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**Geographies of social capital:  
Catastrophe experience, risk perception, and the transformation of social  
space in post-earthquake re-settlements in Sichuan, China**

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## **Geographies of social capital:**

### **Catastrophe experience, risk perception, and the transformation of social space in post-earthquake re-settlements in Sichuan, China**

#### **Abstract**

This article explores the relationships between catastrophe experience and risk perception, social interaction, and household response to future catastrophes. Our main argument recognizes the geographical context in which social capital is formed and reproduced. Social relationships and norms adjust to the social landscape, which can be transformed by the spatial consequences of natural catastrophes. We therefore argue that sources of household resilience may be derived from the spatial transformation of social practices, and not necessarily from catastrophe experience and risk perception directly. A case study was conducted in two post-earthquake rural communities in China. The inquiry is primarily based on a household survey of 371 local residents and is further supported by an analysis of additional in-depth interviews and a review of key changes in the neighbourhoods under study. The findings challenge the assumption that catastrophe experience and risk perception are related to residents' intention to prepare for future catastrophes. Nonetheless, the relationship may be mediated by social relationships and social norms. Catastrophe experience and risk perception can be construed as a geographical contextual factor. Further analysis provides one example of such a factor: the spatial features of post-earthquake resettlements have increased the proximity between residents. This shift facilitates neighbourly interaction and risk communication across a neighbourhood. We discuss the non-linear, dynamic relationships between the variables examined and the grounding of social capital in space.

*Keywords: earthquake, social interaction, catastrophe experience, household behaviour, China*

## 1. Introduction

Community resilience to environmental change can be enhanced by social capital, which captures the idea that the integrative features of social organizations, such as trust norms and social networks, form the basis of sustainable communities. Social capital has proven to be important for accelerating recovery from large-scale natural catastrophes, including disruptive earthquakes in Kobe, Japan in 1995 and the deadly tsunami in South Asia in 2004 (Aldrich 2011a, 2011b; Shaw and Goda 2004). This article offers further evidence of the complex implications of social norms and social relationships for household resilience to earthquakes.

Major earthquakes create enormous physical damage and disrupt the spatial organization of human settlements and the livelihood of local residents. The massive damage and disruption often result in forced relocation, with far-reaching societal consequences. Possible changes in social practice include the reinforcement of norms and the formation of new social networks (Lo 2013; Aldrich 2011a, 2011b). Some of these norms and networks can increase the capacity of resource-dependent societies to cope with impending environmental change and reduce their vulnerability to its impacts (Adger 2000, 2003; Pelling 2011; Pelling and High 2005; Oulahan et al. 2015).

The ways in which these sources of social capital evolve in a social space that is shocked and transformed by natural disturbances are highly complex. The past two decades have witnessed a heightened interest in exploring these complexities (Osbaahr et al. 2008; Goulden et al. 2013). What remains contested are the pathways by which social norms and social relationships are linked to household responses that contribute to resilience. One of the issues that require particular attention is how these social elements fit into existing conceptual frameworks that put considerable emphasis on catastrophe experience and risk perception.

The conventional view is that household response is shaped by the perception of risk, which is subject to social influences and peer pressures. Grothmann and Patt (2005, p. 204), for example, have described 'social discourse' as a determinant of individuals'

risk perception, which then directly influences their response to environmental change. However, recent studies have provided limited evidence of the direct effects of risk perception on behaviour (Bubeck, Botzen, and Aerts 2012). The relationship between these elements is found to be non-linear and mediated by social factors (Wolf et al. 2010; Frank, Eakin, and López-Carr 2011; Lo 2013). This evidence moves the debate beyond an individualistic focus on human cognition toward a focus on social practice.

We advance the social focus by putting those social elements in a geographical context that recognizes individuals' experience with environmental change and the associated spatial consequences. Social interactions among members of a community and the informal institutions that govern these interactions are spatially organized and shaped by their encounters with environmental stressors. We contribute to the debate by suggesting that household responses that contribute to resilience are a function of spatially shaped social interactions and have only a weak linkage to catastrophe experience and risk perception. Our framework draws a closer link between social capital and community resilience.

Specifically, this research examines the complex relationships between earthquake experience and risk perception, perceptions of social norms and relationships, and intended behavioural responses. We report a case study of two rural communities in Sichuan Province, China, which recorded massive damage during a 7.9-magnitude earthquake in 2008. Mixed-method research approaches that combine quantitative and qualitative analyses have proven to be useful for investigating household decisions in China (Tian et al. 2015). Our research is based on an extensive survey of indigenous residents and a quantitative analysis. It is supported by a qualitative analysis based on additional in-depth interviews and a review of key changes in the neighbourhoods under study. The results of the survey demonstrate an alternative pathway by which risk perception and social capital affect a household's intention to prepare for future catastrophes, while the supporting materials help to identify one of the most important spatial driving forces that leads to changes in social

practice. The findings draw attention to the mediating role of social practice in influencing the adoption of coping strategies and enhancing household resilience.

In the next section, we review the literature and further elaborate on the problem being addressed and the conceptual premises. The study area and research methods are then described. The ensuing section presents the results of the survey and a regression analysis based on structural equation modelling. These results are further discussed in conjunction with observations from face-to-face interviews and wider changes in the neighbourhoods. We then discuss the non-linear, dynamic relationships between the variables examined herein and the grounding of social capital in space.

## **2. The geographical context of social capital**

### **2.1 National catastrophe and the changing social landscape**

Social capital is generated and accumulated in the processes of social interaction and engagement with social networks and institutions, both formal and informal, yielding a wide range of economic and societal benefits. Putnam (1995, p. 664-665) defines social capital as an enabler of collective action: “features of social life – networks, norms and trust – that enable participants to act together more effectively to pursue shared objectives”. He suggests that these networks, norms and relationships of trust can foster coordination and communication among members of a community.

By enabling individuals to act collectively and effectively, social capital plays a central role in the lived experience of coping with catastrophes. Adger (2003) describes it as a “glue” that brings together individuals in coping with unforeseen and periodic hazardous events. Social norms and networks act as informal institutions, influencing the ways in which individuals and communities respond to the shocks and stresses experienced by the social-ecological system (Adger, 2003; Pelling and High, 2005). These networked relationships enable the sharing of knowledge, risk, and information and can strengthen solidarity and allow claims for reciprocity in times of crisis. Because “the

quality of relationships between individuals is shaped by, and itself shapes the character of, the contexts in which they live” (Mohan and Mohan, 2002, p. 193), social capital is grounded in a particular place and time. It is, therefore, a geographical concept (Adger, 2003).

The grounding of social networks and norms in space and time means that their formation and reproduction can be driven or interrupted by changes in physical and spatial conditions. Research has found the aftermath of catastrophes to be an important driver of changes in social practice, with both intrinsic and extrinsic dimensions. The motivation of victims to seek help from, or offer help to, each other is intrinsic. Individuals’ propensity to cooperate with each other increases because individual efforts are far from adequate for mitigating massive impacts on the entire system. Neighbourly interaction is one form of social activity that is crucial for victims to counter deteriorating physical conditions. An openness to deeper social engagement is further reinforced by individuals’ past experience with devastating catastrophic events (Bihari and Ryan 2012; Yamamura 2010). Thus, major earthquakes often lead to the formation of new social organizations and the enhancement of cooperation between governments and local communities (Shaw and Goda, 2004; Solnit 2010). Crises open up new social spaces by increasing the demand for collective and coordinated responses that individuals alone fail to deliver.

