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Living and dying with glaciers: people's historical vulnerability to avalanches and outburst floods in Peru☆

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Abstract

Human populations worldwide are vulnerable to natural disasters. Certain conditions—such as geographical location or people's income level—can affect the degree to which natural disasters impact people's homes and livelihoods. This paper suggests that vulnerability to natural disasters increases when local people, scientists, and policymakers do not communicate and trust each other. Additionally, a breakdown in interaction and confidence among these groups can disrupt the implementation of sound science or well-intentioned policies. This case study analyzes how local people, scientists, and government officials responded to glacier hazards in Peru's Cordillera Blanca mountain range. Cordillera Blanca glacier retreat since the late-19th century has triggered some of the world's most deadly avalanches and glacial lake outburst floods. Although a Peruvian glaciology and lakes security office has "controlled" 35 Cordillera Blanca glacial lakes, 30 glacier disasters have killed nearly 30,000 people in this region since 1941. A lack of local faith in government officials and scientists as well as the State's failure to follow scientists' warnings about potential disasters have endangered or led to the death of thousands of local residents, many of which remain living in hazard zones today.

Keywords: glacier retreat; glacier hazards; local people; policy; Cordillera Blanca; Peru

1. Introduction

On March 19, 2003, surging water in the Quillcay River that flows through the Peruvian city of Huaraz frightened local residents. Twenty-five kilometers above Huaraz in the Cordillera Blanca mountain range, a landslide into glacial Lake Palcacocha had caused the lake to overflow and release water downstream. Although no damage occurred, Huaraz residents had reason to be scared: in 1941, this same lake produced an outburst flood that destroyed a third of the city and killed 5000 people. Less than a month after the 2003 flood, the United States space agency NASA announced that a fissure had opened in a glacier above Lake Palcacocha (Bhattacharya, 2003; Steitz and Buis, 2003). NASA concluded that the glacier could break apart at any point, sending a

☆ All translations from the Spanish are those of the author, unless otherwise noted. Names of personal informants have been changed or omitted.

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catastrophic avalanche toward Huaraz and its 100,000 inhabitants. Local residents (again) had historical reasons to fear: in 1962, a glacier avalanche from nearby Mt. Huascarán killed 4000 people; then in 1970, a massive earthquake killed 70,000 Peruvians and detonated another avalanche from Mt. Huascarán that killed 18,000 people.

Although Lake Palcacocha probably does not pose an imminent threat to Huaraz today (UGRH, 2003), and although many scientists have challenged the NASA report (Anonymous, 2003; Kaser and Georges, 2003), Peruvian authorities have not been able to calm local residents. While scientists and government officials asserted that there was no danger in 2003, radio stations in Huaraz urged residents to pack their valuables in small bags and sleep clothed to make a quick getaway in case of an outburst flood. As one resident said anxiously, "We were all very worried in my family—we packed suitcases with clothes and blankets" (BBC News, 2003). In late 2003 and early 2004, locals continually asked me "Is the glacier really going to crash down on us?" Others believe the government is intentionally hiding information about Lake Palcacocha and nearby glaciers. One person told me she did not trust her own government that instead "what NASA says must be the truth." Peruvian glaciologists and geologists working in Huaraz are also frustrated. The national government keeps slashing their budget, making it nearly impossible to monitor the Cordillera Blanca's ~600 glaciers and 374 glacial lakes or to maintain the region's 35 "lakes security projects" that have been completed since 1941. The situation in the Cordillera Blanca is thus problematic: thousands of people inhabit hazard zones of potential avalanches or outburst floods; local residents lack faith in the government to protect them and do not trust information from Peruvian scientists or government officials; and scientists have miniscule budgets with which to investigate new glacier-related threats, maintain existing programs, or initiate new disaster mitigation projects at glacial lakes.

Why are so many Peruvians in the Cordillera Blanca uninformed about potential glacier dangers and unwilling to listen to scientists and government officials? Why have so many people died from glacier-related disasters since the 1940s? Why do so many people remain vulnerable to these glacier disasters? Part of the answer has to do with natural processes. Global warming since the late-19th century has caused glacier retreat worldwide (Tufnell, 1984; Grove, 1987; Huybrechts and Wolde, 1999; Alley, 2000; IPCC, 2001). In Peru's Cordillera Blanca mountain range, retreating glaciers have led to the formation of precariously dammed glacial lakes as well as to the thinning and fracturing of glaciers. These new glacial lakes have generated at least 24 outburst floods that killed roughly 6000 people in the past 150 years. And the unstable glaciers have produced at least six avalanches that killed approximately 22,000 people during the 20th century (Ames Marquez and Francou, 1995; Portocarrero, 1995; Zapata Luyo, 2002). However, part of the answer also has to do with the social, economic, and political contexts that shape the ways in which societies respond to environmental change (Steinberg, 2002). Nature never acts alone in human tragedy or vulnerability to natural disasters (Maskrey, 1993; Lavell and Franco, 1996; Silva Martos, 1997; IPCC, 2001; De et al., 2004).

