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Integrated risk governance in the Yungui Plateau, China: The 2008 ice-snow storm disaster

Qian Ye, Ming Wang and Jiarui Han

AUTHOR’S NOTE

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1 In recent years, China has increasingly drawn great interest and attention from the international community, primarily because of its emergence as the second largest economic power on the global scale due to its rapid and steady economic growth over the past thirty years. After thirty years of fast economic development, China is now experiencing a dramatic transition period in its economy, society and environment. First, issues such as population growth, impacts of globalization and urbanization on national and regional economies, environmental degradation and corruption on various levels of governments have been widely discussed (e.g. Lin et al., 2003). Second, unbalanced social-economic development (e.g. between urban and rural locations, industry and agriculture, and east coast areas and western remote mountain areas) combined with environment and biodiversity degradation has been drawing increased attention from policy makers, domestic and international researchers, and the general public. Third, in the context of global climate change, it is expected that China as a whole, and mountain marginal areas specifically, will be affected by increases of all kinds of disaster risks (Zou, 2011) through changes to vulnerabilities as well as hazards.

2 In recent years, both the international scientific community and governments at all levels have begun to realize the challenges from significant impacts of disasters at all spatial and temporal scales, such as the Japanese tsunami in 2011 and the global financial crisis.
since 2008, on the sustainable development at both national and international levels (IRG Project Science Plan, 2011). It has been recognized that all these disasters have patterns which are extremely difficult to deal with by applying traditional or familiar risk management systems. To meet such challenges, an integrated risk governance framework has been developed in which decisions to respond to risks are made based on five phases: pre-assessment, appraisal, characterization and evaluation, management, and communication (International Risk Governance Council, 2008).

In this paper, following a brief review of the complexity of the economic, social and ecological characteristics, inherent to the landscape of Yungui Plateau, a comprehensive overview of the causes and consequences of the Southern China Ice-Snow disaster of 2008 will be provided. Afterwards, an analysis of the environmental, social, economic and political factors of this disaster is given. Discussions and suggestions on future disaster risk reduction for the Yungui Plateau are summarized based on the theoretical framework of integrated risk governance.

Marginality of the Yungui Plateau

As Mehretu et al. (2000) write, “marginality is a complex condition of disadvantage that individuals and communities may experience because of vulnerabilities which may arise from unequal or inequitable environmental, ethnic, cultural, social, political and economic factors.” In this section, the natural and social conditions of the Yungui Plateau are briefly described to better understand the root causes of unequal social and economic development in the region when compared to the east coastal region of China.

Physical geography and climate

China’s geographical landscape is generally sloping from the west to the east in a three-tier staircase: the Qinghai-Tibet Plateau (4000 meters above sea level) as the first tier, the Yungui Plateau (1000 to 2000 meters above sea level) in the southwest and other plateaus in the northeast as the second tier; and plains and hills in the east (below 1000 meters above sea level). It is in south China, mainly in the Yungui Plateau, that the most typical and diverse karst landforms are developed. Centered by Guizhou Province and covering some 600,000 square kilometers, South China’s Karst terrain is believed to be the largest single karst area in the world. With a high altitude plateau (average 2000 meters elevation) in the northwest and low-lying plains (average 100 meters elevation) in the southeast, the overall topography features a giant slope declining from northwest to southeast (Figure 1).