Moreover, new social spaces may gain impetus from post-disaster reconstruction. The new urbanism literature has suggested that spatial proximity is an important extrinsic factor determining the quality of social capital in a community. As social ties between members of neighbourhoods tend to form based on proximity, certain features of the built environment that bring houses and residents closer to each other are conducive to fostering social interaction (Cabrera and Najarian 2015). Sidewalk continuity, for example, can foster neighbourly interactions (Wilkerson et al. 2012). Talen (1999) notes that patterns of social interaction in a neighbourhood are shaped by the specific design elements of the residential space and the surrounding

public space that encourage residents to leave their houses and go out into the public sphere. Porches, for example, can generate pedestrian traffic by projecting the human presence within a house to those passing by on the street. Neighbourhoods with a clearly defined centre and clear boundaries can engender a sense of community and neighbourliness. Similarly, communal gathering places can serve as a counter-pressure to community fragmentation and nurture a sense of place (Talen, 1999, p. 1363-4).

Although spatial organization is not sufficient for building social capital, it is one key factor that warrants consideration in the study of community resilience to geophysical catastrophes, notably earthquakes. Earthquakes disrupt the spatial structure of neighbourhoods. Post-disaster housing arrangements and the structure of new housing determine the ways in which victims, other residents, and local volunteers interact with each other. Temporary shelters and long-term housing that group together survivors from the same area are key to maintaining existing stocks of social capital (Aldrich 2011b). As we show later in this paper, this effect can be achieved by building a new settlement for the entire village and placing occupants' units closer to one other. An appropriate degree of spatial proximity between victims can help build solidarity within the community.

Therefore, the demand as well as opportunities for social interaction may increase in the wake of a major earthquake. Resilient communities develop new norms and bring new features to the built environment to help victims cope with the dreadful consequences of earthquakes and prepare for future shocks. Catastrophes may result in the transformation of the social landscapes on which networks and norms are grounded. As such, individuals' experience with catastrophes and the resulting spatial reorganization of a neighbourhood have important implications for social practice, which is itself a determinant of the intention to adopt strategies for coping with environmental threats, as described in Figure 1 (1a).

## 2.2 The contested role of social interaction



The view that social practice is a dynamic mediating factor embedded into the geographical context, however, is not clearly reflected in other conceptual formulations. The social context in which interactions between individuals occur and social norms and relationships are formed is often construed as a background factor (Figure 1, 1b). Knowledge about the ways in which the social context is shaped by the consequences of catastrophes remains incomplete. Underlying these formulations are two assumptions.

First, it is assumed that social interaction influences individuals' perception of risk. Second, risk perception determines behavioural adjustments. These assumptions and their causal relationship have been articulated by Renn (2011, p. 156):

Social interactions can heighten or attenuate perceptions of risk. By shaping perceptions of risk, they also influence risk behaviour.

This argument suggests that risk perceptions mediate between social interactions and behavioural changes, rather than social interactions themselves functioning as mediators. Other empirical reports that draw upon the same conceptual framework adopted by Renn (2011)<sup>1</sup> also tend to focus on how societal processes affect risk perceptions (Pidgeon, Kasperson, and Slovic 2003).

Although nuanced differences exist as to how social discourse is understood and positioned in relation to catastrophe experience and risk perception, some scholars portray a linear relationship between these attributes. In a widely discussed paper, Grothmann and Patt (2005) propose a model known as the 'Model of Private Proactive Adaptation to Climate Change' (MPPACC). The MPPACC defines behavioural adaptation

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<sup>1</sup> Renn (2011) adopts the 'Social Amplification of Risk Framework' (Kasperson et al., 1988; Renn et al., 1992). This framework is proposed as an interpretative framework for understanding experiences of risk and their behavioural and broader societal implications. It is based on the assumption that individuals process risk information either by amplifying signals that appear to be frightening or by attenuating those that are less threatening. This process is driven by or highly sensitive to social parameters, such as social norms, which are creatively described as a social 'amplifier' of risk. The functioning and transmission powers of such amplifiers crucially influence the formation of risk perceptions. They operate through multiple feedback mechanisms and complicate the ways in which risk perceptions impact human actions. By placing social-cognitive factors at the centre, the framework could offer explanations as to why risk-related behaviours appear to be insensitive to risk perceptions in some cases.

to environmental change as a function of risk perception (or threat appraisal), which is amenable to social discourse, among other factors. As Grothmann and Patt (2005, p. 205) explain:

We include the social discourse (or more specifically: the perception of the social discourse) as a determinant of people's risk perception and perceived adaptive capacity in our model.

Like Renn (2011), Grothmann and Patt (2005) recognize that the social discourse is subject to what individuals hear and encounter in interacting with friends, neighbours, and society at large. What remains unspecified is how the perception of social discourse is constructed upon experience with – and perception of – environmental change.

Evidence of the effects of risk perception or threat appraisal on behavioural response poses challenges to these assumptions. In China, Wong and Zhao (2001) have suggested that direct experience with flooding does not necessarily result in protective behavioural responses. Frank et al.'s (2011, p. 75) Mexican study shows that “risk perception and experience with particular hazards alone remain insufficient to motivate adaptation [to climate change]” and that social identity plays a mediating role. This finding is corroborated by a recent Australian study (Lo, 2013). Bubeck et al. (2012) review 16 empirical studies about flood risk mitigation worldwide and conclude that risk perception is a weak predictor of mitigation behaviour. This converging evidence from multiple sources calls for further investigation into the role of risk experience and perception as well as examination of the pathway by which social interactions or discourse influence behavioural response, as described by Renn (2011) and Grothmann and Patt (2005) above.

One element that has been missing from these other formulations is the geographical context. These studies do not explicitly recognize that social interactions, norms, and networks are sites for learning from grounded experience. Individuals' experience with and expectations about environmental change – including that of the natural and built environments – can shape social discourse, or more accurately, the

*perception* of social discourse (Grothmann and Patt, 2005). These experiences and expectations can lead to changes in the organization of social practice. One possible change, for example, is the provision of more communal spaces in post-earthquake reconstruction.

Based on the assumption that social relationships and norms are derived from grounded experience, we argue that these social elements are not merely a background factor but a mediating factor that links one variable with another. The perception of these social elements can shape and be shaped by the perception of, and experience with, changes in the natural and built environments. The reinforcement of perceptions provides an alternative pathway linking intended action with risk perception and catastrophe experience (Figure 1, 1a), thus addressing the limitations of other conceptual accounts, such as Grothmann and Patt (2005).

Our primary research hypothesis is that catastrophe experience and risk perception are related to perceptions of social relationships and norms, but only the latter are associated with the intention to adopt coping strategies. This hypothesis can be used to demonstrate the mediating effects previously discussed by Frank et al. (2011) and Lo (2013). Moreover, we examine how the quality of social capital is affected by the spatial reorganization of a neighbourhood after a catastrophic earthquake. Evidence was solicited from a case study in Sichuan Province, China.

