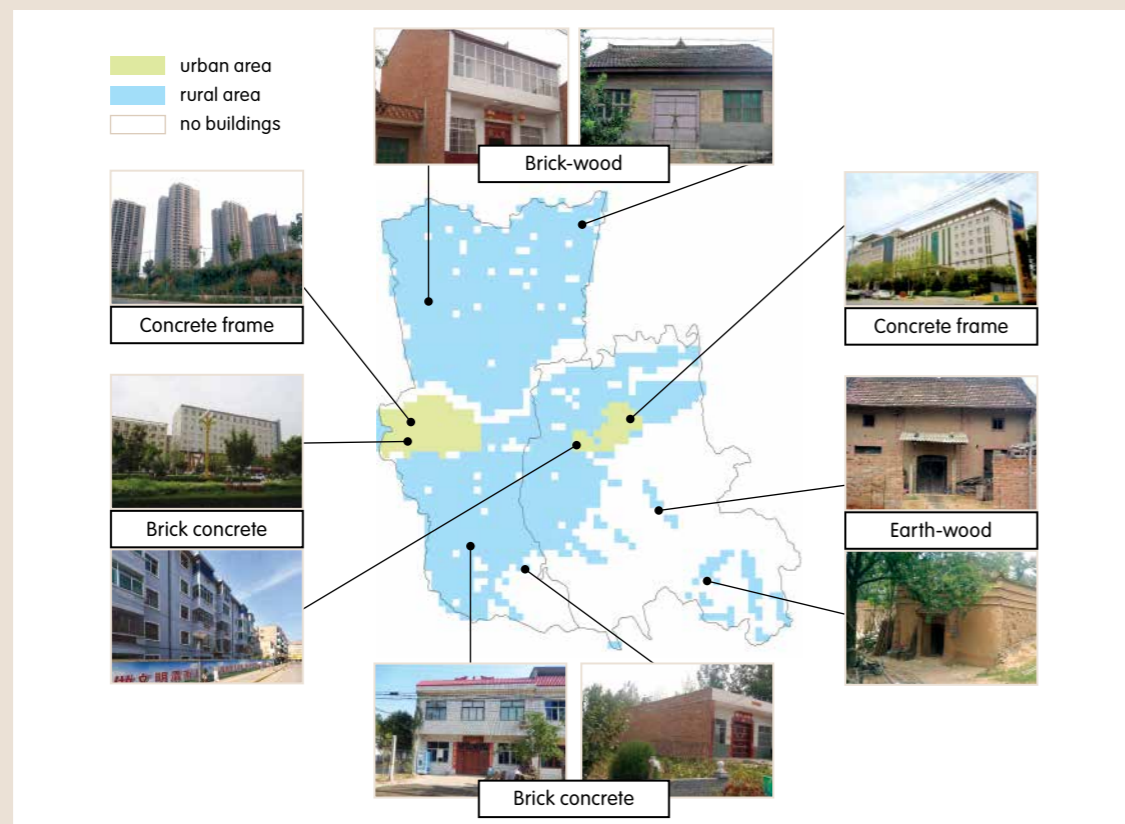
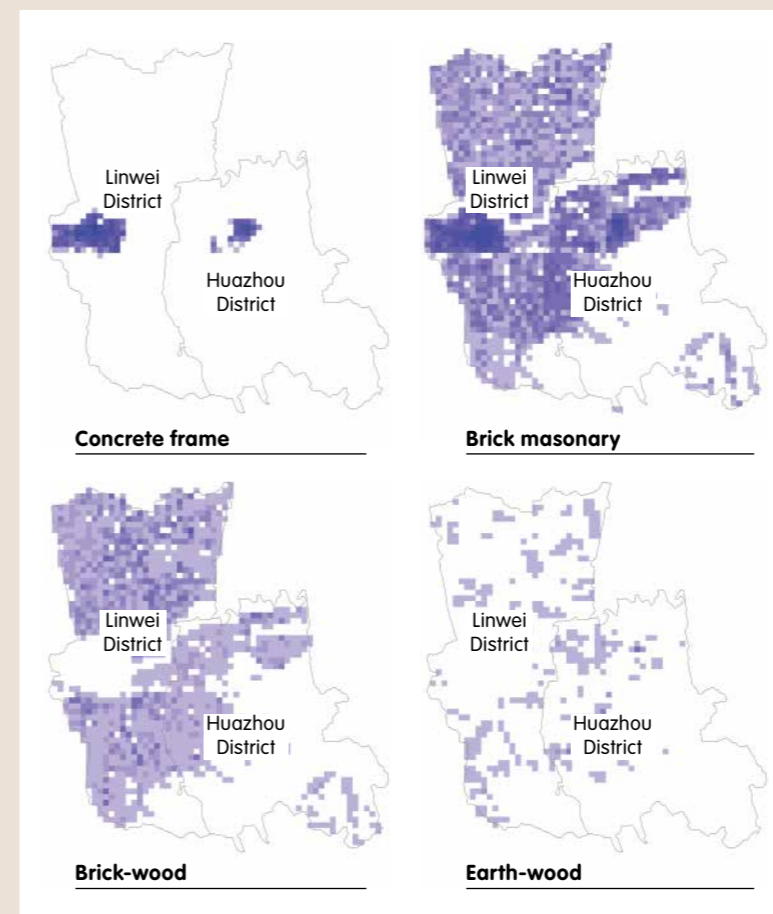


FIG. 4 A long-range photo of Linwei city

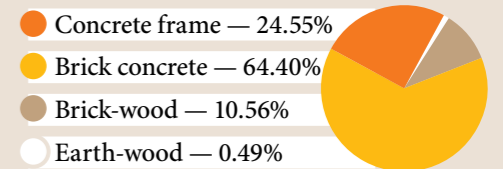
TABLE 2 Total area and percentage of each type of building

	Total area		Urban area		Rural area	
	Area million m ²	Proportion of each type of building %	Area million m ²	Proportion of each type of building %	Area million m ²	Proportion of each type of building %
Total area	71.52	100.00	45.18	100.00	26.34	100.00
Concrete frame	17.56	24.55	17.56	38.86	0	0.00
Brick-concrete	46.06	64.40	27.62	61.13	18.44	70.02
Brick-wood	7.55	10.56	0.003	0.007	7.547	28.66
Earth-wood	0.35	0.49	0.001	0.003	0.349	1.32

FIG. 5 Distribution of each building type in the study area



Area ratio



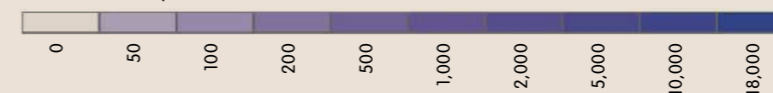
The two districts have a total building area of 71.52 million m². Urban locations have 45.18 million m² (over 62,800 individual buildings), taking up 63.17% of the total building area, while the rural parts have 26.34 million m², taking up 36.83%.

For the whole study area, the proportions of earth-wood, brick-wood, brick-concrete, and concrete frame buildings are 0.49%, 10.56%, 64.40%, and 24.55% respectively.

The buildings in urban Linwei and Huazhou are almost all brick-concrete (61.13%) and concrete frame buildings (38.86%). Of these urban buildings, 79.08% are for residential use.

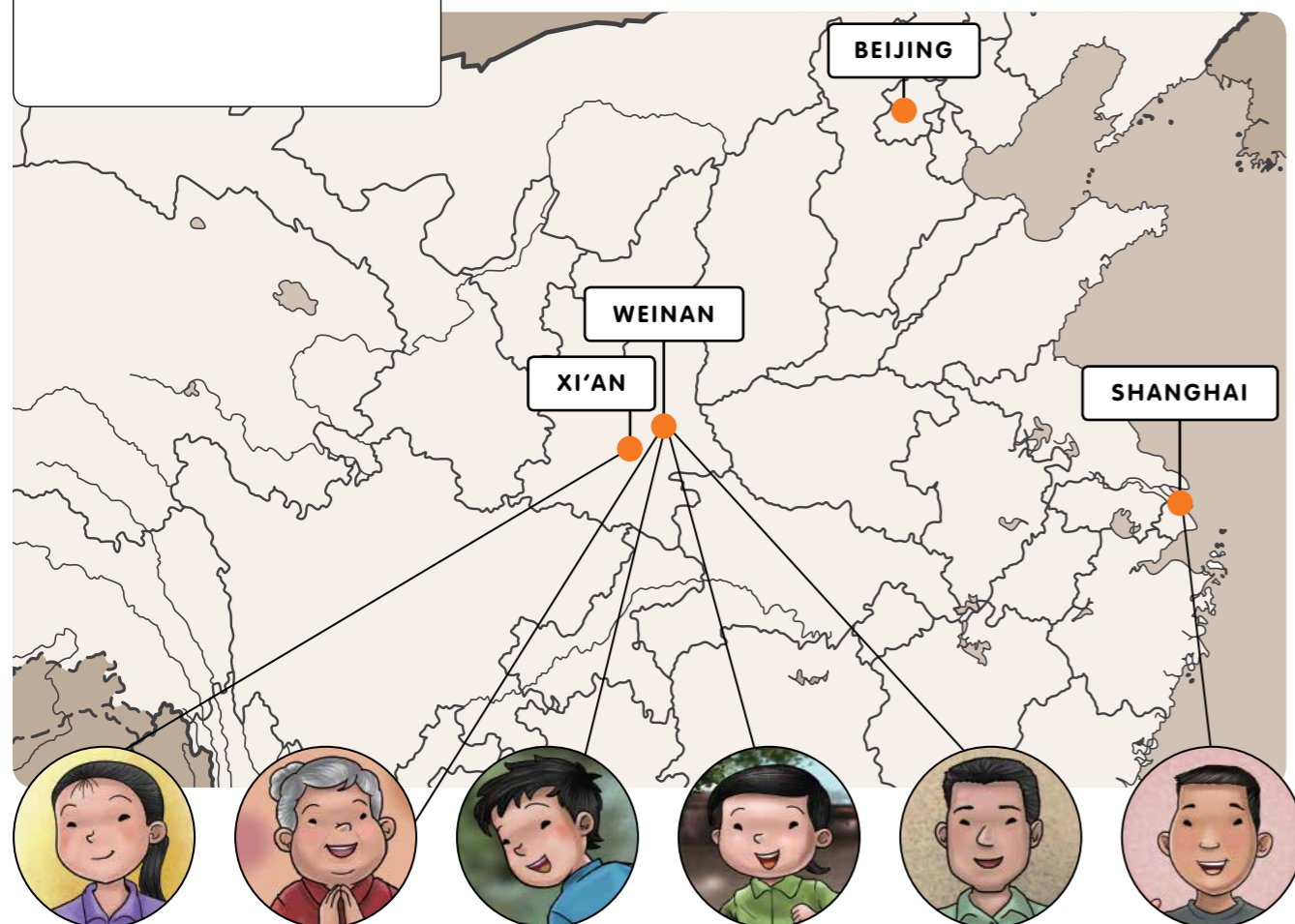
The buildings in rural parts of the study area are almost all brick-concrete (70.02%) and brick-wood (28.66%) buildings. Almost all rural buildings are for residential use.

Unit: hundred square meters



Earthquake Scenario Story

The Characters



Haiyan

In her 30s, daughter-in-law, works waiting tables at a restaurant in Xi'an

Grandma

60 years old, mother of Jianguo and Jianjun, she looks after two grandchildren and their orchard, in a village on the Weinan tableland

Xiaoshuai

12-year-old grandson, attends school in a neighboring village

Xiaomei

8-year-old granddaughter, attends school in a neighboring village

Uncle Jianjun

28 years old, younger son, a veteran, works as a government officer in Weinan

Jianguo

In his 30s, older son, works on a concrete crew for a construction company in Shanghai

The Best Noodles

TIME / Friday evening, April
PLACE / Xingfu Village, atop the Weinan tableland in Linwei District

"Eat some more *Saozi mian*, Xiaomei," Grandma instructed, lifting another portion of the thick noodles into Xiaomei's bowl. "Otherwise, your brother will eat them all." Turning to Xiaoshuai, she admonished, "You eat so much these days, but you are still that thin. Where does it all go?" Xiaoshuai flashed a twelve-

year-old grin and returned to slurping down his noodles at an astonishing rate. "Yeah – save me some!" eight-year-old Xiaomei protested, lifting a noodle and eating it almost as quickly. It was a Friday evening in April, and the siblings had just returned home from school in a neighboring village of Linwei district, where they

had been staying since Monday. "I miss your noodles during the week, Grandma," Xiaomei said. "The noodles in our school are good, but yours are the best." "Yeah, theirs aren't nearly as good," added Xiaoshuai. "Why can't you come and be the cook at our school?" asked Xiaomei. Grandma laughed. "That's just what I want to do in my old age, feed a hundred children every day that eat like you two."

"And besides," she said more seriously, "who would take care of the orchard? Without your grandfather, it's just me and your uncle – when he can come up and help me a little bit – now that your father is in Shanghai building those tall buildings and your mother is serving people noodles at that restaurant down in Xi'an." "I know," said Xiaomei, "but it's nice to imagine. And why can't Ma come home more often, on the weekend, like she used to? I miss her and Pa so much!" Across the table that their grandfather had made, before he got sick, Xiaoshuai shot his sister a cautioning look. He was old enough to notice the hint of sadness in Grandma's voice every time she had to answer that type of question, even though her reply was predictably cheerful. This time was no different. "Xiaomei, we can't keep all the good noodles to ourselves, now can we?" asked Grandma with a grin. "Now," she said, clapping her hands together, "finish eating so that we'll have time to clean up before your father calls."