The climate in Yungui Plateau is in the sub-tropical climate zone and primarily divided into dry and wet seasons. Due to its high elevation and low latitude, the description of the climate is complicated on the Yungui Plateau as the temperature varies from place to place, with a large daily fluctuation and little yearly variation.
There are more than 18,000 high plant species (51.6% of China's total) and 1,836 vertebrate species (54.8% of China's total) with more than 150 rare and endangered plant species (42.6% of China's protected plants) living in the Yungui Plateau (Zhang and Ma, 2008). The forest and mountains provide habitat for over 30 rare and endangered species, including the Snow Leopard, the Yunnan Black Golden Monkey or Snub-nosed Monkey, the Red or Lesser Panda, and the Black Necked Crane, in addition to Himalayan bears, wolves, foxes, mountain sheep, and mountain goats. Out of 335 of China's priority-protected wild animals, Yunnan alone has 243 species, accounting for 72.5% of China's total, 15% of which are species endemic to Yunnan (Yang et al., 2004). Forest coverage within the Plateau is far higher than the national average (20.36%): 49.91% of Yunnan, 39.9% of Guizhou and 54.2% of Guangxi. Such an ecosystem has generated abundant biological resources and genetic resources within the region (Pu et al., 2007).

In addition to its biodiversity significance, the Yungui Plateau provides very important ecological services for four international rivers, i.e., the Yarlung Zangbo, the Yuanjiang, the Lancang (which is the upper part of the Mekong River) and the Nujiang (which is the upper part of the Salween River), which reach nearly half of the population of China and millions of other Southeast Asians.

Culture

China is a large multi-national state comprising 56 ethnic groups. Although the 55 ethnic minorities comprise only a small proportion, about 8.4%, of the overall Chinese population, they are distributed extensively throughout different regions of China. Southwest China is rich in ethnic “minority” nationalities. After a long period of
evolution and development, China has nurtured diverse cultures. The specific cultural make-up of the area includes the coexistence of many cultures, combinations of original and modern cultures, and an embedding of foreign culture within local cultural systems. There are 25 ethnic minorities in Yunnan and 17 in Guizhou. Each ethnic group has their own unique culture and cultural expressions, such as festivals, clothing, food, and art including dance and music (e.g. Donaldson, 2003).

**Economic and social development (Table 1)**

10 Yungui Plateau is in the Karst area and most of the land is mountainous terrain. Land shortage, less than 0.04 hectares per person, is one of the main dilemmas for farmers and local communities, as well as one of the driving forces of farmer migration. Local people cultivate crops intensively and usually intercrop maize with other crops, such as soybean, sweet potato, vegetables, and beans. Biodiversity loss is one of the biggest challenges in the region to ensure future food security and sustainable agricultural development (Huang, 2003). As pointed out by Li and Song (2010, p. 17), “the main constraints and threats for local livelihood and traditional knowledge are limited sources of cultivated land, unstable and unclear land rights, continuous institutional interventions on the traditional knowledge system and customary laws, and increasing commercialization and globalization.”

11 As an example, over the last decade, due to the adoption of hybrid crop varieties, hybrids bring high yield to farmers while also bringing risks for farmers’ livelihoods and local agro-biodiversity, because hybrids are less genetically diverse and hence less resilient under changing climate conditions.

Table 1. Population and economic development based on 2010 census report

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Ethnic minorities</th>
<th>Illiteracy rate</th>
<th>Urbanization level</th>
<th>GDP in billions of RMB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guizhou</td>
<td>34,746,468</td>
<td>36.11%</td>
<td>8.74%</td>
<td>28%</td>
<td>459.3 (26th in national rank)</td>
</tr>
<tr>
<td>Yunnan</td>
<td>45,966,239</td>
<td>33.43%</td>
<td>6.03%</td>
<td>30%</td>
<td>722 (24th in national rank)</td>
</tr>
<tr>
<td>China</td>
<td>1,339,724,852</td>
<td>8.49%</td>
<td>4.08%</td>
<td>50%</td>
<td>39,798.3</td>
</tr>
</tbody>
</table>

Source: National Statistics Bureau

12 In the past thirty years, the central government of China has paid great attention to the social and economic development in Yungui Plateau region in order to reduce its vulnerabilities to hazards from the environment. Efforts such as improving transportation systems include building new highway systems to help local businesses and using electric locomotives in the regional railroad systems to reduce pollution while enhancing the local transport capacity. In the next section, the 2008 ice-snow disasters in
Southern China represent an example showing how the lack of comprehensive risk management within the region could lead to more vulnerability to extreme weather events.