### **3. Case study: Sichuan Wolong (四川卧龙)**

#### **3.1 Location and demographics**

Sichuan is an inland province located in the southwestern part of China. The province recorded a GDP per capita of \$32,617 Chinese yuan (approx. US\$5,030) in 2013, which is lower than the national estimate \$43,320 Chinese yuan (approx. US\$6,681) in the same year (National Bureau of Statistics of China 2015). Our study area is a Special Administrative Region located in Sichuan Province, known as Wolong National Nature

Reserve (N30°45' - 31°25', E102°52' - 103°24') (hereafter, 'Wolong') (Figure 2). Wolong has a total area of 2,000 km<sup>2</sup> and is a national protected area best known for its large population of giant pandas. The region has been under the provincial government's direct control since it was established in 1983.

According to a recent report (Sichuan Academy of Forestry 2014), Wolong has a total population of 5,216 and a relatively large proportion of ethnic minorities, namely, *Tibetan* (藏族), *Qiang* (羌族), and *Hui* (回族), who account for more than 85% of the total population. All of the local residents live in the two main towns, i.e., Wolong Town (卧龙镇) and Gengda Town (耿达镇), which are home to 2,292 and 2,924 residents, respectively. By the end of 2013, Wolong's GDP was estimated at \$52.7 million Chinese yuan, or US\$8.62 million, and the GDP per capita was \$6,888 Chinese yuan, or US\$1,127, which is far below the provincial and national estimates. A total of 4,750 residents, or 91% of the total population, works in agriculture. Agricultural incomes derived from crop production, forestry, and pastures account for 42.4% of the region's total income (Sichuan Academy of Forestry, 2014).

### 3.2 Sichuan earthquakes

Wolong falls within the geographic boundaries of Wenchuan County, which was the epicentre of the catastrophic 7.9-magnitude earthquake that struck the region on 12 May 2008. The Wenchuan earthquake occurred along the Longmenshan fault, which is a thrust structure along the border of the Indo-Australian Plate and the Eurasian Plate. Seismic activities were concentrated near the mid-fracture. The rupture lasted nearly 2 minutes, while the majority of the energy was released within the first 80 seconds. The earthquake started in Wenchuan and propagated at an average speed of 3.1 kilometres per second at 49° towards the northeast. The fault was 300 km long. The maximum displacement was estimated as 9 metres, and the focus was deeper than 10 km (China Earthquake Administration 2008).

According to the International Disaster Database (2014), the Wenchuan earthquake was the most destructive natural catastrophe in China since 1976 and one of the most damaging earthquakes in human history in terms of socioeconomic losses. Damage costs amounted to US\$85 billion (International Disaster Database 2014). Swiss Re, a global reinsurance company, reported a larger number; total economic losses were estimated at US\$137 billion, whereas insured losses were only US\$0.4 billion (i.e., 0.3% insured) (Swiss Re 2014). Therefore, the economic damage accounted for 1.9% to 3.1% of China's GDP in 2008: \$30,067 billion Chinese yuan (National Bureau of Statistics of China 2009) or US\$4,410 billion.

Massive casualties were the worst consequence; 87,449 people died in the earthquake event, 375,000 were injured, 15 million people were rendered homeless, 5 million houses were destroyed, and 18,500 schools collapsed (Swiss Re, 2014). For comparison, Japan's '3.11' earthquake and tsunami in 2011 killed 18,520 individuals and injured 5,893; 0.4 million people lost their homes. Although the earthquake in Japan was the world's costliest seismic disaster in the past decade, approximately 16.7% of the total economic damage was insured (Swiss Re, 2014). Thus, the Wenchuan earthquake was relatively more destructive in terms of the number of casualties and the relative size of economic losses.

Sichuan was hit by another major earthquake on 20 April 2013, which is commonly known as the Lushan or Ya'an earthquake. The Lushan earthquake was measured at a magnitude of 7.0, and the epicentre was located in Sichuan's Lushan County, which is approximately 85 km from southwestern Wenchuan County. According to Swiss Re (2014), the 2013 earthquake resulted in less damage than the 2008 event: 214 deaths and 13,484 injuries. Nearly US\$7 billion in economic losses were recorded, but only 0.4% of these losses were insured.

Both the 2008 and 2013 earthquakes were considered economic disasters. The massive damage further impoverished the poverty-stricken agricultural communities in Sichuan. Sun et al. (2010) report that the Wenchuan earthquake more than doubled the

poverty rate of 43 counties, and farmers' per capita net income in these areas decreased from \$1,873 Chinese yuan (approx. US\$305) at the end of 2007 to less than \$1,000 Chinese yuan (approx. US\$163) in the aftermath of the 2008 catastrophe. Both events suggest that China's southwestern population remains economically vulnerable to seismic hazards. Enhancing the community's economic resilience to unavoidable geophysical hazards, such as earthquakes, is imperative.

#### **4. Research methods**

##### **4.1 Fieldwork**

Our case study includes a household survey in Wolong and a quantitative analysis. During the spring-summer of 2014, we visited Wolong Town and Gengda Town, which each include three administrative villages. According to local residents and available records, until 2008, these six villages had not experienced a major earthquake of a magnitude of 6.5 or above during the past few decades. However, they experienced significant losses during the 2008 Wenchuan earthquake event due to their close proximity (i.e., within 40 km) to the epicentre. The two towns recorded similar levels of damage as they are located within a relatively small geographic area.

We invited residents of these villages to participate in face-to-face interviews based on a structured questionnaire. Six college students were recruited as research assistants. These student research assistants were fluent in the local dialect and were trained in the procedure and etiquette of face-to-face interviews. Each assistant was assigned to one village and visited every household in that village while accompanied by a local government officer from the Wolong Nature Reserve Administration, which granted permission for the interviews and offered logistical support. One member of each household aged 16 or older was invited to complete the questionnaire. The household surveys were conducted on weekdays and weekends. Each interview, on

average, lasted 15 minutes. All of the interviewees received a small gift as a token of appreciation after completing the survey.

As a follow-up survey, we returned to the study sites in November 2014 and conducted in-depth interviews with residents of the four largest villages in Wolong Town and Gengda Town. Each village has approximately 80-100 households, from which we randomly selected six to eight households and invited them to participate in the research. The sample consists of 26 individuals and mainly includes heads of household because some of the interview questions concerned household decisions, which in Chinese villages often fall under the domestic authority of the head of household. Each interview lasted approximately 20 minutes. Based on these individual interviews, we reviewed and observed the key structural changes in the study areas damaged by the 2008 earthquake.

#### *4.2 Survey instrument*

The primary survey instrument is a structured questionnaire that includes three sets of questions, described below, that was originally presented in the Chinese language.

##### *A. Residents' propensity to make arrangements for coping with future earthquakes*

Five closed-ended questions elicited respondents' propensity to make arrangements that could reduce potential economic losses from major earthquakes or help them to recover faster (Table 1). Each question presented a possible option or opportunity, namely, diversifying sources of income to spread risk, taking out insurance, seeking remittance to maintain livelihood, and acquiring liquid assets that can be sold for cash. In poor villages, regular welfare payments cannot be taken for granted, as the rural government and civil society are poorly resourced. Residents must rely on their own efforts in spreading risk and must make use of personal networks. The design of these

questionnaires was informed by key research reports, notably Alinovi, Mane, and Romano (2009) and the World Bank (2010). All of these questions were read in the context of the earthquakes in Sichuan. Responses were recorded using a five-point Likert scale (1 = 'Definitely not'... 5 = 'Definitely'). Higher scores denote stronger intention to adopt these strategies.