Home is Far Away

TIME / Friday 21:30
 PLACE / Xi'an and Shanghai

"Pick up the phooone," muttered Haiyan into her phone, as she tapped the video call icon for the third time. "My break is going to be over in 10 minutes." She closed her eyes in frustration, only to hear "Hiiiiii beeee-yoooouuu-teeee-fullll" coming from her phone. She hid a grin behind her hand. Jianguo's sense of humor didn't seem to diminish by what must have been a long day pumping concrete for the new skyscraper his employer was building. He had sent her a photo of the Shanghai construction site every day, taken at the same spot with himself in some silly pose. She was putting them together into a time lapse video for the kids.

"I thought you were asleep because you weren't picking up. Aren't you tired?" she asked. "And miss talking to my beautiful wife after her long evening of slinging noodles? Noooo." "I do NOT sling anybody's noodles!" retorted

Haiyan, laughing. "Now, because Somebody wouldn't pick up my call, I have only 10 minutes before staff dinner. How was your day? Did you talk to the kids yet?"

"Just talked to them. Today was great - we're up to the 50th floor!" he beamed. "We should finish in a month, and then the boss Mr. Liu says the top-performing concrete crews can all have a week off at home before we start the next job. So far, we are the top crew. If you can get time off then too, we can go back home together." While a whole week together with Xiaoshuai and Xiaomei was nearly too nice to think about, Haiyan worried about taking time off.

"That's great, but how can we afford it, Jianguo? We just came home for Spring Festival. We could barely make our payment to the lender. How can we take a week off again so soon?" "Don't worry! Mr. Liu is going to give the top two crews a full week, paid." Jianguo paused for effect, watching his wife's expression carefully. "And

a bonus," he said triumphantly. This was the tallest building Huangpu Building Construction had ever built, business was good, and the executive director was feeling generous. He was also a shrewd businessman. Mr. Liu was experimenting with performance incentives to see if that would increase the productivity of key work crews. The bonus would replace Haiyan's week of pay, plus a little more. Jianguo watched as Haiyan let herself smile.



Scenario Earthquake

The scenario earthquake strikes

IF the 1568 approximately M7 earthquake occurs in the present day...

TIME At 14:02 local time on a Saturday of April

PLACE Along the Weinan-Jingyang Fault on the west side of Linwei district, towards Xi'an

An approximately M7 earthquake

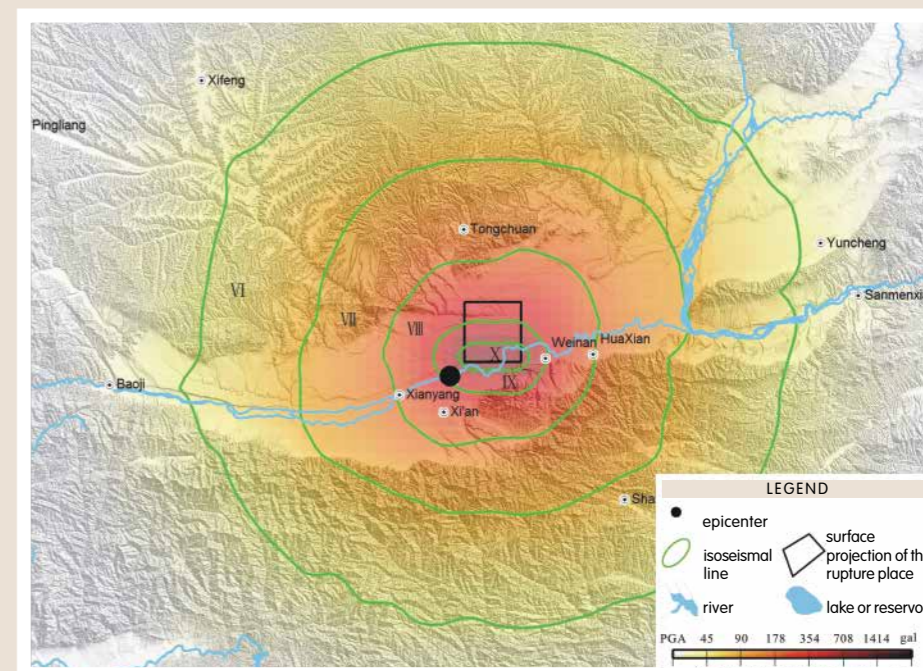


FIG. 6 Shaking intensity map of a repeat of the approximately M7 1568 Shaanxi Gaoling (Northeast Xi'an) earthquake

At 14:02 local time on a Saturday of April, an approximately M7 earthquake occurs along the Weinan-Jingyang Fault on the west side of Linwei district, towards Xi'an. The earthquake ruptures the ground surface for 56 km, with the north side of the fault moving downwards relative to the south side by more than 60 cm on average, and by more than 1 m in some locations. This fault movement damages rail lines, roads, pipes, flood protection

structures, and buildings. Near the fault, the shaking is intensity IX to X, meaning that people riding bicycles fall down, many buildings are damaged and destroyed, and slopes collapse. Similarly strong shaking has been observed in past earthquakes of this type and size elsewhere in the world. In urban Linwei, the ground shakes strongly for more than 20 seconds. (In comparison, the 2008 Wenchuan earthquake shook for up to 90 seconds.)

Earthquake!!!

TIME / Saturday 14:02
PLACE / Xingfu Village, atop the Weinan
tableland in Linwei District

Xiaoshuai ran down the path, the rows of trees flashing past. "You're so slow, Xiaomei!" he taunted. "No, I'm not!" his younger sister came shrieking down the path behind him. "You always get a head start – it's not fair!" "I would beat you even if you got a head start, So Slow," Xiaoshuai shouted over his shoulder, almost tripping on a root. Even though he knew it wasn't true, he couldn't resist teasing Xiaomei. She certainly deserved it for all the little-sister things she had done to him. Like the time when... A sudden bump interrupted Xiaoshuai's thoughts.

Thinking Xiaomei would catch him if he turned around, he tried to go faster and felt something very strange – the path beneath him seemed to move sideways. He heard a noise like a train or distant thunder, but much louder. Just as he turned to look back for his sister, the ground really started to shake, and he couldn't run anymore. In a flash, he remembered bits of stories from his uncle Jianjun and some tips he learned at school. "Earthquake! Earthquake! Xiaomei, crouch down on the ground!"



TIME / Saturday 14:05
PLACE / The restaurant in
south Xi'an

People packed Yanta Road in south Xi'an, filling every available place to stand. Everyone was on edge after the earthquake and on their phone, but there were few conversations. No one could get through because the phone systems were overloaded by distress calls. Haiyan and her coworkers threaded through the crowd, looking for an open space. "Is everyone out?" she called over her shoulder to Ms. Mai, the manager. "Yes, I think everyone but Mr. Li who went to make sure the gas is off," Ms. Mai replied. "I saw the kitchen staff go out the back door. And of course the customers were all long gone as soon as the shaking stopped. Or before! Get the servers together and stay outside in one spot," Ms. Mai ordered. "I'll get everyone else from the back and bring them."

Where is Grandma?

TIME / Saturday 14:06
PLACE / Xingfu Village, atop the Weinan
tableland in Linwei District

"Xiaoshuai, wait!" called Xiaomei through the thick dust cloud, "I can barely see you." Landslides along the edge of the loess plateau and collapsing buildings had sent large clouds of dust billowing into the air. It all seemed to be drifting over their village. "I think it's getting thicker," Xiaoshuai said as he turned and took his sister's hand, "cover your nose and mouth so you won't breathe in so much dust. Hurry! You know Grandma's worried about us."

Through the dimness, Xiaoshuai could just make out the outline of their house. Or was it? It was a strange shape, as if the corner had been sawn off by a giant hand, and the tall roof wasn't as tall and straight anymore. As they came closer, they could see roof tiles lying in heaps on the ground. They saw large cracks in the walls and stopped short, fearful of going closer. "Grandma! Grandma! Where are you?" Xiaoshuai called out. There was no answer, only a soft muffled noise. "We're here, we're okay. There was so much dust we could barely see to come home," he shouted toward the house, hoping Grandma was somewhere and could hear him. There was another muffled noise. "Grandma?" called



Xiaomei. Again there was a faint sound. "Grandma?" "That's her! I think she's somewhere inside," Xiaoshuai said to his sister. "Where are you? If you can hear us, say something," he shouted back toward the house. Another faint noise, and this time they could tell it was coming from the back corner. They ran toward the sound.

The back corner of the house was obliterated, like it had been smashed by a giant club. Near a pile of bricks, Xiaomei spotted Grandma's shirt. Another muffled sound came from the direction

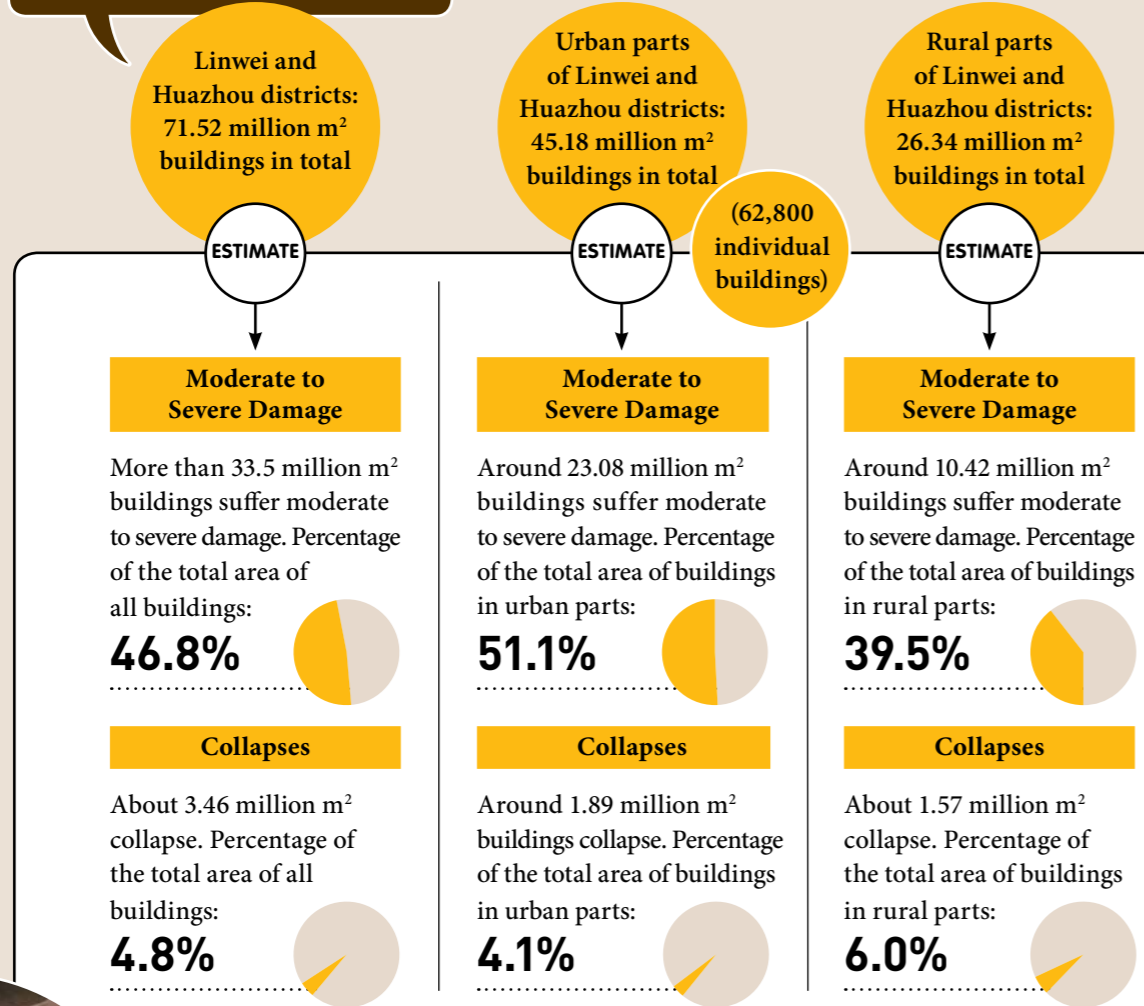
of the pile. Loose bricks hung like teeth from the still-standing part of the shattered wall above. "She's underneath those bricks. There," shouted Xiaomei, pointing. "Grandma, we're going to get you out," called Xiaoshuai, moving toward the pile. "No, Xiaoshuai! Those bricks will fall on you," cried Xiaomei, holding him back by the arm. "We have to get her out before there's an aftershock," Xiaoshuai shot back, yanking his arm free. "Go get Mr. Zhang to help. Run fast."

Building Damage

Overview of building damage

IF the 1568 approximately M7 earthquake occurs in the present day...

Across Linwei and Huazhou districts, cracks lace across walls and columns, bricks fall, and roofing tiles crash to the ground.