**The 2008 ice-snow disasters in Southern China**

From January 10 to February 2, 2008, five continuously sub-events of winter storms in the form of low-temperature sleet and snow processes hit southern China. The events have a return period range from 50 to 100 years (Shi et al., 2008). In Yungui Plateau, the multi-sub-event hazard led to an extremely serious disaster rarely seen in the history of China. The continuous low-temperature sleet and snow weather brought extreme damages to electricity and traffic facilities, resulting in heavy losses to lives and property of people, and agricultural and industrial production.

**Main features of the hazardous ice-snow events**

From January 1 to February 2, 2008, the sleet and snowfall was largely concentrated in the areas of the Yungui Plateau with a total precipitation of 50-100 mm and some places exceeding 100 mm, representing 1-2 times greater than normal climatic averages. Meanwhile, the average air temperature in the region was 1-4°C lower than average. These weather developments actually consisted of five sub-events (Table 2).

**Table 2. The five sub weather events from January 10 to February 2, 2008**

<table>
<thead>
<tr>
<th>Sub event</th>
<th>Snow and heavy snow areas</th>
<th>Sleet areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-event 1 (Jan. 10-16)</td>
<td>Central part of Shaanxi, south part of Shanxi, Henan, central and north part of Anhui, north part of Jiangsu, Hubei, Hunan and northeast part of Jiangxi</td>
<td>Central and south part of Hunan, western and south parts of Guizhou</td>
</tr>
<tr>
<td>Sub-event 2 (Jan. 18-22)</td>
<td>Eastern part of Hubei, southern part of Henan, middle &amp; northern parts of Anhui, northern part of Jiangxi, and northern part of Hunan</td>
<td>Southern part of Anhui, majority areas in Hunan, the all-around Guizhou, northern east part of Guangxi</td>
</tr>
<tr>
<td>Sub-event 3 (Jan. 25-29)</td>
<td>Snow appeared in southern part of Henan, eastern part of Hubei, Anhui, Jiangsu and northern part of Zhejiang. The depth of snow on Jan. 28 reached 20-45cm.</td>
<td>Majority areas in Jiangxi, majority areas in Guizhou, some areas in Hunan</td>
</tr>
<tr>
<td>Sub-event 4 (Jan. 31 - Feb. 2)</td>
<td>Snow appeared in middle part of Hunan, northern part of Jiangxi, southern part of Anhui, southern part of Jiangsu, and northern part of Zhejiang etc. The depth of snow in local areas on Feb. 2 reached 20 − 35cm.</td>
<td>Guizhou, Hunan, Jiangxi, Zhejiang, Yunnan etc.</td>
</tr>
</tbody>
</table>
The meteorological characteristics of note were:

Long duration: From December 1, 2007 to February 2, 2008, the continuous period of average daily temperatures below 1°C in Guizhou was the second longest, only after that of 1954-55. The number of days of average frosting period in the region, however, exceeded that of 1954-55.

Low temperature: The temperature in the Yungui Plateau broke the record low for the same period in history. Meanwhile, continuous sleet and snowfall were very intense, with low average air temperatures (2-4°C below average) and abnormal lower average values of maximum air temperature (5-10°C below average).

Heavy precipitation: The precipitation level was the third maximum of the same period in history of the Yungui Plateau. The amount of precipitation in part of Guangxi and Yunnan exceeded 100 mm. The area of snow coverage accounted for 40-90% of the total area in the region.

Thick snow deposition: The ice thickness on power/telecom cables in Guizhou province broke the meteorological record and the frosting period in 49 counties (or cities) exceeded the historical record. It was difficult to remove the deposited snow by wind or through evaporation naturally due to low wind speeds and high atmospheric humidity.