### *B. Residents' perception of social norms and social relationships*

Subjective perceptions of social norms and social relationships were prompted by six questions (Table 2). These questions were equally divided into two groups, one concerning the social-normative effects on respondents' decisions to make arrangements for coping with earthquakes (e.g., "*Do you think your family would want you to prepare for strong earthquakes?*"), and the second on the quality of one's social relationships (e.g., "*How is your relationship with other people in Wolong?*"). Responses were recorded using a five-point Likert scale. Higher scores mean that the individuals were more likely to be subject to social norms and to have closer relationships with the people they know. Although these items do not represent the full range of social capital attributes, they capture the key aspects of social interactions and social ties that are regarded as important factors influencing risk perception and behaviour, and they therefore can help us examine our research hypothesis.

### *C. Residents' risk perception and experience with earthquakes*

Another set of survey items recorded respondents' risk perception and actual experience with earthquakes (Table 3). Two questions measured perceptions of the likelihood and severity of another major earthquake: "*How likely is Wolong to experience a magnitude 7 earthquake in the next ten years?*", and "*How much personal damage would it cause?*" Because causality cannot be determined by testing the statistical correlation between perceived risk and perceived social norms and



relationships, we used a qualitative measure of actual experience with major earthquakes to support the interpretation. Whether one had been affected by earthquakes is unlikely to be affected by perceived social norms and relationships. Additionally, whether one had been affected by earthquakes is closely related to how people perceive future risks. Therefore, this measurement allows a logical inference and can be used to indirectly examine the conjecture that risk perception influences the perception of social norms and relationships. Because nearly all of the Wolong residents had experienced a major earthquake, we formulated the questions about actual experience in terms of incurred damage instead of whether they had earthquake experience to provide adequate variation for statistical analysis. A binary (yes/no) item was used to ascertain whether the respondents had incurred any damage from a major earthquake in the past ten years. This item was followed by an inquiry into the extent of the actual damage: *“How damaging was the last major earthquake to you and your family?”*

The responses to these questions form three sets of statistical variables. Our working hypothesis is that perception of social norms and social relationships (A) and earthquake risk perception and experience (B) are correlated with one another, but only the former is associated with the propensity to make arrangements for coping with future earthquakes (C). We analysed the structural relationships between these three sets of variables. The results are presented below.

## **5. Results**

A total of 425 Wolong residents from six villages were invited to participate in the household survey; 380 agreed to be interviewed. Only 371 individuals completed the interviews, yielding an effective response rate of 89%. The sample therefore consists of 371 observations. Before presenting the results of our analysis, we briefly describe the socioeconomic characteristics of the respondents and discuss the test variables. Due to

space limitations, we dispense with detailed breakdowns and focus on the associations between the variables.

## 5.1 Descriptive statistics

The average respondent was 41 years old and had lived in Wolong for 36 years, thus suggesting that the majority of the respondents were native. The average and median monthly incomes were \$1,578 Chinese yuan (approx. US\$255) and \$1,000 Chinese yuan (approx. US\$161), respectively, which are well below the provincial average of \$2,718 (approx. US\$419) (National Bureau of Statistics of China 2015). More than half of the respondents were female (54.5%). Many had received only elementary education (43.1%), and some had attended middle school (32.5%), whereas less than 10% had received post-secondary education. The sample includes 252 (67.9%) ethnic Tibetans and only 97 (26.1%) individuals of *Han* origin. As many as 70.6% of the respondents engaged in agricultural activities, and only 38.8% received all or part of their income from non-agricultural sources.

The statistics for the three sets of variables are displayed in Tables 1-3. The mean scores of the five items related to the propensity to make arrangements for catastrophes ranged from 2.11 to 3.81. According to these scores (Table 1), the respondents had a greater intention to prepare for catastrophes by diversifying their income and assets and taking out insurance. The tendencies for seeking remittance from family and friends are not clear. Acquiring liquid assets was a relatively less common strategy.

The three items related to perceived social norms yielded consistent results, with mean scores ranging from 3.72 to 3.89 (Table 2). This outcome suggests that the respondents generally felt that they were subject to expectations from family, friends, and other individuals in Wolong to prepare for a major earthquake. The scores of the other three items related to perceived social relationships ranged from 3.87 to 4.49. In

general, the respondents indicated good relationships with all of the above three groups – particularly with their family.

The mean scores for risk perception (Table 3) suggest that the likelihood of another magnitude-7 earthquake was perceived to be low (2.28); however, the respondents indicated that should another major earthquake occur, they expected it to be highly damaging (4.11). The overwhelming majority (0.94, or 94%) of the respondents had recorded losses during a major earthquake in the past ten years. Actual damage on the household was significant (4.20).

## 5.2 Structural relationships between key variables

A path analysis examined the structural relationships between the variables based on Structural Equation Modelling. Each of the conceptual components described above is defined as an unobserved, latent variable in the model that is predicted through the observed variables measured by the questionnaire. Each latent variable is assigned a label, such as EARTHQUAKE RISK PERCEPTION and PROPENSITY. The relationships between the latent variables are assessed in terms of standardized coefficients and significance levels, which indicate the strength of association between variables.

Figure 3 presents the path analysis for risk perception (EARTHQUAKE RISK PERCEPTION), perceived social norms (SOCIAL NORMS), social relationships (SOCIAL RELATIONSHIP), and the propensity to make arrangements for coping with future earthquakes (PROPENSITY). The latent variable EARTHQUAKE RISK PERCEPTION, which is predicted through the perceived likelihood and severity of future earthquakes, was not a significant predictor of PROPENSITY. However, this variable is significantly related to SOCIAL RELATIONSHIP. Conversely, there is a strong association between SOCIAL RELATIONSHIP and SOCIAL NORMS, and both predicted PROPENSITY. The model variables explained 16% of the variation in PROPENSITY.

To check for model fitness, we computed the following estimates: root mean square error of approximation (RMSEA), comparative fit index (CFI), incremental fit index (IFI), and chi-square relative to degree of freedom ( $\chi^2/df$ ). As a rule of thumb, the RMSEA should be lower than or at least close to 0.05, with the CFI exceeding 0.93, IFI exceeding 0.90, and  $\chi^2/df$  below 2.00. Our model achieved a RMSEA value of 0.05, CFI 0.91, IFI 0.92, and  $\chi^2/df$  2.04, thus suggesting that it came very close to the usual benchmark.

Figure 4 shows the second model, which was created by replacing EARTHQUAKE RISK PERCEPTION with EARTHQUAKE EXPERIENCE. Consistent with the first model, EARTHQUAKE EXPERIENCE was not associated with PROPENSITY but had some impact on SOCIAL RELATIONSHIP and SOCIAL NORMS. PROPENSITY was a function of SOCIAL NORMS, but not SOCIAL RELATIONSHIP. These variables explained 19% of the variation in the dependent variable. The second model achieved a RMSEA value of 0.05, CFI 0.92, IFI 0.92, and  $\chi^2/df$  1.98.

A schematic summary of these results is presented in Figure 5. Both models indicate that the propensity to make arrangements is a function of perceived social norms and, to a lesser extent, social relationships. Risk perception and damage experience do not predict propensity and perception of social norms. Nonetheless, both are related to social relationships. Note that experience with actual damage should be viewed as a cause rather than an effect, as it is a past event and therefore unlikely to be affected by the perception of present social relationships, whereas earthquake risk perception tends to be subjective and therefore causality cannot be determined for this variable. These results imply that although catastrophe experience and perception do not produce significant effects on intended behaviour, they may create indirect impacts by shaping perceptions of social norms and social relationships, which play a mediating role.