Rural areas in western Linwei district suffer very strong shaking and the heaviest building damage. In rural Linwei area, there are 16.77 million m² buildings, and almost all of them are either the brick-wood (28.7%) or brick-concrete (70%) type according to the commonly used Chinese building type classification. Under the scenario

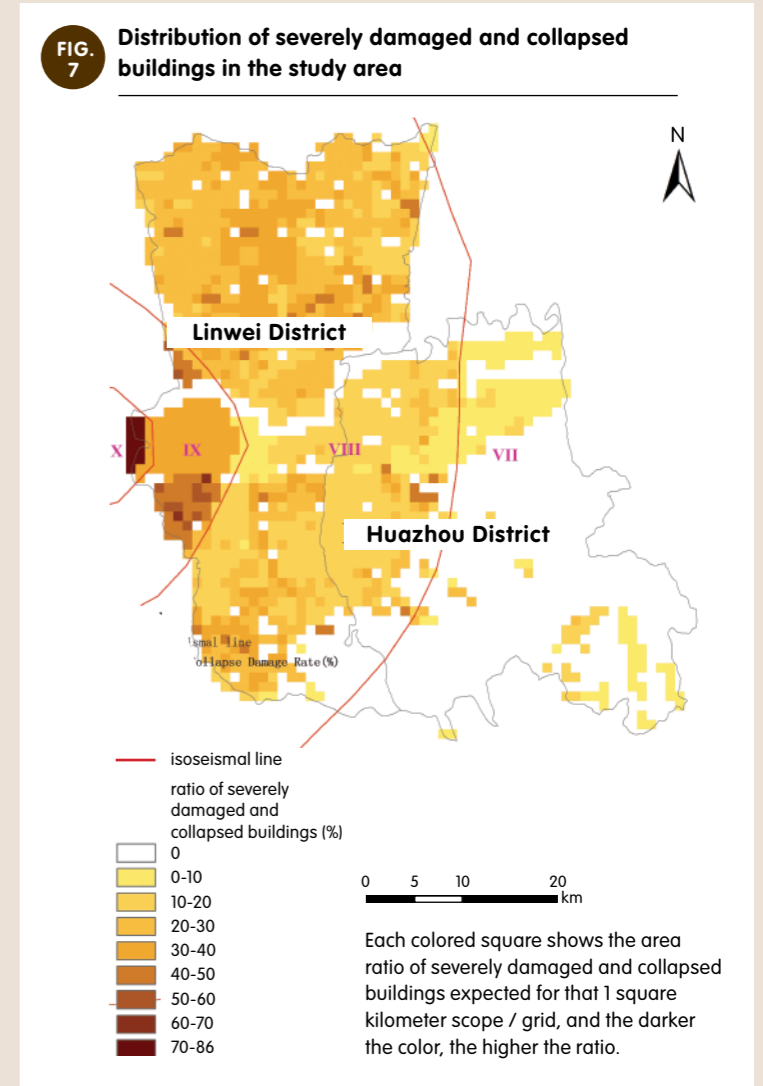
earthquake shaking, nearly 1.33 million m² of these buildings collapse, taking up 7.9% of the total building area in rural Linwei, and a further 7.27 million m² suffer moderate to severe damage, 43.4% of the total rural buildings of Linwei district. Most of these rural buildings are self-built by owners, and not constructed to any building code or with

RECOMMENDATIONS

Ensuring that all new buildings comply with building codes for earthquake resistance, including owner-built houses in rural areas, will prevent tragic loss of life by keeping buildings from collapsing in future earthquakes. Existing vulnerable buildings can be replaced with new, earthquake-resistant ones, or strengthened in a process called seismic retrofitting.

earthquake-resistant features. Unreinforced masonry buildings, like the Zhao family home and the new village leader Mr. Wang's house in the story, are hardest hit. In urban Linwei, small commercial and older residential masonry buildings also suffer proportionally heavier damage. Many of these buildings were built before modern earthquake-resistant codes. Even in the comparatively newer buildings, the decorations and partition walls might be damaged and required to be repaired in a short time after the earthquake.

Huazhou district is farther from the earthquake fault, so the shaking is not so strong as the one in Linwei. There is less damage in Huazhou.



The Community Helps Each Other

TIME / Saturday 14:43

PLACE / Xingfu Village, atop the Weinan tableland in Linwei District



Xiaomei took a long look at her brother's determined face, and turned and ran as fast as she could toward the lane and down to the street where the Zhang family lived. She knew Xiaoshuai would go inside the damaged house to try to free Grandma. He was a lot like their father and Uncle Jianjun, who had been in the military during the 2008 earthquake and told them stories about rescuing trapped people. But this was not Uncle Jianjun's weekend to come up from Weinan where he now worked as a civil servant. And of course, their father was in Shanghai and their mother was in Xi'an. Rescuing Grandma was up to her and Xiaoshuai. She hoped she could get back with help in time.

By now, the dust had mostly cleared, and she sprinted past heaps of rubble where gates and houses once stood. Other people were going to need help too, she thought. She hoped that Mr. Zhang Ming was okay and that he was still at home. She didn't know what to do otherwise. Mr. Zhang Ming was one of the few people remaining in the village that could

lift heavy things. The others had gone to the cities to work.

Xiaoshuai took a deep breath. "Grandma, I'm coming!" he shouted, stepping across the few bricks at the base of where the wall once stood, and into the house.

Xiaomei sped around the corner and saw the Zhang house still standing. The Zhangs had recently built a new house, using an earthquake-resistant design and employing builders trained under the Skill Training Project for Rural Construction Workers on Earthquake-Resistant Buildings. As a result, it did not have much damage. People were there! Almost everyone turned to look at Xiaomei as she flew down the street, and skidded to a stop. "Grandpa Zhang! Grandpa Zhang!..." Xiaomei gasped. After running, she could not get a complete sentence out. "Xiaomei! Slow down, and tell me what happened to your family," said the elder Mr. Zhang, Mr. Zhang Ming's elderly father. He had



retired from being the village leader a few years ago, but he was still able to take charge of a situation. His son Ming, the strong one, his daughter-in-law Yan, and one of his teenage nephews stood at his side. They had been planning what to do. The elderly Mrs. Zhang sat holding a small, crying child.

"Grandma is trapped under a pile of bricks, the wall fell on her," Xiaomei panted, "please come now and help dig her out!" Her tears started to well up as she thought of her grandmother under all those bricks. "Can you hear or see her?" the elder Mr. Zhang asked. "We heard her but



all we can see is part of her shirt. Please hurry! Xiaoshuai is there by himself and I am afraid he will go in and more bricks will fall down on him or an aftershock will happen," she blurted out, words running together and tears now running down her cheeks.

"Mingming, go with Xiaomei now! Be careful not to hurt Grandma Zhao further when you take her out and be safe yourself. And help Xiaomei to calm down," the elder Zhang directed his son. "Yanyan, the nephews and I will try to find Mr. Wang and assess the situation. The mobile service isn't working so we will have to go in person. Hurry, a lot of people may need help. But her situation seems quite serious," he said, gesturing toward Xiaomei. Mr. Wang was the new village leader. He lived in a very tall house at the other end of the village, with high brick walls that seemed enormous to Xiaomei.

Xiaomei!" ordered Zhang Ming. "Go see if you can find your brother a pair of gloves and a basket for carrying bricks. Look in the yard. Don't go back in the house. Good work, Xiaoshuai, but you go out too. I don't want you under this damaged wall. Work from the outside. And first see if you can find a board to put underneath her so we can lift her without moving her as much." As Xiaomei and Xiaoshuai ran to do as asked, Zhang Ming turned back to Grandma. "We're going to get you out, Grandma Zhao."

Thirty minutes later, Grandma was finally out of the house. One leg was clearly badly broken, so Zhang Ming splinted it to a board with strips of cloth. The other was bruised and swollen. Though she was almost too weak to speak, she complained of pains in her hips, too. Zhang Ming and Xiaoshuai lifted her on a board and gently placed

Xiaomei took off at a sprint. Jogging behind, Zhang Ming pulled on a pair of work gloves. When they reached the house, Xiaoshuai was indeed inside, picking up bricks one at a time from the pile, and tossing them aside. He had managed to fully uncover Grandma's head and arms, which were dusty but otherwise looked pretty good. She had just managed to shield her head with a wooden cutting board when the wall came down on her. The tallest part of the brick pile pinned her right leg. "Stay out,



Economic Loss

IF the 1568 approximately M7 earthquake occurs in the present day...

The estimated direct economic losses from building damage alone could be over 41.4 billion yuan RMB, which almost equals the present day total annual GDP of the two districts (46.55 billion yuan RMB in 2017).

Economic loss by building type

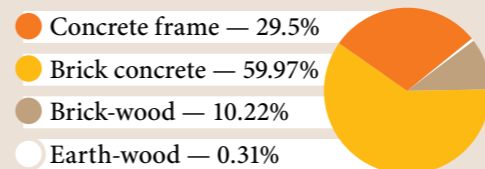
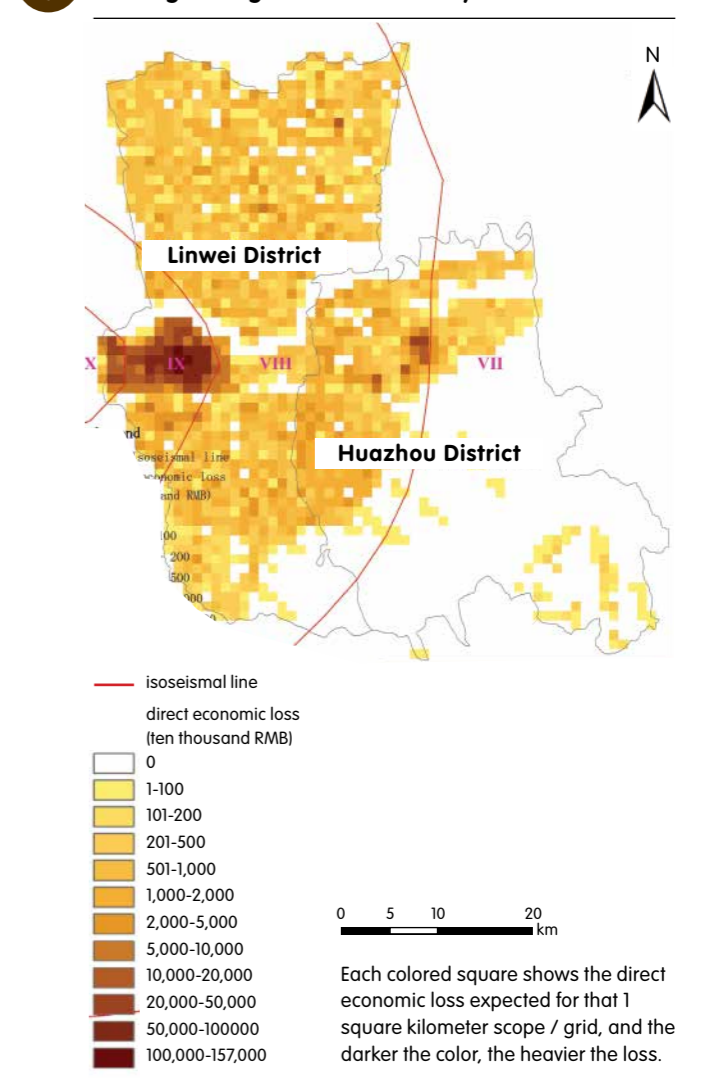


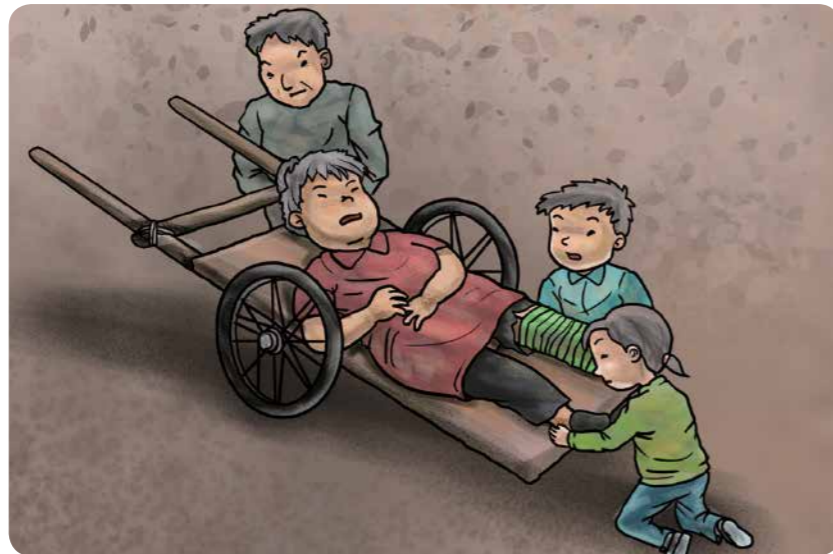
FIG. 8 Distribution of the direct economic loss caused by building damage alone in the study area



her in a wheelbarrow from the toolshed. Grandma groaned softly as Zhang Ming guided the wheelbarrow down the rough path. They were headed to the Zhang house, where the elder Zhang was organizing the response.

A nephew had run by to give Zhang Ming the report that the tall Wang house built by untrained builders had collapsed. Sadly, there were no signs of life from inside. Zhang Ming's wife Yan was making a quick survey of the damage. Fourteen houses had completely collapsed, and at least twenty others were badly damaged. Though most people, and almost all the children, had been outside when the earthquake struck, so far at least twenty people were missing and likely trapped in rubble. Smoke rose from a fire in a nearby village. "I don't know how they will put it out," the elder Zhang had said. "The brick water towers have fallen, so there's no water. Everyone please be careful not to start a fire here."

Once Grandma was at the Zhang house where the other injured people were brought, Zhang Ming joined one of the three small



volunteer search and rescue teams composed of villagers in his village, which his father had formed. He took Xiaoshuai with him to support the search and rescue team, and told Xiaomei to stay at the Zhang house and help Grandma Zhang with whatever she needed done. Zhang Ming handed Xiaoshuai a first aid kit. "Though it's not safe for you to help us search, you can help our team with simple first aid, and running messages back here," he said. "Yes, sir, we learned about first aid in school. I'll do my best," Xiaoshuai replied, standing up very straight.

Elder Zhang sent off Grandma and two other badly injured people in a vehicle to the nearest township-level hospital, a 20-minute drive along the flat top of the Weinan tableland. When they arrived, everyone, including the patients, was outside. The

hospital's walls were cracked, the power was out, and there was no water. Nurses worked to lay a continual stream of injured people in rows on the ground, while the few doctors rushed to treat those they could. The driver ran to get a nurse, and brought her back to the vehicle. "Don't bother unloading them," she said after a brief examination. "They are all too badly injured for us to help here. Take them down to Hospital No. 1 in Weinan city. Hurry. They might not survive." Just then, another car pulled in. "Why are you back? Didn't I tell you to take them to Weinan city?" the nurse shouted at the thin young man driving. "There was a landslide and the road to the city is just gone. We can't get through," he replied tersely. "We'll have to wait here for help."