Disaster losses

Livelihoods: Food shortages with soaring prices caused people in mountainous areas to lose access to food, clothes, drinking water, candles, and other goods, as well as seeds and other integral materials for farming. The transportation problems affecting livelihoods are detailed later. This disaster showed that for people living in poverty, of which a higher percentage reside in the Yungui Plateau region, they are the most vulnerable group when hit by disasters because of not only their poor social-economic conditions and lack of disaster and vulnerability knowledge – they do not have the resources or choices to improve – but also their extremely vulnerable physical links with the outside world which affects their livelihoods (Shi et al., 2009).

Power Facilities: Approximately 35,710 power lines of the state and local grids and 2007 substations were shut down by the disaster. The operational capability of power systems for 13 provinces was interrupted. Power failure occurred in 170 cities and counties (Committee of Experts of State Disaster Relief Commission, 2008). Power failure throughout vast areas of Guizhou affected oil pipeline transportation in the southeast, threatened the market supply of gasoline in Guizhou and Yunnan, and supplies of gas used in production were restricted or even stopped in some areas.

Transportation: The disaster occurred precisely during the peak season of transportation for the Spring Festival of China. Due to power failure, the major national railway systems...
collapsed, stranding almost 1.8 million passengers in main railway stations. For the highway system in Yungui Plateau, the road foundation and side slope of some sections collapsed and various main highways in the disaster area were closed due to freezing. More than 20,000 vehicles and 10,000 passengers were trapped, some for more than 40 hours leading to casualties (Shi et al., 2009). The rain and snow weather resulted in the cancelation of 3840 flights across China and the delay of 9550 flights so that huge masses of passengers were stranded in the airports.

24 Agriculture: Crops were negatively affected by the disaster across the country. Provinces on the Yungui Plateau, Guizhou, and Yunnan, suffered most. Grapes, vegetables, mandarin oranges and other commercial crops were severely affected by the cold. Six million cattle and 62 million poultry died. Water resource facilities, irrigation and waterlog discharging canal system facilities, dikes, reservoirs, culverts, and water gates around the countryside were seriously damaged.

25 Forestry and Ecological System: The area of affected forest was more than 22 million hectares, about 7.4% of China’s total forests. Moreover, the most affected forest zones were the areas which had the best forest resources. The disaster distressed not only the local forestry business but it also greatly impeded ecological re-construction activities implemented by the central government more than ten years ago. Most of the ecological systems in secondary forests were destroyed and the ecosystems in artificial forests were completely destroyed. Wild animals also suffered extensive impacts, wherein, some threatened and endangered species of animals, for example, musk deer, in several natural forests were almost close to extinction locally.

26 Business Interruption: Hundreds of coal mines in Guizhou and Yunnan were shut down and other industrial activities interfered with. Television transmission stations and networks were damaged, resulting in transmission interruption in rural and urban areas.

Table 3. Estimate disaster losses in both Yunnan and Guizhou provinces

<table>
<thead>
<tr>
<th></th>
<th>Affected Population (millions persons)</th>
<th>Deaths</th>
<th>Affected crop area (thousands of hectares)</th>
<th>Collapsed buildings (thousands of compartments)</th>
<th>Direct economic losses (billion RMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guizhou</td>
<td>26.6</td>
<td>27</td>
<td>1489.7</td>
<td>31</td>
<td>19.8</td>
</tr>
<tr>
<td>Yunnan</td>
<td>11.4</td>
<td>22</td>
<td>590.9</td>
<td>39</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Source: Shi et al. (2009)

Causes of the disaster

27 Four main factors contributed to the disaster cause:

28 Extreme weather events combined with unique local complex topography: this disastrous weather covered nearly half of mainland China for a long duration of time with low temperatures, heavy precipitation, thick snow and frost accumulation which broke the historical record at the time. The disaster losses across the Yungui Plateau were greatly amplified by the complex topography, landscape, and multiple meteorological
phenomena. Within that context, the area’s marginalization from decision-making centers, who were not fully aware of the complexity of the topography or of the situation, also impacted the preparedness and response to the disaster. Due to the Yungui Plateau’s high elevation and high humidity, the air is usually saturated so that snow on the ground does not evaporate. Sleet lasting for days accumulates and ice rapidly forms on all infrastructures. Most power supplies and communication facilities collapse when the accumulated ice and snow is more than 10 times heavier than the design standards.