These results beg the question of how the consequences of a major earthquake might intervene in local residents' social interactions. A structural change in the built environment caused by the catastrophic event in 2008 offers one possible explanation.

### 5.3 Spatial proximity in the post-earthquake resettlements

The aftermath of the Wenchuan earthquake resulted in the creation of denser neighbourhoods, bringing positive changes to the social landscape. Before the 2008 earthquake, most Wolong villagers, particularly low-income earners and farmers, lived in poorly maintained cottages. Figure 6 shows an aerial photo of some of these cottages, which are now used for non-residential purposes (e.g., storage) or have even been abandoned since the emergency evacuation during the earthquake event or the managed relocation afterwards. Although these detached cottages were situated at a short, walkable distance from one other and there might be more than one household in adjacent houses, their scattered distribution did not provide good conditions for frequent visits and social interactions among multiple households. Considering the mountainous terrain of Sichuan and the poor infrastructure in some of its remote areas, large group meetings and daily encounters were particularly difficult for those living farther away from each other.

Many rural residents lost their homes during the Wenchuan earthquakes or found them to be no longer habitable. With a generous supply of external financial support amounting to \$2.2 billion Chinese yuan, or US\$0.35 billion (Sichuan Academy of Forestry, 2014, p. 24), the Wolong government was able to rebuild the infrastructure and resettle affected residents by constructing a number of 'new villages'. Larger resettlement sites accommodate 50-80 households each; an example is presented in Figure 7. Houses on these sites are more closely packed than were their predecessors. Many have multiple (2-3) storeys and a total area of approximately 200-500 m<sup>2</sup> per household (i.e., house allocation depends on household size). Figure 8 provides a closer

look at these houses, which are typically semi-detached or terraced. As of the middle of 2014, at least 757 houses have been built (Sichuan Academy of Forestry, 2014, p. 24).

Importantly, these resettlements provide a spatially bounded community with denser neighbourhoods and more clearly defined communal spaces. One of the key planning principles was to rehouse affected residents who were originally from the same culture, community, or village in the same resettlement or in nearby sites whenever possible. Thus, efforts were made to avoid neighbourhood fragmentation and mass migration. A long-term effect is that individual residents who used to live at a distance from each other now live in closer proximity to their neighbours.

#### 5.4 Spatially enhanced social interactions

Our in-depth interviews with 26 residents from these new villages reveal that resettlement has contributed to a subtle change in the social landscape. Respondents were asked, among other open-ended questions, how the major earthquake affected the social relationships between neighbours. We found that, in general, there is a moderately strong level of trust among villagers, and they know most of their neighbours within the community. Neighbourly activities are frequent. Most of the respondents (15 out of 26) indicated that social relationships had improved since the 2008 earthquake, and closer proximity was the primary reason.

While there is more interior space within the respondents' new houses, the distance between houses and neighbours has been reduced. A farmer from Wolong Town (female, 38) responded that people moved to the resettlement after the earthquake and 'live together', making everyday contact more frequent and the community livelier. As shown in the pictures above, these new villages are essentially gated communities with small pockets of built communal spaces where neighbours can visit with each other every day, whereas their former homes put them in disparate locations. Another resident of Wolong (male, 67) said that they 'live and eat' closer to

each other and meet their neighbours on the street more often than before. Due to the closer proximity, there are more opportunities for '*chuànmén*' (串门), or casual visits to a neighbour's home, and more neighbourly interactions. Many other respondents mentioned that they have better social relationships because they now live closer to each other and see each other more often than before.

These spatially enhanced neighbourly activities, such as *chuànmén*, are important for enhancing communication among members of the community and strengthening mutual support. In the wake of the major earthquake, Wolong residents became more aware of hazard risks (including those of earthquakes as well as landslides), and the new social space within resettlements is one of the main channels through which risk information is communicated. The respondents were asked whether they observed any change in the frequency of exchange and communication related to hazard risks after the 2008 event; most responded affirmatively. Apart from *chuànmén*, residents indicated that they often participate in '*lóngménzhèn*' (龙门阵) (literally means 'dragon squad'), which refers to an informal or semi-formal discussion or debate about a variety of community affairs among a group of people, usually adult males. As the higher neighbourhood densities reduce the efforts required for getting together, there are more opportunities for residents to set up *lóngménzhèn*. According to a local driver (male, 26), these gatherings function as a primary means by which residents access risk information, exchange opinions, and make recommendations to village leaders. The new spatial setting is conducive to informing residents of potential threats to their community and livelihoods.

Although these casual visits and regular meetings do not always cover issues related to natural hazards, as indicated by another respondent (female, 41), they are crucial for spreading useful information about a wide variety of community topics. By promoting access to this information 'hub' and speaking to informed individuals, residents know where to seek help should the need arise and become messengers themselves. Therefore, the *in-situ* re-settlement has led to the re-organization of space

by creating new sites for social interactions. By increasing the spatial proximity between residents, resettlement has strengthened the existing social networks and facilitated social interactions within communities.

## **6. Discussion**

Catastrophic earthquakes are rare, but the poverty-stricken rural communities in Sichuan must address a wide range of risks, including not only future earthquakes but also landslides and climate-change impacts on agricultural production. Household preparation for unforeseen changes in livelihood may be driven by actual experience with, and perceptions of, an impending threat. These experiences and perceptions can be enhanced or 'attenuated' by social interactions and the sociocultural context (Kasperson et al., 1988; Ren et al., 1992). Nonetheless, there are multiple interpretations for the relationships between these elements, and they remain a contested issue in scholarly debates.

The conceptual understanding that we seek to advance is consistent with a context-dependent perspective about these social elements. Numerous studies have been conducted to ascertain how social systems are transformed in response to environmental change and its local consequences (Pelling, 2011). A key concept advanced by these studies is the notion of social capital, whose formation and reproduction is regarded as largely dependent upon the geographical context (Adger, 2003; Pelling and High, 2005; Goulden et al., 2013; Lo et al., 2015). Following Mohan and Mohan (2002), we argue that while aspects of social capital such as social interactions, networks, and norms can create various impacts on humans' subjective experience with natural catastrophes, they are simultaneously a product of such experiences, i.e., the process is dynamic. Social networks and norms are grounded in space; thus, their formation and reproduction can be driven or interrupted by changes in physical and spatial conditions.



We began by recalling two standard assumptions. The conventional view is that catastrophe experience and perception first determine behavioural responses (Kunreuther 2006; Kunreuther, Meyer, and Michel-Kerjan 2009) and, second, that catastrophe experience and perception are themselves determined by social interactions (Renn, 2011) or the perception of 'social discourse' (Grothmann and Patt, 2005). Our household survey offers little evidence of the first assumption, i.e., neither actual experience with a major earthquake nor a perception of earthquake risks is associated with a propensity to make economic arrangements to cope with future earthquakes. This finding corroborates similar observations reported by Frank et al. (2011), Bubeck et al. (2012), and Lo (2013). As the surveyed villages in Wolong were located within a small area and the residents have similar experiences with earthquakes, there is limited statistical variance in the Earthquake Victim variable, which may have contributed to the insignificant relationship between earthquake experience and propensity to adopt coping strategies. The second assumption is partially supported, i.e., perceptions of social relationships correlate with catastrophe experience and perception. However, earthquake experience is likely to be a cause rather than an effect. Although causality cannot be determined for risk perception, it is plausible to suggest that these social perceptions are influenced by earthquake experience.