Casualties

IF the 1568 approximately M7 earthquake occurs in the present day...

In Linwei and Huazhou districts more than two thousand (the estimated number is 2,138) fatalities are expected due to building damage and collapses of vulnerable buildings caused by shaking. Additional deaths are expected due to

landslides, fires and other secondary disasters caused by shaking. Due to building damage alone, over 10,000 (the estimated number is 10,690) people will be injured seriously enough to seek treatment at a hospital. Because the number of seriously injured victims is large, some may need to be sent to larger hospitals for treatment, as Grandma Zhao was in the story, and as occurred in reality during the 2008 M8.0 Wenchuan earthquake.

Hospitals

backup power systems

building utility systems

hospital equipment

damage to interior walls

damage to ceilings

topped furniture

In urban Linwei's newer hospitals, the staff are not able to use some parts of the buildings, and some facilities cannot provide certain important services. Backup power systems, building utility systems, and equipment are not working because they are not seismically protected. Damage to interior walls and ceilings, as well as toppled furniture, creates significant disruption, though the buildings' structural system is not damaged. At the Number 2 hospital, the electric grid and backup power systems both fail, and operating suites cannot be used. Rural hospitals, especially older ones like the one in the story, are more badly damaged. Most of them are not built to be earthquake resistant. A number of patients need to be transferred out of the area.

RECOMMENDATIONS

Protecting hospitals' backup power, water and communications systems against earthquake damage; anchoring major equipment; and bracing fire protection piping and architectural features like suspended ceilings can reduce damage that often keeps hospitals from functioning after strong earthquakes.

The local healthcare system should use this scenario as a starting point to identify the risk earthquakes pose to their systems, and prepare their own detailed internal loss estimates and scenarios.

Housing Impacts

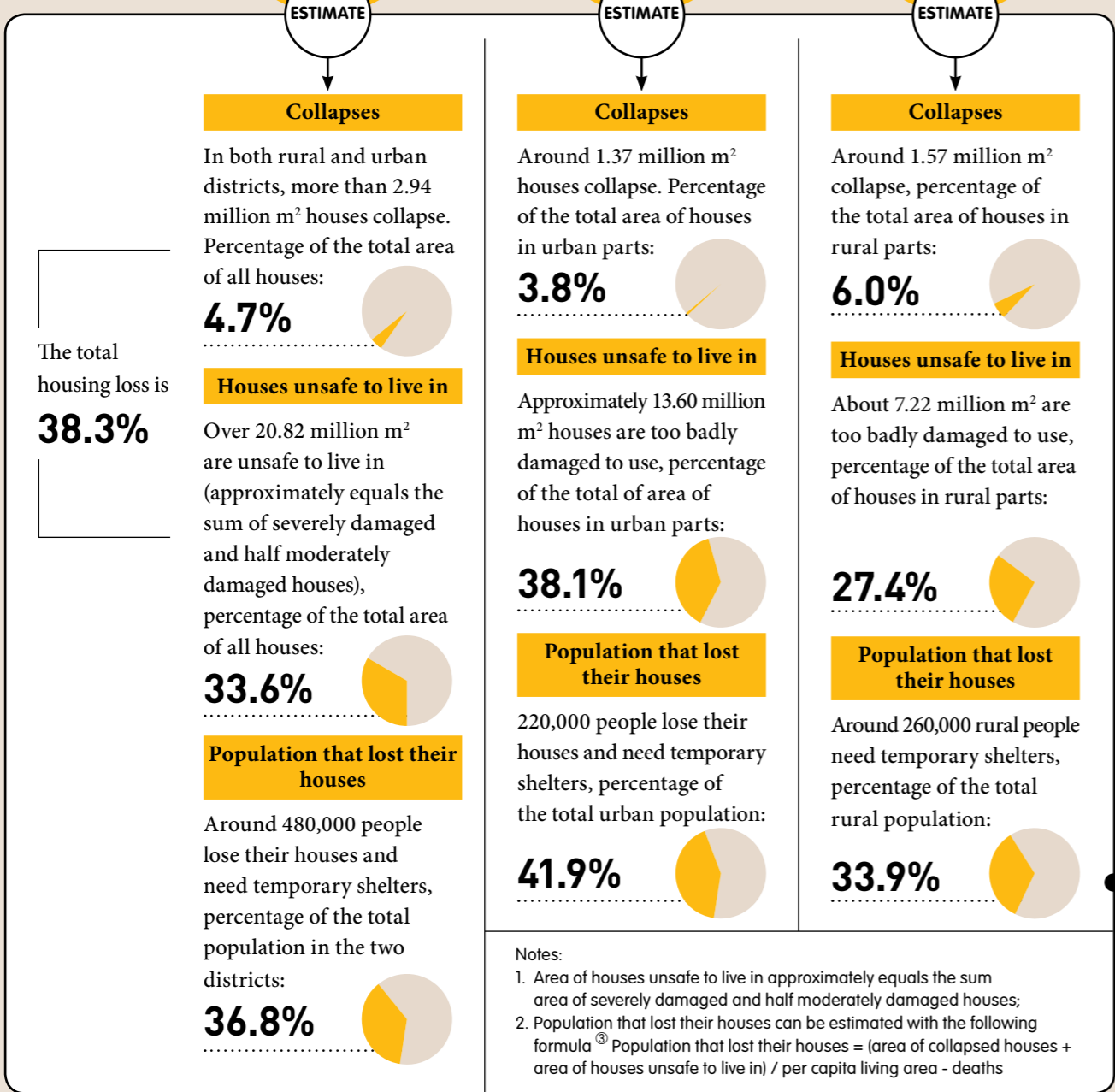
Residential buildings in Linwei and Huazhou

IF the 1568 approximately M7 earthquake occurs in the present day...

Linwei and Huazhou districts:
62.07 million m² houses (residential buildings) in total

Urban parts of the two districts:
35.73 million m² (51,534 individual buildings)

Rural parts of the two districts:
26.34 million m² rural houses



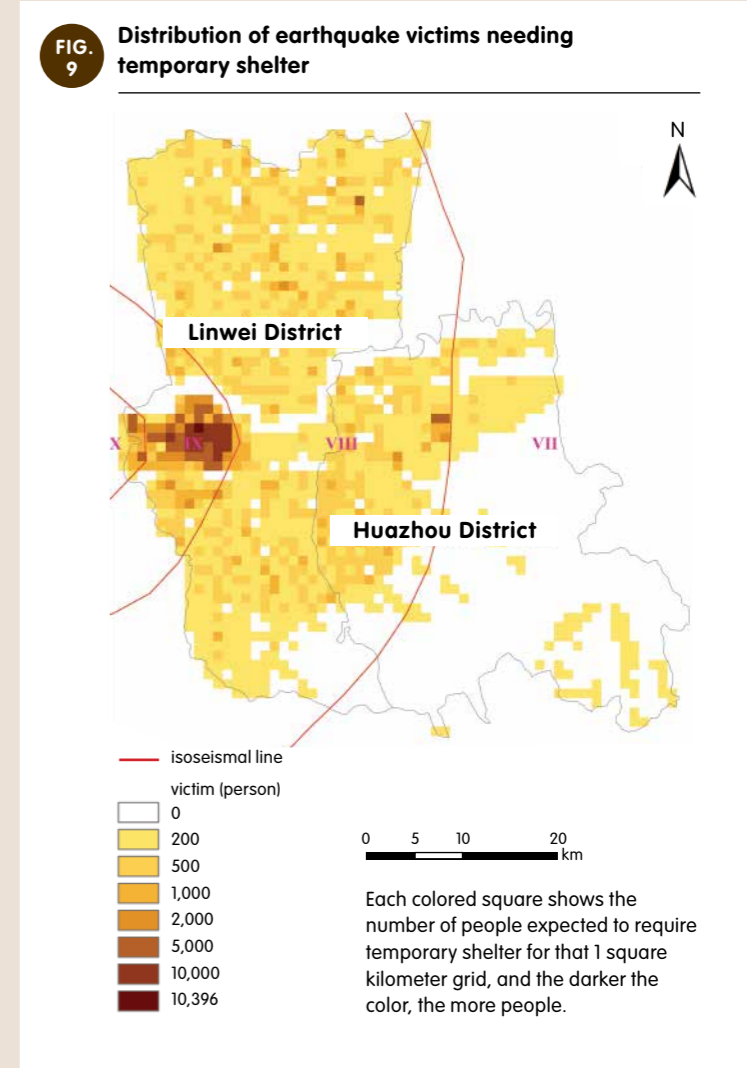
Notes:
1. Area of houses unsafe to live in approximately equals the sum area of severely damaged and half moderately damaged houses;
2. Population that lost their houses can be estimated with the following formula ③ Population that lost their houses = (area of collapsed houses + area of houses unsafe to live in) / per capita living area - deaths

During the first days, or even weeks, after the scenario earthquake, most of these displaced people have to shelter in tents or camps provided by various rescue and relief teams and local governments. A small number of them might go outside to live with relatives, as Zhao Juan, Grandma Zhao Mei's sister does in the story. After one month or so, many of these people are moved into the so-called "prefabricated board houses" (活动板房), which is similar to what happened on very large scale following the 2008 Wenchuan earthquake. They need to live in these provisional houses for months to years, depending on the progress of repair or reconstruction of their permanent houses. In the story described here, Jianguo's family may be provided with a temporary prefabricated board house, or might stay in a temporary shelter.

RECOMMENDATIONS

Making housing earthquake-resistant now, by strengthening older buildings or by replacing them with locally acceptable and earthquake-resistant new buildings, will reduce the number of people who lose their family home in a future earthquake.

The rural population in Linwei and Huazhou districts is more vulnerable than the urban population, due to having fewer economic resources and a greater proportion of elderly people and young children.



③ Yifan Yuan (Editor in chief). 2007. Training material / textbook on China's national standard 'Direct loss assessment of earthquake disaster (GB/T 18208.4-2005)'. Beijing: Seismological Press.

Rushing Home – Jianguo

TIME / Saturday 15:30
PLACE / A construction jobsite for a new skyscraper in Shanghai

Across the sprawling jobsite, workers stopped, looked up from their tasks, and put down their tools. On each floor of the skyscraper where a crew worked, the foreman called a halt and told workers to assemble outside in the yard far below. Executive Director Liu had called an urgent meeting. Jianguo and his colleagues descended in the construction lift. No one spoke. Trying to distract himself from the overwhelming sense of foreboding, Jianguo took his phone from his pocket where it sat switched off all day, in keeping with jobsite policy. A moment later, he wished he hadn't. His WeChat feed lit up. Earthquake. Xi'an. Damage. Ominously, there were no messages from his wife or mother. Everyone packed into the small open ground at the front of the site, around the back of a truck where Mr. Liu was standing.

"I called this meeting today to put your mind at ease, during this time of great difficulty for Weinan," Mr. Liu began slowly. Murmurs rose immediately in the crowd of workers. "Which is home to a number of you," he continued after most of the workers were quiet again, "that our company will stand strong together." He paused. "Over an hour ago, a major earthquake occurred

between Weinan and Xi'an. Rescue operations are underway. Though we do not know the full scale of the damage yet, media reports so far are showing extensive damage in Weinan and some damage in Xi'an. Those of you who are from the affected areas should try to contact your families immediately. In addition, I am announcing that Huangpu Building Construction will grant leave of up to ten days to affected workers, starting immediately. Workers from Weinan or Xi'an, please assemble in the trailer for further instructions. All others please return to work. Thank you."

In the trailer, foreman Guo pulled Jianguo aside and showed him a map on his phone with the

western part of Weinan covered in angry red and orange. "This is the shaking intensity map from the Earthquake Administration. Your home may be badly affected." He pressed a set of keys to a company truck and some cash for gas into Jianguo's hand. "Go now. Take Zhou and Ma with you. Maybe you can arrive before they close the road. The military keeps everyone but relief vehicles out, but if you are local they may let you through. We will send others that live a little further from the epicenter by train." Jianguo, Zhou and Ma started the 14 hour drive on interstate G40 – the straight-arrow route to Xi'an – direct from the jobsite. They rotated the driving duties, obsessed over the tiniest bits of news from WeChat, and tried to call and message their families. No one got through to relatives in Xi'an for almost three hours due to system overload, and they couldn't reach Weinan at all. Despite the fatigue, their thoughts raced, making it impossible to sleep.



Communications

Damage to communications infrastructure

Three telecommunications companies provide services in Weinan, using a network of towers, repeaters, buildings with equipment, fiber optic lines, and more. The ground shaking damages buildings and unprotected equipment. Landslides and liquefaction damage some towers, putting them out of service. Some other towers on buildings within Weinan are also damaged and out of service.

Restoration

As soon as the shaking stops, people call their loved ones, overloading the mobile networks almost immediately. In the story, the Zhao's home village loses mobile service. Parents separated from their children, like Haiyan and Jianguo, call and message repeatedly, but get no answers.

Without power from the grid, towers that remain usable are working on battery backup power. But this backup emergency power runs out after several hours, in some cases before grid power returns. In the areas of strongest shaking, the mobile networks start to be restored in about 1 to 2 days using emergency generators. Other mobile equipment like cells on wheels are used to restore the communications network.

RECOMMEN- DATIONS

Planning ahead for how to obtain and provide accurate and timely information to the relevant authorities and the public, in the event that mobile communications are disrupted or overloaded after an earthquake, is an essential preparedness step. For example, equip key agencies, lifeline service providers, high-occupancy buildings, and similar important locations with backup communications such as satellite phones.