Engineering design failure combined with lack of local knowledge: across the Yungui Plateau, major power supply infrastructure and communication facilities are commonly built on high mountains. During this disaster, major blackouts occurred, affecting lifelines including railways, roads, electric power lines, communication systems, and water and gas supply systems. This directly reflects weaknesses in infrastructure in these locations, such as construction and maintenance standards of power and water supplies as well as limitations of transportation routes. In this case of engineering systems, the local knowledge on extreme weather and climate has not been considered. That reflects the marginalization in that local peoples could assist with larger-scale planning, but they are not necessarily consulted and their cultural knowledge is not necessarily taken into account.

Vulnerability of the existing ecological system due to lack of scientific knowledge in decision making processes: although the governments at all levels in China have put forth great efforts to reconstruct ecosystems which are severely being damaged by fast economic development, more attention has been paid to counting the percentage of forest coverage, which only reflects the forest quantity but not the quality and ecological values of the forests. Counting the number of trees being planted was the only index for assessing the success of reforestation. As a result, not only is forest productivity in the Yungui Plateau low, but also its hazard-resisting ability is weak due to insufficient funds for planning, managing, and maintaining efforts. Examples of hazards affecting the forests are insects, disease, invasive species, wildfire, and drought. The forest damage from this cold weather disaster also demonstrates the problems, suggesting that the disaster impacts were amplified by ecosystem vulnerability that was created artificially.

Social and economic underdevelopment: the overall disaster risk reduction capacity of the people living across the Yungui Plateau is generally limited, in terms of aspects such as awareness, vulnerability reduction, emergency self-rescue, and local community self-help. For example, in the Yungui Plateau, the speed of development and the rate of maintaining national and provincial highways lags far behind the number of vehicles increasing in the region. Few efforts are put into reducing the number of private vehicles while providing viable alternatives. The railway transportation capacity is extremely limited during the holiday season of the Chinese Spring Festival. As a result, as the scope of the disaster became clearer, local capacity was insufficient to deal with the problems and external help could not be delivered due to the clogged roads, railways, and airports. In this instance, remoteness contributed to vulnerability because remoteness was permitted to create marginalization.
Lessons learned

32 The 2008 Ice-Snow storm disaster in the Yungui Plateau helped the governments at all levels and the disaster scientific research community in China learn many valuable lessons. These lessons are being applied to improve disaster risk reduction in the area.

33 The knowledge of local stakeholders, who have information on the region’s biodiversity, in addition to scientific ecological research, must be incorporated with national and local social-economic development plans. In order to overcome mountain peoples’ economic, social, and physical vulnerability, stakeholders at national, regional, and local levels must collaborate to develop integrated and innovative solutions (Xu et al., 2005). For example, for post-disaster reconstruction of forest ecosystems, it is important not only to improve the disaster-resistant abilities of the forest ecosystem by optimizing the configuration of different kinds of trees, but also to initiate more efforts in developing the forest disaster insurance system.

34 Disaster risk reduction and emergency management mechanisms must be incorporated into the social-economic development plan, especially in regions which are extremely vulnerable to natural hazards, such as the Yungui Plateau. Before the 2008 disaster, most development plans in the region were designed and implemented with few considerations on dealing with unprecedented extreme weather events, climate and other natural hazards. For example, the collapse of power lines has been identified as the leading cause of chaos during the early stages of the 2008 Great Ice Storm Disaster (National Development and Reform Commission, 2008; Shi et al., 2008). The lack of construction standards applied when building the power infrastructure, which should be specifically designed for the region, is the major cause for the collapse.