In Wolong, past experience with environmental change, driven by earthquakes, is part of the geographical context in which social interactions among villagers occur and social relationships develop. New neighbourhoods were formed in the wake of the 2008 earthquake, and consequently, spaces for social interactions were reorganized. Changes in social relationships run parallel to social expectations, which nonetheless do not correlate with catastrophe experience and perception. In our case study, therefore, past experience with environmental change does not directly influence the propensity to act or perceptions of social norms; rather, experience has an indirect effect by shaping social relationships (see Figure 5 above).

Our further analysis provides one example of changes in the built environment that have shaped the social space. The 2008 Wenchuan earthquake disrupted the social life of neighbourhoods. One of the long-term consequences, however, can be described as an unexpected spatial propinquity effect, which is a term borrowed from Cabrera and Najarian (2015). According to the new urbanists such as Talen (1999) and Cabrera and Najarian (2015), social capital is a function of spatial proximity between social contacts, such as neighbours. The Wenchuan earthquake directly contributed to the construction of permanent resettlements. By increasing neighbourhood densities, these resettlements created a new social space that is conducive to neighbourly interaction. Resettlements strengthened the 'spatial norms' and the neighbourhoods' physical conditions that promote everyday contact between residents who formerly lived in disparate locations prior to the major earthquake. As part of the geographical context, spatial reorganization proves to have significant implications for patterns of social interactions and the quality of social capital.

As such, the major earthquake in Sichuan led to a subtle change in the social landscape upon which social networks and norms are grounded. In the more interactive social environment, individuals may *feel* greater social pressures to prepare for environmental change, as individuals' concerns are more widely spread and information flows faster. Material damage to households created by past earthquakes could reinforce this feeling. While a catastrophe might not be an immediate driver of behavioural responses to impending threats, it could have an impact in shaping the social context that determines the ways in which information about risks and coping arrangements are disseminated and conveyed.

These findings recognize the social system as a critical site for learning from a grounded experience with the natural and built environments. The collapse of old neighbourhoods due to earthquakes does not necessarily have immediate effects on residents' intentions to prepare for future earthquakes – in fact, it should not, as the local residents are well informed of the rarity of a magnitude-7 earthquake occurring in

the same place. The main effects of neighbourhood collapse are thus systemic, changing the larger context in which individuals interact and social practices operate. These changes may be incremental, e.g., with residents merely living closer to each other, yet they contribute to social dynamics and may collectively lead to the formation of new villagers' cooperatives or social orders over time. Natural catastrophes are likely to result in sharp changes in victims' adaptive or preventive actions, but their primary effects on the individual are not limited to psychological responses and do not directly originate with environmental stressors and shocks. Catastrophic events can create systemic effects, such as the reorganization of social spaces in which every day neighbourly activities take place, as we have shown in Wolong.

## **7. Conclusions**

This article has examined how catastrophe experience and risk perception are associated with social norms and relationships, and how these risk and social factors contribute to individuals' intention to make economic preparations for natural catastrophes. We reported a case study of two rural communities in China's Wolong region that suffered massive damage during a 7.9-magnitude earthquake in 2008.

The findings challenge the assumption that the intention to prepare for future catastrophes is a function of catastrophic experience and perception. We understand catastrophe experience and perception as part of the geographic context shaping social interactions. Consistent with this view, the findings of this study suggest that social relationships and social norms mediate between the geographic context and a household's behavioural response to earthquakes. Thus, this study calls for more serious engagement with the dynamic role of social capital.

The concept of social capital requires an analytical focus on social life. Another contribution of this study is its demonstration of how Wolong residents' social life has

been affected by the reorganization of space in the neighbourhood. As a consequence of the major earthquake in 2008, the resettlement of victims in new residential sites is manifested as a spatial force, thus creating conditions for more frequent interactions between residents and new social practices. Although the spatial transformation of social practice is merely one example of the multiple consequences of earthquakes linked with the formation and reproduction of social capital, it is important to recognize that both social practice and household response are situated within the natural system and built environment that are subject to disturbances and shocks. The grounding of social and individual responses in space therefore warrants consideration by both risk managers and spatial planners.

Policies and interventions should account for the social process that determines household resilience to environmental change. Strategies and measures that contribute to household resilience can be promoted by creating a favourable social environment that can help to disseminate useful information about risks and emergency arrangements and spread positive messages that promote desirable behavioural responses, such as insuring against risks and prearranging contingency funds. This endeavour could benefit from a social learning process in which expectations and encouragement from family, peers and the wider community are articulated and circulated among individuals and families at risk from natural catastrophes. To enhance community resilience, spatial planners should take into account the additional benefits of providing more communal spaces for neighbourly interaction and reducing spatial proximity between residents. This approach is particularly important for resource-dependent societies where economic capital is relatively scarce and the main source of resilience is social capital.

A limitation of this study is that our qualitative findings do not directly demonstrate the hypothesized association between the enhanced social interactions and relationships and the propensity to adopt coping strategies. Further evidence is needed, and one way of soliciting such evidence is to include a control group in the interviews, i.e. residents who were not re-settled after the earthquake, and compare their responses with re-settled households. Although such a comparative approach is

not possible in our case study - because all of the residents of the two towns had moved to the re-settlements and the geographic context of their social lives was likely to be similar, it would be instrumental in demonstrating the role of geographic context in altering social practices and consequently driving hazard adjustments.

### **Acknowledgement**

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**Table 1 Residents' propensity to make arrangements for coping with future earthquakes (N = 371)**

	<b>Description</b>	<b>Range</b>	<b>Mean</b>	<b>Standard deviation</b>
Diversify incomes	Would you try to explore alternative sources of income that are unlikely to be affected by strong earthquakes?	1 – 5	3.81	1.12
Take out insurance	How likely would you take out insurance, if available to you, that covers part of your potential losses due to strong earthquakes?	1 – 5	3.68	1.18
Seek remittance (family)	Would you ask your family members living outside the town to send you money (remittance), if your livelihood is severely affected by the consequences of earthquakes?	1 – 5	2.98	1.38
Seek remittance (friends)	Would you ask your friends to send you money (remittance), if your livelihood is severely affected by the consequences of earthquakes?	1 – 5	2.82	1.24
Acquire liquid assets	Would you try to acquire more liquid assets (in order to cope with catastrophes such as earthquakes)?	1 – 5	2.11	1.11

All measured on a five-point scale: 1 = 'Definitely not'... 5 = 'Definitely'.