Local communication system operators should use this scenario as a starting point to identify the risk earthquakes pose to their systems, and prepare their own detailed internal loss estimates and scenarios.

Rushing Home – Haiyan

TIME / Saturday 16:30
PLACE / Around a restaurant in South Xi'an

Haiyan and her three coworkers stared up at the apartment building where they share a tiny flat on the third floor. "Do you think it's safe to go up?" Haiyan asked. "I don't see any cracks anywhere, do you?" her friend responded. "No. I'm going," said Haiyan. "I've got to get my bag in case I need to go home. I'll come right back down. If I could just call or find out anything..." her voice trailed off. "We don't even know how big it was or where it was. The network is jammed. I'm sure they're fine," the other friend said soothingly. "Wait, I just got signal!" cried the first friend. They all crowded around her phone as she pulled up the news feed. "Major earthquake rocks Weinan... Damage reported from Xi'an... China Earthquake Networks

Center: Linwei and Huazhou districts likely to be hardest hit..." blared the headlines. Haiyan took the stairs two at a time.

With her small bag sitting beside her on the curb, Haiyan checked her phone again. Still no signal. This was the downside of a cheap phone plan, she thought. Seeing her expression, her friend handed over her phone. Her family living to the west of Xi'an was fine. Haiyan gave up after four tries to Grandma's phone and three to her brother-in-law Jianjun, and messaged Jianguo that she was okay. "On my way. There in 10 hours" was the immediate response. "Can't reach anyone. No signal yet on my phone. Going home. See you there," she

messaged back. It took all her willpower not to call, but she knew she should message, to help keep the network from getting overloaded again.

She handed the phone back with a quick thank you and flagged down a motorcycle taxi. "Please. My kids are in Linwei and I can't reach them. Can you take me?" Haiyan asked, blinking back tears. "Yeah, if you buy the petrol," he offered. Haiyan did a quick mental calculation, thankful to be pulled back, by the exercise, from the brink of crying in front of a stranger. That was probably a quarter of the usual price. Even at a time like this, she had to watch expenses. Paying for her father-in-law's medical treatments had put them deep into debt. But she smiled every time she thought of him sitting with Xiaoshuai and then Xiaomei in the chair, telling them stories. Or letting them name all of the trees in the orchard – even if the names were ridiculous – and giving them nightly "updates" over dinner on which trees had done what, to howls of delight. Those treatments had kept him alive for eight years, long enough to know his grandchildren, to laugh with them and to love them. Even though his passing was two long years ago now, Xiaoshuai and Xiaomei would sit in the courtyard,



Electrical Power

- equipment damaged
- transformers toppled
- brittle ceramic isolators cracked
- power outages
- hospitals, water pumps affected
- Facilities lose the ability to function

Damage to electrical power infrastructure

Weinan's electric power supply comes from the national grid. Transmission lines crisscrossing the Wei River valley send power to the local network substations. Strong shaking damages equipment, topples unsecured transformers, and cracks brittle ceramic isolators in the substations.

Restoration

The power goes out, and Linwei and Huazhou go dark. Typical outages last hours to a few days, depending on the location. Power outages affect hospitals, water pumps, industrial plants, and businesses. Strongly shaken areas, such as the Zhao family's village in the Weinan tableland, have longer outages due to greater damage from shaking and ground failure. Facilities without backup generators and adequate fuel lose the ability to function. Power is restored in most areas within two days, and almost everywhere within a week.

RECOMMENDATIONS

Seismically protecting electrical equipment in substations, especially those supplying power to hospitals, fire stations, water system facilities and other important facilities, will help to prevent interruptions in function at these facilities. All essential facilities should have seismically protected power backup systems that are regularly tested.

Local electrical systems operators should use this scenario as a starting point to identify the risk earthquakes pose to their systems, and prepare their own detailed internal loss estimates and scenarios.



laughing and telling each other his stories, still remembering every detail. It was worth it, all of it. Haiyan held on tight to the driver's shoulder as he sped off.

They threaded slowly through the heavy traffic in south Xi'an. The power outage had darkened the traffic signals, bringing traffic to a near-standstill. "Everyone else will be on the back roads with us. A landslide came down onto the expressway. And they have to inspect the bridges. They're not letting anyone on," the driver shouted over his shoulder. "Okay," Haiyan shouted back. Good, she thought. No tolls. Finally outside of Xi'an, they started to see cracks in buildings, and people sitting outside. They made it as far as a Yuanshang, where they came to a makeshift checkpoint. A soldier turned them back. "The road is completely buried by landslides up ahead. We don't know when we can reopen it. I'm sorry."

The driver knew another route, further to the south and longer. "We can try it," he said, "but I doubt we'll get through. It's going to be dark soon." Haiyan tried her phone again. Signal! But there was no response from Grandma's basic phone which was in the empty, shattered house, untouched from where it fell during the earthquake. She stifled a near-overwhelming urge to get on WeChat as she bounced along on the back of the motorbike, fearful of dropping her phone. After another two hours of driving slowly past damaged buildings and avoiding debris in the road, a barricade appeared in the motorcycle's headlight. "Can you please let us pass?" the driver enquired. "She lives up on top of the tableland and needs to get home to her children," he said, gesturing behind him at Haiyan. "This road is closed. I have orders not to let any civilians through, especially at night." the soldier replied. "Please, sir," Haiyan begged, "my children and mother-

in-law are up there and I can't reach them. I've called and called. Please."

The soldier was unmoved by Haiyan's pleading. "I understand, but cannot help, ma'am. It's not safe to drive it at night. The road has cracks everywhere and parts of walls and power lines fell down into it. And there are some unstable sections. We aren't even permitted to drive it after dark." Just then, the ground began to shake. "Aftershock!" shouted the soldier. "Everyone down!" It was a small one, but once it was over, the driver got up and looked hard at Haiyan. "We have to go back to Xi'an tonight. If I'm feeling lucky, we can try again tomorrow."

At the first opportunity – a long stoplight in Xi'an – Haiyan messaged Jianguo about the change of plans. "Please call me" was the response. "Soon" she tapped back, as the light changed. After several hours struggling back to Xi'an, Haiyan wearily got off the back of the bike in front of her apartment. "Thanks for trying so hard to help me get home today. Could you take me again early tomorrow morning? Please?" asked Haiyan, a pleading note in her voice. "Sure! Message me the time you want to go ... and stay safe tonight." the driver replied. She saw a light on her apartment and went up. The power was back on, and it seemed almost everyone decided it was safe enough to go inside for the night. Good thing, because it was starting to rain. She dropped her bag on the apartment floor, plugged in her phone, and called Jianguo.

Landslides

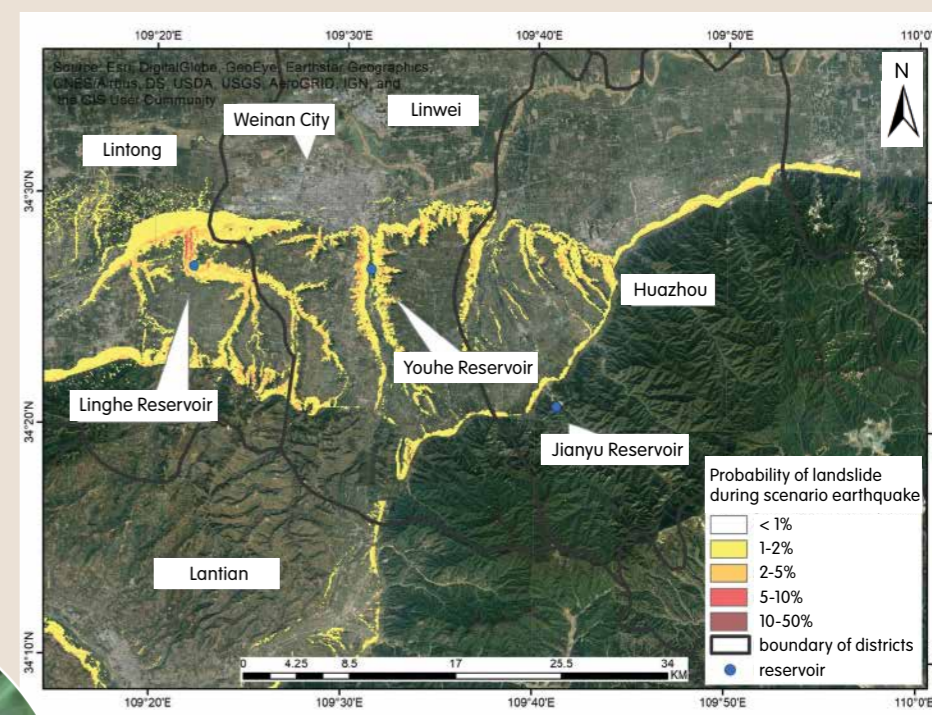


FIG. 10 Probability of landslides with area greater than 100 m² during the scenario earthquake



IF the 1568 approximately M7 earthquake occurs in the present day...

Earthquake shaking triggers about 100 to 150 landslides in the Weinan tableland, concentrated along the tableland edges and in the incised valleys within the tableland, particularly in the northern and western parts. In an instant, the deceptively stable-looking loess – a wind-deposited soil – loses its strength, rushing down into the roads, the expressway, rail lines, and the You He reservoir. Landslides rupture gas lines, slice through roads and carry away buildings in local villages.

Further east along the Huashan mountain front, smaller rock slides and rockfalls send rocks down onto railway tracks, fields, and mountain roads. Up to 700 additional smaller landslides of one hundred to one million m³ occur in the steep mountain areas south and east of Weinan city. People in villages and traveling on the road and rail segments are caught in landslides, and some are injured or killed. In subsequent months and years, landslide debris will wash into streams, creating debris flows, choking channels with sediment and increasing the local flood hazard. Heavy rains trigger further landsliding on weakened hillsides.

Waiting for Morning to Come

TIME / 05:30 the morning after the earthquake
PLACE / South of Xi'an

Haiyan rose before dawn to meet Jianguo at a petrol station beside the G40 expressway southeast of Xi'an that they agreed on the night before. This was supposed to cost a couple more liters of petrol for the motorcycle taxi man, but he was so relieved to avoid a harrowing ride up the tableland that he didn't charge her. "Hope your kids are okay," he said gruffly, giving Haiyan a sympathetic departing wave after leaving her at the edge of the windswept station, gray in the predawn air. "Thank you, thank you so much! Please take care of yourself. Bye-Bye," Haiyan responded with gratitude. She sat on her bag to wait and watch the expressway, phone in hand. She had a bigger bag this time, filled with water bottles, packs of snacks, a few clothes, and the two blankets she could stuff inside.

on a transport like that, headed for the areas hit by the 2008 Wenchuan earthquake, Haiyan remembered. Jianjun's unit hiked two days into Beichuan county where there was exceptional devastation. Years later, when he was able to talk about it, he would tell earthquake stories. He told Xiaoshuai and Xiaomei "hero stories" about the people his unit saved, but after the children were safely asleep he told Jianguo and Haiyan that there were many that didn't make it. His words came rushing back to Haiyan's mind. "The best thing is to make your house earthquake-resistant," he had said. "The army can't help if your house falls down and kills you," he had said. "Those people, especially in rural areas, were almost totally unprepared," he had said. "The worst earthquake in China's entire history happened

here in Weinan in 1556," he had said. "There was a smaller but still strong one in 1568," he had said. "Get ready."

Had they listened? No, not really. And they had not done anything to strengthen the old house, despite Jianjun telling them it could be done inexpensively. There was always something more urgent. But they would listen now, Haiyan resolved. Actually, she was quite sorry now that they had not taken Jianjun's advice seriously before the earthquake.

A small truck in the long line parted from the stream and pulled off at the station. In a moment, Jianguo was there. Neither spoke for a long minute. "Let's go home," he finally said. He refueled the truck while his colleagues got out and waited for their ride. Zhou's brother was coming to take them to their village in north Linwei, just across the Wei River. It would be a long journey because they had to go around to the east and then north to avoid closed-off bridges

On the G40, a seemingly unending line of heavy transports streamed past, bearing soldiers and relief supplies bound for the earthquake zone. Over ten years ago, Jianguo's younger brother was



Liquefaction

When water-saturated sandy soils are shaken by an earthquake, a phenomenon called *liquefaction* causes the soil to lose its strength and flow as a thick fluid. In the scenario earthquake, soils liquefy across strongly shaken parts of the Wei River Basin, as occurred in 1568 and other past earthquakes. Liquefaction can cause major damage, as occurred in the 2018 Palu, Indonesia earthquake.

In the scenario, as a result of liquefaction, roadbeds settle and some buildings sink or tilt. Water and gas pipes break. Canals and irrigation channels develop cracks and their banks slump. In fields and vineyards, liquefied sand bubbles up through sand boils, which are miniature sand "volcanoes." These appear in fields near Zhou and Ma's villages in north Linwei in the story. Along the Wei River, thin layers of soil liquefy, and large areas of soil above them slide slowly toward the river, a process known as lateral spreading. Floodwalls and embankments are damaged in several locations, causing significant damage to flood protection systems for Linwei district. There will be only a short time to repair the flood protection system before the rainy season begins in May.