35 Scientific understanding of forecasting and early warning systems for extreme weather must be enhanced (Glantz, 2003, 2004). During the disaster, the China Meteorological Administration issued relatively accurate forecasts in the east coast areas with better observation networks. In the Yungui Plateau, limited by the monitoring capacity and scientific knowledge, the formation mechanism and possible consequences of the weather experienced was not well understood. Moreover, the interaction between geological and climatic events was not well documented or considered in emergency planning.

36 Building local capacity in a multi-disciplinary way is necessary for mountainous regions with a large population with low social-economic status but high ecological services. Local people should be engaged in knowledge sharing and training support on their own terms so they can raise their own risk consciousness and self-help in ways that they support for themselves. It is understood that in order to cope with weather and climate extremes efficiently and effectively and with a high degree of maneuverability and coordination, building local capacity so that people can help themselves is key (Lewis, 1999; Wisner et al., 2004).

37 All these lessons exemplify the challenges of vulnerability and marginalization in isolated locations, including mountain regions such as the Yungui Plateau. They also indicate the strong possibility for using local capacity to try to overcome the challenges faced. The weather made transportation to the location very difficult. Yet the specific hazard parameters, while extreme, were still survivable without major suffering if the local people and systems were ready to deal with them and if the infrastructure, ecology, and
social systems had been built up to deal with them. Because that was not the case, a disaster happened. As such, while marginalization might be difficult to overcome, since that requires changes in external viewpoints, marginalization does not necessarily need to create vulnerability. Locals in the areas can accept the marginalization and take control of their own disaster risk reduction through integrated risk governance in order to ensure that extreme weather events do not become a disaster.

Conclusion

Like many countries in the world, China has experienced unbalanced social-economic development between two areas, in this case its east coast areas and its western remote mountain areas. Mountain regions in Southwest China, especially the Yungui Plateau, are home to some of the country’s greatest geographic and cultural diversities. The relatively low coping capacity of local governments, including inadequate disaster warning systems (social and technical), deficiencies in emergency equipment, skills, and supplies; low disaster resistance of lifeline infrastructure and systems; and inadequate risk prevention consciousness makes the Yungui Plateau highly vulnerable to natural hazards and significantly limits the region’s social-economic development.

As a centralized country, China’s top-down governance mechanism can show its efficiency and effectiveness for dealing with a large-scale disaster occurrence. Due to inherent complexities in disasters, especially at larger scales, new multi-scale, multi-actor, cross-sector measures are required to meet new challenges in order to reduce human, economic, and environmental losses. The 2008 Ice-Snow Storm Disaster provided a great learning opportunity for national and local policy and decision makers, the scientific research community, business sectors, and the general public to reevaluate the current development pathway being undertaken in this mountainous region, especially regarding reducing disaster vulnerability. One aspect is Integrated Risk Governance to ensure that environmental, social, economic and political factors are all integrated in the context of risk governance.

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ABSTRACTS

Yungui Plateau in Southwestern China is regarded as one of the major bio- and cultural diversity centers in the world because it contains a remarkable variety of ecological niches and ethnic groups. Due to its unique mountain geographic landscape and domination by a monsoon climate, it has high vulnerabilities and is frequently hit by various climatic and geological hazards such as droughts, floods, earthquakes, and landslides. In the past two decades, while the region has enjoyed rapid social and economic development, vegetation degradation, water pollution and soil loss, as well as other environmental problems, have become major concerns in the region. In January 2008, nearly half of China was hit by an unprecedented series of hazards of low temperature, persistent rain, snow, and a series of ice storms with South China suffering the most. In this paper, with a comprehensive overview of the causes and consequences of the disaster, a disaster chain in Yungui Plateau is identified and environmental, social, economic and political factors are analyzed under a framework of integrated risk governance.

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Keywords: disaster chain, diversity, integrated risk governance, Yungui Plateau

AUTHORS

QIAN YE
State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, China
qianye@yahoo.com

MING WANG
State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, China

JIARUI HAN
Center for Development Research, China Meteorological Administration, China