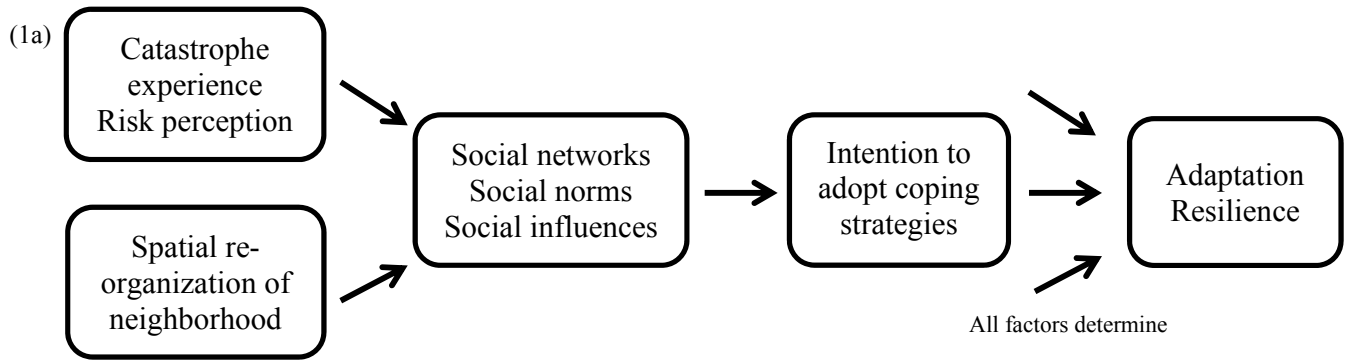
**Table 2****Perceptions of social norms and social relationship (N = 371)**

	<b>Description</b>	<b>Range</b>	<b>Mean</b>	<b>Standard deviation</b>
Social Norms	Do you think ..... would want you to prepare for strong earthquakes? (1 = 'absolutely not' ... 5 = 'absolutely')			
	your family	1 - 5	3.89	0.92
	your friends	1 - 5	3.84	0.88
	other people in Wolong	1 - 5	3.72	0.90
Social Relationship	How is your relationship ..... (1 = 'very bad' ... 5 = 'very good')			
	with other members of your family?	1 - 5	4.49	0.73
	your friends?	1 - 5	4.19	0.77
	other people in Wolong?	1 - 5	3.87	0.80

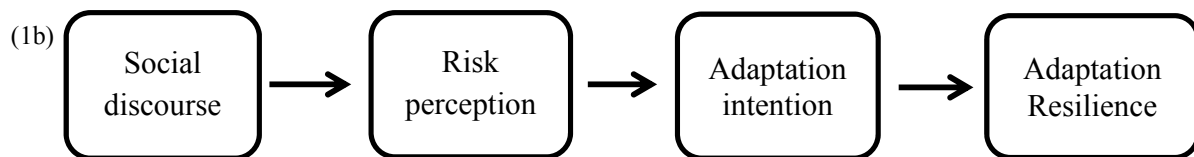
**Table 3 Risk perception and actual damage due to major earthquake (N = 371)**

<b>Description</b>		<b>Range</b>	<b>Mean</b>	<b>Standard deviation</b>
<i>Earthquake Risk Perception</i>				
Perceived likelihood of earthquake	How likely is Wolong to experience a magnitude 7 earthquake in the next ten years? (1 = 'Very unlikely' ... 5 = 'Very likely')	1 - 5	2.28	0.83
Perceived severity of damage	How much personal damage would another magnitude 7 earthquake cause? (1 = 'No damage' ... 5 = 'Extremely damaging')	1 - 5	4.11	0.98
<i>Earthquake Experience</i>				
Earthquake victim	Did you or your family suffer any damage due to a major earthquake in the past ten years? (0 = 'No', 1 = 'Yes')	0 - 1	0.94	0.23
Severity of actual damage	How damaging was the last major earthquake to you and your family? (1 = 'No damage' ... 5 = 'Extremely damaging')	1 - 5	4.20	1.01

**Figure 1** Schematic representations of conceptual frameworks



Source: Authors

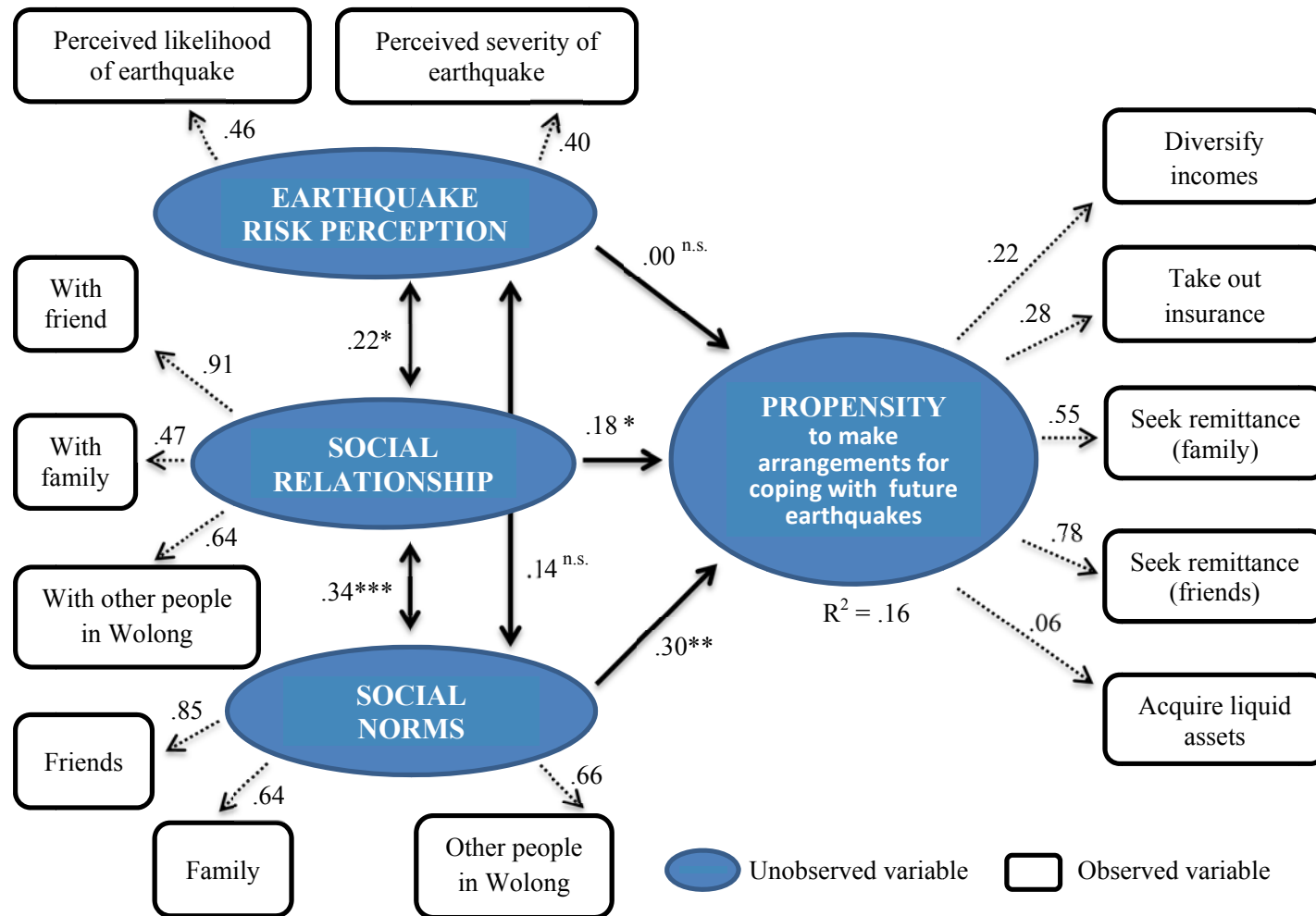


Source: Partial representation of Grothmann and Patt's (2005, p. 204) conceptual framework