FIG. 11 Liquefaction caused by the 2011 M5.8 Yingjiang earthquake in Yunnan province, China, as evidenced by sand boils



FIG. 12 Liquefaction caused by the 2003 M6.8 Bachu-Jiashi earthquake, western area of Xinjiang Uygur autonomous region, China

RECOMMENDATIONS

Local agencies responsible for land resources and geo-hazards should use this scenario as a starting point to identify earthquake-induced risks in the area, including landslides, liquefaction, ground fissures, etc., and prepare more detailed loss and impact estimates and scenarios, to further improve associated geo-hazard prevention and mitigation work.

across or near the Weihe River in the areas most affected by the earthquake. Massive cracks had opened as the land near the river banks slid toward the river, damaging the roads up to the bridges. The G30 expressway had been closed just east of Xi'an so that engineers could inspect the Bahe bridge. Zhou's and Ma's families had been outside and were okay, but there was damage to the houses, and the ground had settled unevenly in places. There was no water service, and the fields had strange little cones of sand all over that looked like miniature volcanoes. I wonder if we'll see any of those, thought Haiyan, as she looked at a photo of them from Zhou's WeChat. Jianguo wished Zhou and Ma well, and drove back along the G40 eastward, until he reached the junction for the route to the tableland from the south. The road seemed okay and there was less damage to buildings than Haiyan had seen on the north side the previous day.

Past Houzhen on the south side of the hills, they saw a checkpoint ahead. Haiyan's countenance dropped. Jianguo put his hand on hers. "I'll talk us through," he said, trying to appear more confident than he felt. Haiyan had told him about her lack of success with checkpoints the day before. He eased to a stop and handed their ID cards to the soldier. "Our kids

and my mother are over there. We came as quickly as we could." "You live in the tableland?" The soldier asked, gesturing toward the north. "Yes," they replied in unison. "Drive slowly. Some small rocks might still be in the road from last night's aftershocks. There is a lot of damage on the other side. Watch out for downed power lines and debris in the road," the soldier warned as he waved them through.



Ma and Pa are Back!

TIME / 10:50 the day after the earthquake
PLACE / Xingfu Village, atop the Weinan tableland in Linwei District

After four long hours, the truck rolled to a stop in the lane outside their house, and Haiyan jumped out. With Jianguo behind her, she ran through the gate into the courtyard. "Xiaoshuai! Xiaomei! Ma! We're here!" she shouted. Everything was completely still. She dashed around to the back of the house, and saw the gaping hole in the back corner. It appeared there had been a rescue of some sort – bricks were piled in odd spots and boards of different lengths and sizes were lying about. That meant someone had been underneath all those bricks. Haiyan couldn't breathe for a moment. Jianguo held her by both shoulders. "They are going to be okay. They are going to be

okay, Haiyan. Maybe they're at the Wang or Zhang house," Jianguo said slowly. "Let's go."

As they pulled up to the hive of activity that was the Zhang house, Haiyan was out of the truck before it stopped moving. "They should have information," she called to Jianguo as she went. Ten minutes later, they were back in the truck again, this time headed for the home of Jianguo's elderly uncle. Now that the military was there, the elder Mr. Zhang didn't need the truck, or Jianguo, for the rescue and relief effort, though Jianguo had offered.

Gas and Fuel

Pipelines may break and leak

Natural gas is brought to Weinan by pipeline. In areas of severe ground movement, the pipelines may break and leak, including the steel pipe transmission line coming from the north. It crosses areas that are likely to have liquefaction and large lateral spreads (in which the ground slides gradually toward the river and develops large fissures). Natural gas is delivered to homes in polyethylene pipes, which generally resist earthquake forces well and remain undamaged, except in a few locations with very large ground failures. In the Weinan tableland, a landslide that moves a long distance ruptures a 300mm gas line. Leaking gas ignites and causes a fire in the area, which was revegetated

with pine trees after the gas line was installed. The lack of water supply limits the ability to extinguish fires, as occurs in the neighboring village in the story.

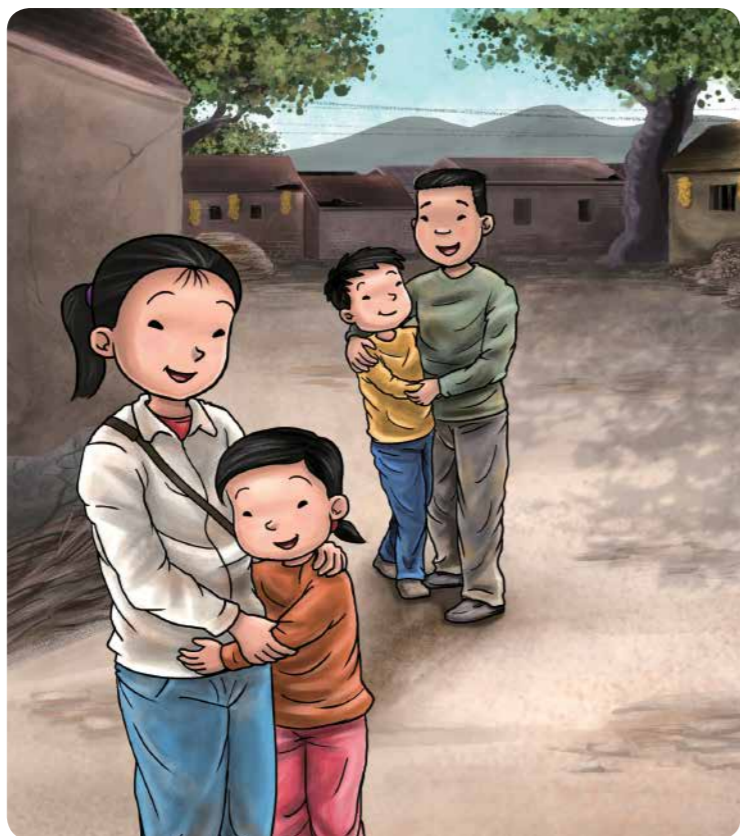
Limited local storage

Fuel is brought by truck to Weinan. Petrol stations have limited local storage capacity and need open roads to receive more supply. Road closures affect deliveries to stations until roads reopen.

RECOMMEN- DATIONS

Local gas and fuel supply agencies should use this scenario as a starting point to prepare their own detailed internal scenarios, in which earthquake induced gas leakage, fires, and explosions, and their possible impacts, should be paid particular attention. Good prevention, mitigation and preparedness measures should be taken accordingly.

Most important, the elder Mr. Zhang told them Xiaoshuai and Xiaomei were safe. The children had been sent to stay last night with their great-uncle after Grandma was taken to the nearest township-level hospital. Mr. Zhang also told them that he did not have further information about Grandma. But she was badly injured, especially one of her legs, so he thought she may have been transferred out to a larger hospital where she could get better care. The news of her injury was a hard blow, but at least the children were safe. Oh, they were safe! The seemingly unending hours of striving and not knowing, and the five minutes of terror after seeing the back corner of the house, those were all over now. Haiyan felt the tightness in her chest loosen a bit.



Xiaomei heard the motor of a truck and familiar voices. “Ma! Pa!” she shouted. “Xiaoshuai, it’s Ma and Pa!” Both children shot out of the courtyard where they had been playing. No one wanted to be inside. In fact, they had all spent the night outside together, under a large sheet that Jianguo’s uncle and Xiaoshuai had rigged up to some poles to keep off the rain. The great-uncle was very old, but still gently scolded Xiaoshuai for not knowing how to tie all the knots properly. Aftershocks woke them every so often.

“You came! Both of you!” Xiaomei squealed with glee as she ran to her mother. Xiaoshuai was right behind her and ran straight to his father. “You came all the way from Shanghai!” he said. Though he probably shouldn’t have, he blurted out, “I wish you were here yesterday to help rescue people. Mr. Zhang and I had to take a huge pile of bricks off of Grandma’s legs.” “My son is a little hero! And I wish I could have helped, son,” Jianguo responded. “I came soon as I could, right from the jobsite. It takes 14 hours to drive all that way.” “I tried to come all yesterday afternoon and evening,” said Haiyan. “On the back of a motorcycle,

in the dark, in all this, Jianguo interjected, gesturing toward the jumbled debris that had been the neighbor’s gate. “Your mother is very brave.” Xiaoshuai’s eyes widened a bit. With a small smile at the compliment, Haiyan continued. “The roads from Xi’an were blocked by landslides. The soldiers turned us back twice when I tried two shorter routes home. The motorcycle taxi driver was careful, thankfully, and kept me safe. And today, your father and I had to come all the way from the south. But now we’re here together, and more important, you both are safe,” she said, squeezing both of their shoulders. “And now we’re going to all go together and see Grandma.”

Water System

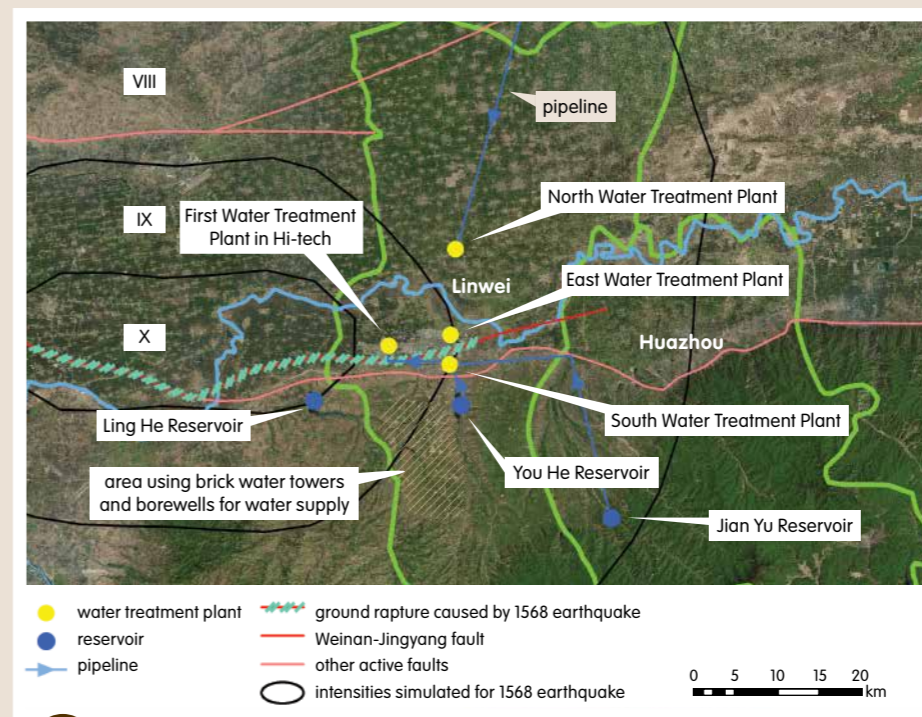


FIG. 13 The outline of water supply system of Linwei district

IF the 1568 approximately M7 earthquake occurs in the present day...

Damages to the water system leave some local residents without water service for hours to months, depending on their location. Water supply for Linwei and Huazhou districts comes from several local reservoirs, the Yellow River, and groundwater. Some facilities lose pumping capacity due to power outages caused by damage to the electrical system. Landslides in the loess of the Weinan tableland damage the You He Reservoir, urban Linwei’s secondary water supply. Fault rupture damages the irrigation channel from Linghe reservoir. The primary Jian Yu reservoir is located

far enough away from this earthquake to escape damage. Soil failures damage the canals and underground pipelines that bring water from the Yellow River to the new North water treatment plant, interrupting its supply. In the treatment plants, buildings crack and equipment slides. Unanchored chlorine tanks roll from their cradles, break their lines, and release dangerous gas. In rural areas, brick water towers located above borewells suffer damage and some collapse. Rural brick water tower damage concentrates in southwest Linwei district. This area has the largest number of brick water towers, and is hit by strong shaking. The brick water tower in the Zhao’s home village collapses in the shaking. Workers labor around the clock to restore water service to affected areas.

RECOMMENDATIONS

Assessing water systems for earthquake vulnerabilities, and then strengthening weaknesses, can prevent significant disruption to Weinan’s essential services and daily life. Brick water towers that can collapse should be replaced with municipal supply connections, and then removed. Chlorine tanks should be secured. Buildings and equipment should be assessed and strengthened to resist damage from shaking. The potential for landslide damage to key facilities, including the You He reservoir and dam, should be investigated and potential hazards properly addressed.

Local water services should use this scenario as a starting point to identify the risk earthquakes pose to their systems, and prepare their own detailed internal loss estimates and scenarios.

Highways, Roads and Bridges

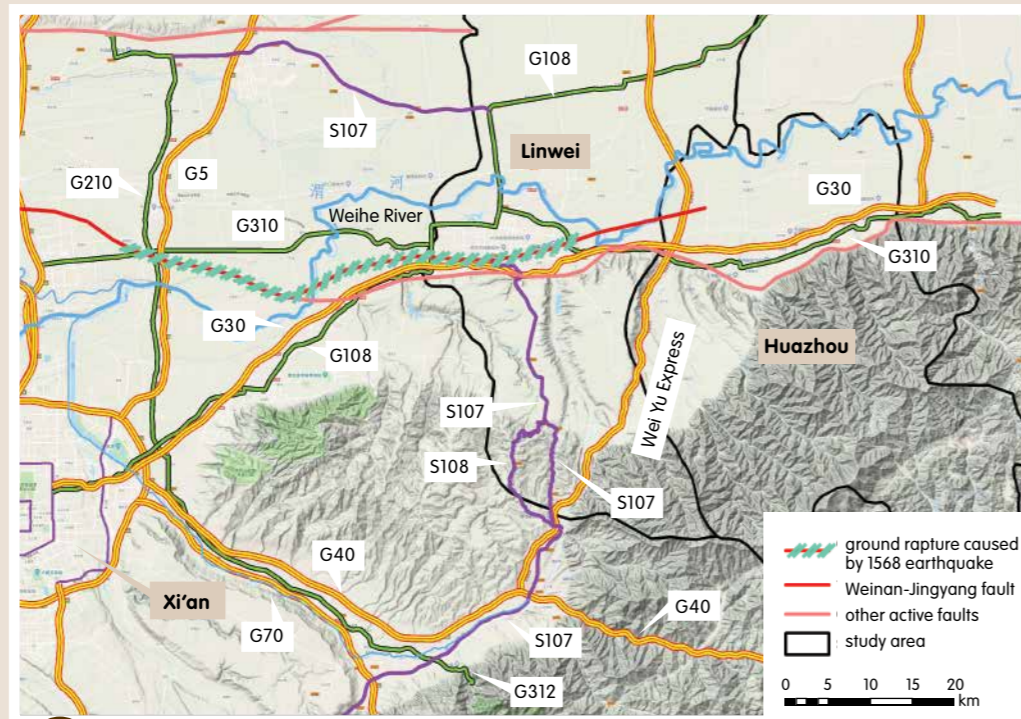


FIG. 14 Transportation network serving Linwei and Huazhou districts

IF the 1568 approximately M7 earthquake occurs in the present day...

Fault rupture

Damage to roads and bridges makes key routes impassible. The fault that caused the earthquake breaks across all lanes of the east-west G30 and G310 expressways connecting Weinan to Xi'an and other local roads. There is more than a half meter "step" that most vehicles can't cross. The fault rupture also damages the north-south G5 and G210 expressways, but there is less displacement than on the G30 and G310.

Landslides

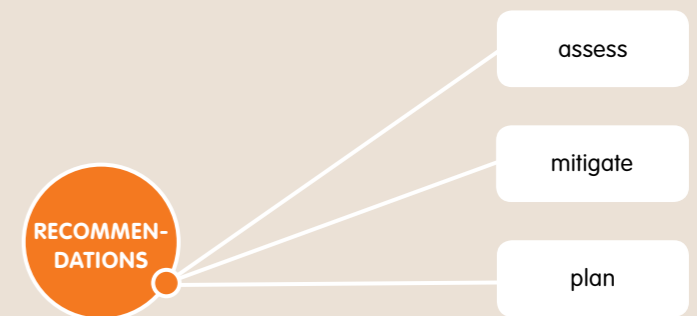
Landslides along the steep margins of the Weinan tableland extend into the G30 and G310 expressways that run along its base. Some local roads in the tableland are damaged or blocked by landslides. In the story, landslides prevent Grandma Zhao and other badly injured people from reaching the hospital in Weinan, forcing them to travel south on local roads to reach a hospital in Xi'an. Blocked roads leave village head Mr. Zhang to manage the relief operations without outside assistance until the second day.

Liquefiable soils

Near the Wei River and in the Wei North Area, soil failure causes road closures. Because the Wei River has saturated, highly liquefiable soils (which flow like a fluid during shaking), nearly all bridges that cross it have minor to significant damage from soil failures affecting the abutments and some supporting piers. The G5 and G210 expressways are also slightly damaged from liquefaction at the Wei River crossing. Slumping and lateral spreading (when the ground atop thin layers of liquefied soil moves towards the river banks) affect roads atop flood control embankments in some places. Roads in areas of liquefaction or lateral spreading crack and settle.

Restoration

The government closes some roads to regular traffic to ensure that relief vehicles have priority access. Immediately after the earthquake, Weinan's primary access is from the east on the G30 and G310, rather than direct from Xi'an. After close inspection and adding some support bracing as needed, some of the Wei River bridges with undamaged decks are reopened. Within a few days many bridges reopen, allowing improved access across the Wei River. Roads with smaller cracks from embankment settlement and liquefaction have basic repairs within a few days, allowing traffic to pass at slow speeds. Some roads and bridges damaged by severe lateral spreading take months to years to restore or reconstruct.



Assessing the potential impacts of liquefaction, landslides, fault rupture, and other types of ground failure; determining how to mitigate them; and planning ahead for impacts to the transportation system will reduce disruptions to critical transportation links in a major earthquake's aftermath, when responders will need roads to help disaster victims.

Local transportation agencies should use this scenario as a starting point to identify the risk earthquakes pose to their systems, and prepare their own detailed internal loss estimates and scenarios.

Looking for Grandma in the Hospital

TIME / 12:00 the day after the earthquake
PLACE / A local township-level hospital on the Weinan tableland

Though a trip to the hospital would be easier without them, Haiyan didn't want to be apart from her children for another minute. On the drive up, Jianguo had told her about the 10 days leave his company had provided to the workers from Weinan and nearby areas. "Foreman Guo told me not to worry. They will take care of us," he said. It looked like they would need every bit of that time together just to deal with what had happened, Haiyan realized. And she doubted Jianguo would get the week off after finishing the top floor, if the company was giving him 10 days paid now. For a moment she was angry that the earthquake had taken away the precious family time that she had just let herself start looking forward to. But, it was difficult to be angry when they had all survived. She was so thankful for that, especially after seeing what had happened to the house. The

Wang family and three others had all lost someone. And Jianguo was getting paid now, even if she wasn't. The restaurant was closed to repair some cracks in the walls. ("They're small, but I guess no one will come in until we fix them," Ms. Mai had said yesterday, before sending them home.) And best of all, her family was together now, mostly, or soon would be once

they were with Grandma. And after that, maybe they could find a way to keep it that way. But, that was almost too much to hope for.

Details poured out of the children on the drive to the township-level hospital. All the dust. Rescuing Grandma and taking her to the Zhang house in the wheelbarrow. Xiaoshuai being the "runner" for Zhang Ming's search and rescue team, and helping with simple first aid for the injured. Xiaomei going with Zhang Yan and the other girls to search for drinking water because the brick water



tower fell down and the taps were dry. Grandma Zhang and her granddaughters managing to give everyone gathered at her home some food yesterday evening. Until the first soldiers came early this morning, everyone wondering when outside help would come.

When Jianguo and his family arrived, the scene at the hospital was very different from the day before. Tents had replaced the rows of patients lying on the ground, and doctors and nurses from other provinces had arrived a few hours earlier to relieve the exhausted local staff. An information officer informed Jianguo that Grandma and other seriously injured patients were driven out in a small convoy late yesterday evening. "They took the road to the south, and we know they passed the checkpoint at Houzhen. By that point the patients were in a very serious condition, so the soldier there sent them on immediately without delaying them to ask for details. But, they must have made it out to Xi'an; but we don't have information yet on which hospital they went to," the information officer explained. "Our mobile tower is still out of service, so we are relying on the military, but we can only send essential communications, because they are also almost over-loaded due to all the rescue and relief communications. We don't have information yet on



which hospital they went to. Before they left, the staff here asked the drivers to bring some food and supplies on the way back if they could manage it. That must be what is taking so long. If we don't hear from the drivers soon, we can make an enquiry for you."

After a very long 15 minutes, Jianguo saw the information officer return to his makeshift desk. Beckoning him over, the officer gestured to a nearby chair. "I have some news," he said quietly. "The drivers reached the Houzhen checkpoint and gave a report. We just got it." Jianguo nodded. The officer folded his hands and looked down at them uncomfortably. "Six patients with very serious injuries were taken to Xi'an to Wei Min Hospital, five elderly women and an elderly man. Some of them were too weak to speak. In the chaos yesterday, there was some confusion about their names. Two of the women

died of their injuries on the way, but we are not completely sure which ones. I'm sorry not to have better news." The officer explained the options to Jianguo. "A driver took a photo of each of the six patients with his phone while the nurses got them ready to transport. But, we can't get his photos without mobile service. You have two options: wait four hours for the drivers to arrive to get further information, or go to Wei Min Hospital in hopes that your mother was one of the survivors. If you want to go to Xi'an today, you should go now. If you wait for the drivers, it will get too late. The road is still dangerous, and they aren't letting any civilians drive it after dark." After quickly conferring with Haiyan, Jianguo asked the information officer to send a message to his uncle by way of Mr. Zhang, and the family was back in the truck, bound for Xi'an.



TIME / 18:30 the day after the earthquake
PLACE / Wei Min Hospital in Xi'an

Pulling a tired Xiaomei by the hand behind her, Haiyan wove through the crowd toward the information desk set up outside the front of the hospital. "Keep up!" she shouted back at Xiaoshuai, who was following behind. The streets around the hospital were so crowded that Jianguo had finally just let them out while he looked for a place to park the truck. Not knowing what she would hear, Haiyan left Xiaoshuai and Xiaomei by a parking lot sign, safely out of earshot of the information desk, with strict instructions not to move.

Finally making it to the desk, she gave Grandma's name. Brow furrowed, the young woman stared at her computer, which was connected by cords snaking behind her into the hospital. "Zhao Mei. I don't see that name here on either the inpatient or the other lists. Are you sure she was brought here?" "Yes, last night from Linwei District of Weinan, up on the tableland. There were six badly injured elderly people, five women, one man. They were unsure of some names. Two didn't survive the trip," Haiyan explained quickly, providing as much information as she knew. "Let me check again," the woman replied. "There should be some information for a group that size." "Okay," she said a few moments later. "Two women from this group are in the ICU and one is in Trauma. In the file it says there is some uncertainty about their names. I'll get a volunteer to take you up. I hope one of them is your mother-in-law."

Xiaoshuai tapped his toe against the rubber baseboard in the corridor outside the Trauma department, as he kept praying silently that Grandma would be okay. Frustratingly, it seemed all he had done today was wait, ride in the truck, and wait some more. Yesterday, at least he could help people. Now, Ma and Pa wouldn't tell him anything other than, "We're going to see Grandma now," and "We're sure she's okay." Ever since they left Linwei, his parents had a strange tightness in their voices. And Grandma had not been in the ICU.

"Zhao Mei's family, please come this way," called a nurse, breaking into Xiaoshuai's thoughts. She led them down a hall and to a small room. Through the doorway, Xiaoshuai could see his father's back, on one side blankets, and on the other, a bruised arm propped on a pillow. Grandma!

Uncle Jianjun's New Earthquake Story

TIME / One week after the earthquake
PLACE / Wei Min Hospital in Xi'an



"Your Grandma has been telling me all about her young heroes," said the nurse to Xiaoshuai as she prepared the transfer request. In another week or so, Grandma would move to a rehabilitation facility, where she would stay for at least three months and try to walk again once her broken leg and hip had healed. It was a small miracle that the doctors had saved

her leg, but after three surgeries, they were cautiously optimistic. Xiaoshuai smiled sheepishly and looked at his toes. "I just did what anybody would do for their grandma," he said. "And Xiaomei was the one to bring back help. If she hadn't run so fast, Mr. Zhang Ming might have already gone to someone else's house. We couldn't have gotten Grandma out ourselves." Xiaomei glowed at this praise from her big brother. From her bed, Grandma smiled.

"I'm very proud of both of you," she beamed. "It seems you were listening to your Uncle Jianjun's earthquake stories after all."

"And he has even more stories to tell, Grandma," Xiaoshuai deflected, trying to get the focus back onto anyone but himself. "I talked to him on the phone yesterday and he was helping to put Weinan city back together again. He didn't want to disturb your rest, and says that he plans to come and see you soon when things are not quite so urgent and he can leave his office. He's working 18 hours a day," Xiaoshuai said, eyes wide, words tumbling out. "He was telling me that there was lots of damage in urban Linwei. They had to dig people out of the rubble, just like in 2008!" he exclaimed. "But Uncle didn't have to dig them out, Grandma," he added quickly, not wanting to worry her.

Soon after Jianguo and Haiyan found Grandma in the hospital, they put her on WeChat with Jianjun so she would know he was safe, but that was days ago. "There were other people digging. And the power was out then, so



they had to get a generator to run the lights at night so they could see," Xiaoshuai continued. "He said during the first day, they didn't have any water and couldn't even call anybody about it because their phones weren't working, so somebody had to go and find water and find generators and fuel. He said it was really tough. Like before mobile phones." "Wow," said Xiaomei slowly. "And they're still clearing rubble out of the streets. Even yesterday," he said. "That's a very impressive report, Xiaoshuai," Grandma replied. "Soon you'll be telling some of your own earthquake stories."

So as not to worry the boy, Uncle Jianjun had not told Xiaoshuai that he, as a veteran with experience saving trapped people in the 2008 Wenchuan earthquake, did in fact need to rescue people, and played a prominent role.

Those stories would have to wait until Xiaoshuai and Xiaomei were older. Drawing on his military experience, Jianjun had quickly recruited a small volunteer rescue team from his office and set off towards an area filled with older buildings shortly after the shaking stopped. An ominous cloud of dust hung overhead. From hard experience in the 2008 Wenchuan earthquake, Jianjun knew what that meant: buildings had collapsed. He quickly recruited men from the neighborhood and organized volunteer self-rescue groups to pull as many people from the rubble as they could until professional help arrived. They first encountered a collapsed three-story apartment. Its poorly joined precast concrete slab floors had come apart. Muffled voices came from below the pieces, meaning people were still alive underneath. Holding up a hand for quiet, Jianjun and his team listened carefully to pinpoint the sources of the sounds. A small hand reached out from under

the corner of a slab. Lying flat on his stomach, Jianjun could see a small girl pinned beneath. Working quickly together, they used scaffolding poles from a nearby construction site to gently lift the nearly 450kg precast slab. "One, two, three, lift!" Two wide eyes blinked in the sunlight. A shout went up. One life saved, many more to go.

The soldiers and professional rescuers from the military, government, and civilian rescue teams arrived in Weinan quickly and saved many lives. Local people, especially those with relevant training, played impressive roles, and as a result had been able to save even more people, by acting immediately after the shaking stopped.

Railways

IF the 1568 approximately M7 earthquake occurs in the present day...

Fault breaks

The rail system, which includes an east-west freight line along the front of the tableland, and a high speed rail line further out in the Wei River valley, needs extensive repairs before trains can operate. The fault breaks across both regular and high speed rail lines, taking them out of service. The high speed rail's elevated trackway requires reconstruction to realign the tracks to accommodate the nearly 1 m of vertical

offset in the piers on either side of the fault. Ordinary tracks crossing the fault must be re-graded and re-laid.