**Figure 2      Location of study areas**

(see attachment)

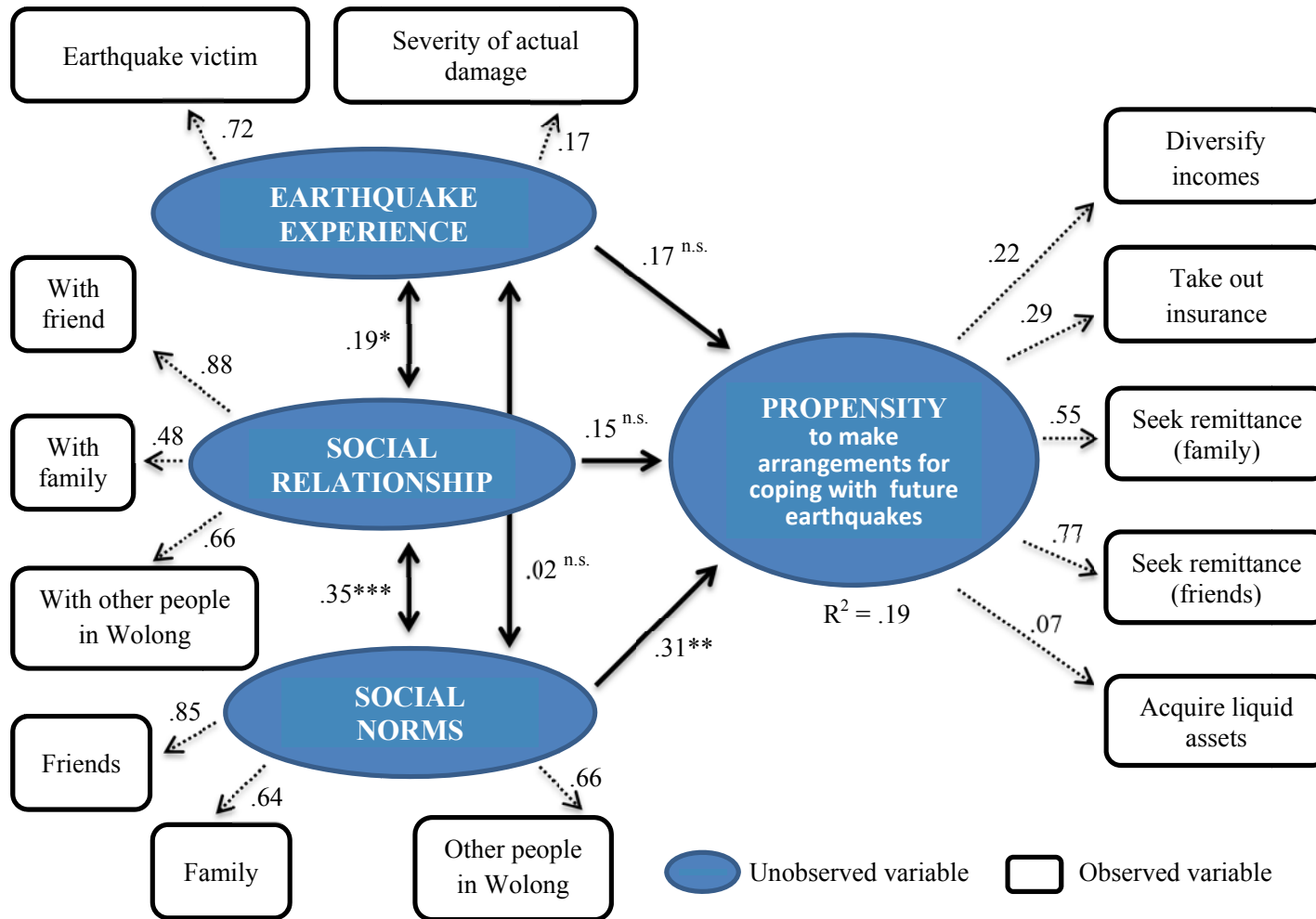
**Figure 3 Path analysis for propensity to act, perceptions of social relationship and social norms, and risk perception**



\*\*\*, \*\* and \* denote significance at .001, .01 and .05 levels respectively. n.s.: not significant at .05 level  
 All coefficients are standardised. RMSEA = 0.05, CFI = 0.91, IFI = 0.92,  $\chi^2/df = 2.04$

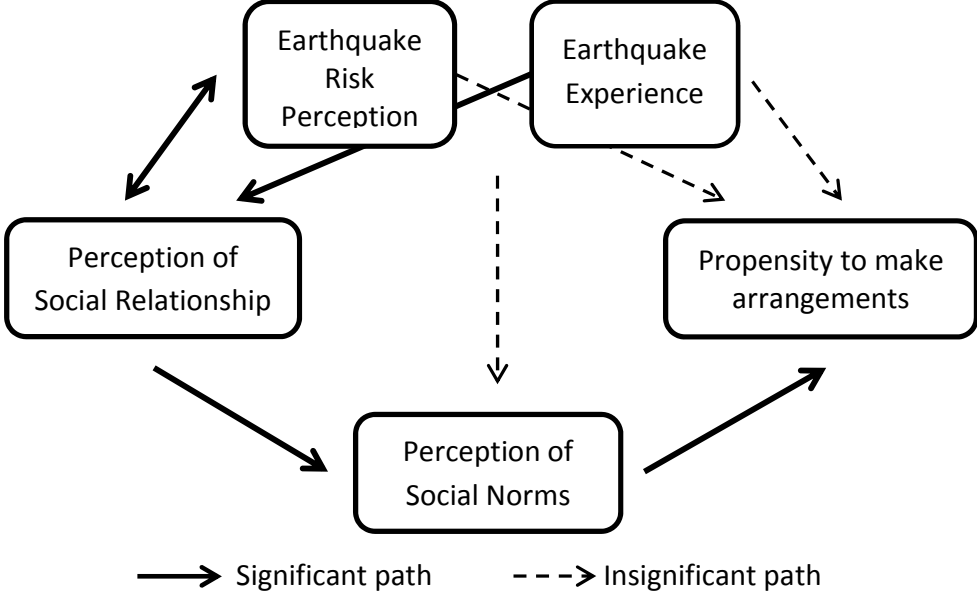


Figure 4 Path analysis for propensity to act, perceptions of social relationship and social norms, and earthquake experience



\*\*\*, \*\* and \* denote significance at .001, .01 and .05 levels respectively. n.s.: not significant at .05 level  
 All coefficients are standardised. RMSEA = 0.05, CFI = 0.92, IFI = 0.92,  $\chi^2/df = 1.98$

Figure 5 Observed relationships between model variables



**Figure 6 Old cottages in Wolong Town, China**



Source: 2015 DigitalGlobe, CNES/Astrium, Map data @ 2015 Google.

**Figure 7** A re-settlement site in Gengda Town, Sichuan, China



Source: 2015 DigitalGlobe, CNES/Astrium, Map data @ 2015 Google.

**Figure 8**      **New houses in two re-settlement sites in Wolong Town, Sichuan, China**



Source: Authors

Location: *Hejiadadi* (何家大地) (right) and *Guanlaojie* (关老街) (left)