Landslides

Landslides along the front of the Weinan tableland bury tracks in several locations between Weinan to Xi'an and damage the railway tunnels in the tableland. Isolated rockfalls along the mountain front in Huazhou district cause precautionary closures of the busy east-west rail line. Several bridges are damaged.

RECOMMENDATIONS

The local railway department should use this scenario as a starting point to identify the risk earthquakes pose to their systems, and prepare their own detailed internal loss estimates and scenarios.

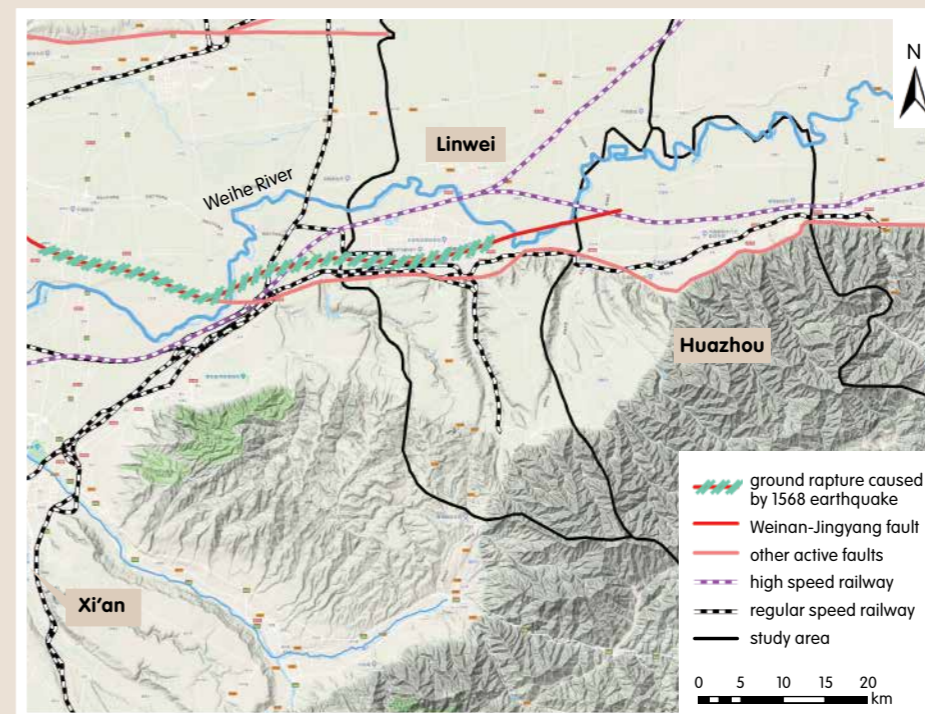


FIG. 15 Railway network relevant to Linwei and Huazhou districts

Homemade Chicken Soup

TIME / Two weeks after the earthquake
 PLACE / Wei Min Hospital in Xi'an

Zhao Juan, Grandma's sister who lived in the mountains of rural Huazhou district, and her daughter Ying stepped off the bus a block from the hospital. Now that the G30 expressway and the railways were open again, they were able to come over from Ying's apartment in urban Huazhou to see Grandma. Haiyan was waiting for them at the hospital entrance. "I'm so glad you could come all this way!" exclaimed Haiyan, spotting them across the parking lot and rushing over. "You look very healthy, Auntie. And how are you, Ying?" "It took a long time to arrive, and we are very worried about Grandma. We had to come," Ying replied.

Led by a nurse, the women filed into the still-bustling Trauma ward, as Haiyan motioned to the children to walk out into the hallway. "You look like you're

recovering very well. We were so worried about you," said Zhao Juan to her sister. Grandma smiled and nodded, happy to see Juan after so much had happened. "Auntie, we brought you some chicken soup from home," Ying added. "Thank you," replied Grandma, "I'm sure it will help me to feel better. And how are you? How is your house?" she continued. Juan looked up at the ceiling and sighed. "My mountain home has a lot of cracks now. Fortunately, I was outside when the earthquake struck. I dare not live in it, so I am staying with Ying for now," she said, looking at her daughter. "Yes, my apartment wasn't damaged but the power went out," Ying added. "And a

few things in the kitchen and living room fell down and broke. Such a mess! Luckily, no one was hurt by them. But we cleaned all that up and now we're okay." "Yes, my daughter cleaned up her house and I have a place to stay now. Some of the neighbors are in bad shape. Their houses had even more cracks than mine," Juan replied. Grandma took all this in, a worried look on her face. "I can see we're worrying you, Mei," Juan said, squeezing her hand. "We will be fine. Don't worry about us. Let me get you some soup," Juan said, as she opened the thermos and poured the fragrant liquid into a bowl. Grandma took a sip of soup. "Now let me tell you what happened to me."



Rural Villages

IF

the 1568 approximately M7 earthquake occurs in the present day...

- buildings collapsed
- people injured
- water pipes damaged
- road damaged
- houses unsafe
- gas lines damaged
- water supply interrupted

Condition at rural villages in Linwei district

Rural villages in Linwei district bear the brunt of the scenario earthquake damage. Some unreinforced brick houses and other buildings collapse, and many more are unsafe. Damaged buildings kill and injure people. Many who survive must stay in temporary emergency shelters or with family members. Near the Wei River, liquefaction and lateral spreading damage village water pipes, roads and buildings. At the edges of Weinan tableland, landslides damage roads, power, water and gas lines, isolating rural people and causing great hardship. Water supply becomes critical for survival. North of the Wei River, most villages are connected to the city water supply system and likely to have their water supply interrupted by damage

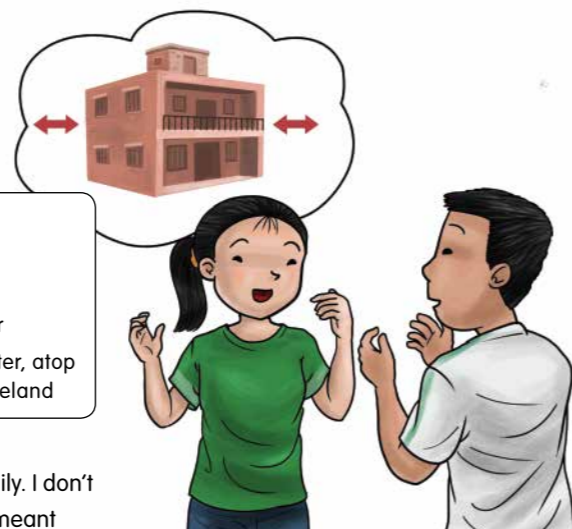
to the system. In other areas, many villages still have wells that feed into brick water towers. These towers are not reinforced for earthquakes and are highly vulnerable to damage. In strongly shaken areas, many brick water towers collapse. The cost to support earthquake relief and recovery for a typical badly damaged village in Linwei district may be in the range of 7.38 billion RMB. The rural population has greater social vulnerability than the urban population. Families are more likely to struggle financially, and many households consist of elderly people and their "left behind" grandchildren, such as the fictional Zhao family. This story describes impacts of the scenario earthquake on one fictional rural village. Many villages will experience similar damage and loss.

RECOMMENDATIONS

Strengthening or replacing vulnerable buildings, including schools and houses, and making rural water systems more robust, will help to prevent death and suffering of vulnerable rural people.

Building an Earthquake-Resistant House

TIME / One month later
PLACE / The village shelter, atop the Weinan tableland



Xiaoshuai and Xiaomei were not the only ones who had been listening to Uncle Jianjun. Haiyan needed no more convincing. "We are NOT going to live in that kind of brick house again," she told Jianguo. "What would have happened if the earthquake was a little stronger? Or at night when they were all inside? It's just too risky." "I agree. But we can't afford one of those apartments I'm building," he sighed. Recently, foreman Guo had gotten him a job with his cousin's construction company doing rebuilding work in Weinan. "I'll miss a good concrete worker like you, but your family needs you more than I do right now," Guo told him. "Why don't we rebuild a good house ourselves?" Haiyan asked. "You know how to build things," she continued, "and we can get a standard plan set and a grant from the Municipality, IF we agree to let them inspect and make sure it's strong enough for earthquakes. We can do it." "Let's think about it some more. But I think we should try," said Jianguo, after a long pause. "I just don't see any other way that

makes sense for our family. I don't think those shelters are meant to last more than a few years." "And what if another earthquake happens in the future? Or a fire or something? We should have a plan and one of those 'go-bags' if we have to evacuate quickly," Haiyan continued. "Yes, I agree," Jianguo responded. "We could all be better prepared, and take part in some of those training and response exercises that Jianjun is always telling us about. I'm not letting my younger brother be the only one who knows about all this anymore," Jianguo added, smiling.

For the moment, the family was crammed into Haiyan's shared apartment in Xi'an. Xiaoshuai and Xiaomei's school was on summer break much earlier than usual due to the earthquake. Haiyan was working in the restaurant during the week, as many shifts as she could manage, and taking Xiaoshuai and Xiaomei to the nearby rehabilitation facility to see Grandma as often as she could. Jianguo stayed in a dormitory on the construction site during the week. On the weekends, they all went to their home village, by

train first and then shared taxi or bus, to salvage what they could from the old house. "Not much we can use for rebuilding," frowned Jianguo to Jianjun, as they set down another load of old, soft bricks on the pile that Haiyan and the children were turning into neat stacks. "These will make a nice path in someone's garden," Haiyan admonished, ever enterprising. "I put them on Taobao. They're a hundred years old. Someone will want them." In another two weekends, the old house would be completely cleared, and they could start building the new earthquake-resistant one. If they all worked very hard and got a little help from Jianguo's construction crew, they could finish the new house by the time Grandma was ready to come home. She still wasn't walking, which worried Jianguo, and faced months of painful rehabilitation. But she was making progress.

Longing to Go Back to School

TIME / Three months later
PLACE / The village shelter, atop the Weinan tableland

"When can I go back to a real school, Ma? It's been a whole month of being in those hot port-a-cabins!" Xiaomei crossed her arms and drew her mouth into a thin line. "Not yet, Xiaomei. They're building a new school," said Haiyan brightly. "Think how nice it will be. And when has my daughter ever complained about going to school?" Xiaomei looked unconvinced. "But why? Can't they just patch the cracks like Uncle Jianjun did for great-uncle's house?" "No, Xiaomei." Haiyan turned back to the vegetables she was chopping and placed her hands on the counter, on either side of the cutting board. "They can't." "Why? Don't they know how to fix it? Principal Wei can fix anything. One time when—" "No, it had too much damage just to patch it," Haiyan said quietly.



"Everyone wants you and your classmates to be safe, so the government is building a new school."

"But I liked my old school. I don't want a different one!" Xiaomei protested, arms crossed. "Xiaomei, they will build back even better than the old one. All your teachers and classmates will be there, and everyone will be safer," Haiyan replied soothingly.

She turned from her vegetables and put her arms around Xiaomei's shoulders. "The new school will be specially designed to be very earthquake-resistant. It takes time to build back better. Let's be patient."

Schools

Because of the way that buildings are economically designed for strong earthquakes (“to bend but not break”), in the scenario some of these schools in areas with strong shaking would be damaged, some to the extent that might be more economical to replace them afterward. In areas where the scenario earthquake shaking is violent and above the level to which schools were reinforced or designed, some are expected to have severe enough damage that they will need to be replaced.



RECOMMEN-
DATIONS

In the past 10 years, a number of schools in Linwei and Huazhou districts were replaced by newer buildings designed to be earthquake-resistant and others were reinforced, as part of a nationwide program. This is excellent progress, and local students are expected to be much safer as a result.

Because earthquake damage is still expected, school officials should plan how to manage damage to school buildings that will close some schools for an extended period of time. Older buildings that were reinforced to meet minimum safety requirements, which might be expected to have more severe damage, could be replaced over time.

A Meal Together

TIME / Four months later
PLACE / Xingfu village atop the Weinan tableland

“Here’s the last bowl, Jianguo,” Grandma called from the kitchen. He carried the steaming bowl of *Saozi mian* and set it gently on the lovely wooden table that Grandpa made years ago. He had pulled Grandpa’s table from the rubble, and Haiyan lovingly cleaned it, sanded it, and rubbed it with oil, before placing it in the center of the dining room in their new house. Grandma followed Jianguo from the kitchen, taking careful steps with her cane. This was their first meal together in their new home, and the first noodles Grandma had cooked for them since her injury. Xiaoshuai and Xiaomei fidgeted in their seats, trying to be as polite as hungry children can be.

Xiaomei. Xiaoshuai grunted in agreement from his bowl. Haiyan smiled warmly at Grandma, not needing to say anything.

After the second helping, Haiyan looked expectantly at Jianguo. He nodded. Knowing what was coming, Grandma allowed a smile to slowly spread across her face. “Xiaoshuai, Xiaomei. Your Ma and I have something important to tell you,” Jianguo announced. Xiaoshuai and Xiaomei looked up from their bowls, expectantly.

“I am not going back to Shanghai.” The siblings’ eyes grew wide. Jianguo let this sink in for a moment.

“And,” he continued, watching his children’s faces grow brighter and brighter like small candles, “your mother took a new job in the Linwei government recovery program, and doesn’t need to go to Xi’an anymore. She starts next week. Being together as a family is more important than anything, even gold. And we will all live here, together.” Haiyan drank in the wonder on her children’s faces.

“All the time?” Xiaomei asked, breathlessly.

“Yes, all the time.”

“Eat, eat!” Grandma ordered with a smile, lowering herself into her seat. “I won’t have anyone starving in this house.”

Haiyan brought the last few small things from the kitchen and slipped into her seat. There was companionable silence as everyone savored their first few bites. “Still the best,” sighed





Yes, all the time.