This study argues that a lack of trust and communication among the local, scientific, and policy communities has caused Peruvian deaths and heightened people's vulnerability to glacier disasters. Without trust in the State, local residents consistently challenged government-distributed information and protested against the State's efforts to prevent future glacier-related disasters. Without government officials' adherence to scientific data, the State failed to consider disaster warnings. And without people's confidence in the experts, residents continued to inhabit hazard zones. Thus, when governments, scientists, and local communities fail to interact and listen to each other, and when local people do not trust government information, laws, or projects that may be for their own protection, then the local population becomes more vulnerable to disaster. When cooperation among locals, scientists, and policymakers broke down in Peru, it was the local population that lived with—or died from—the outburst floods and avalanches that descended periodically from Cordillera Blanca glaciers.

Of course, Peru is not the only country confronting catastrophes caused by global climate change and glacier retreat. Global warming affects people worldwide because, among other impacts, it generally increases natural disasters such as heat waves, cold

snaps, flooding, droughts, hurricanes, increased El Niño frequency, and other extreme weather events (IPCC, 2001; De et al., 2004). Global warming also causes glacier retreat and related glacier catastrophes such as avalanches or outburst floods. Retreating glaciers may thin and fracture, thereby generating avalanches. Also, as glaciers melt and retreat uphill, they can leave precariously dammed glacial lakes where ice previously existed. These unstable lakes occasionally produce outburst floods. In the Himalayas, a growing number of outburst floods caused by glacier retreat have destroyed infrastructure and killed residents (Richardson and Reynolds, 2000b; Benn et al., 2001; Mool, 2001). In 2000, the Centre for Integrated Mountain Development inventoried thousands of Himalayan glacial lakes and found 26 "potentially dangerous" lakes in Nepal and 24 in Bhutan (in Kattelmann, 2003). As Kattelmann (2003) asserts, glacial lake outburst floods in Nepal impact local people, NGOs, the government, tourists, infrastructure, and the international community; consequently, "there is obvious urgency in addressing the problem." Canada too has experienced growing problems with glacial lake outburst floods as at least nine moraine dams have failed at glacial lakes in British Columbia since 1927 (Clague and Evans, 2000). In fact, glacial lake outburst floods endanger people worldwide (Clague and Evans, 2000).

This Peruvian case study suggests how social and political issues affect people's vulnerability to glacier and other natural disasters. Surprisingly, very few studies have analyzed how local populations adapt to climate change at the community or regional scale (Steinberg, 2000; McIntosh et al., 2000). Research indicates that climate change and natural disasters impact poor and marginalized populations disproportionately (IPCC, 2001; AfDB, 2002). Yet social scientists have devoted only limited attention to the social dimensions of climate change or, specifically, to human-glacier interactions through time (for exceptions see Le Roy Ladurie, 1971; Grove, 1988; David and Norman, 1994; Fagan, 2000; Cruikshank, 2001). Even in the Cordillera Blanca where glacier retreat has dramatically affected local human populations, natural and physical scientists—rather than social scientists—have completed most of the research (for an exception, see Oliver-Smith, 1986). Therefore, studies tend to identify direct risks of melting glaciers such as glacier disasters (Reynolds, 1993; Ames Marquez and Francou, 1995; Portocarrero, 1995; Ames, 1998; Zapata Luyo, 2002) or the reduction of water supplies (Portocarrero, 1995; Morales Arnao, 1998). As a result, an analysis of the sociopolitical consequences of glacier retreat, outburst floods, and avalanches in the Cordillera Blanca can illuminate recent Peruvian history and suggest how future societies may respond to natural disasters, glacier retreat, and climate change.

2. A note on methodology

Rather than presenting the views of academics, engineers, or government officials, this study attempts to divulge local people's own opinions and analyses of their situation below the melting glaciers in Peru's Cordillera Blanca. The historical approach allows a long-term comparative perspective that differs from analyses of single natural disasters or projections about future impacts. This study presents these comparisons and conclusions, not through an exhaustive presentation of every local perspective, but instead by noting long-term trends. Representative examples come from an investigation of diverse sources such as newspapers, correspondence, government reports, oral history, and published literature.

3. Glacier retreat and disaster mitigation: a brief overview

With 19 glaciated mountain ranges, Peru contains more than half of the world's tropical glaciers. Most of the country's glaciers are located in the Cordillera Blanca: ~600 glaciers in this range cover approximately 620 km^2, making it the most glaciated tropical mountain range in the world (Kaser and Osmaston, 2002; Georges, 2004). Like all glaciers, tropical glaciers tend to retreat when temperatures rise (or advance when temperatures fall); many other physical and climatic variables determine glacier size and behavior, but temperature is nonetheless a strong forcing mechanism (Kaser, 2001).

Since the end of the Little Ice Age in the late-19th century, Cordillera Blanca glaciers have generally been in retreat, with pronounced and more rapid retreat since the 1980s (Kaser et al., 1990; Thompson,

1995; Kaser and Georges, 1997; Ames, 1998; Morales Arnao, 1998; Kaser and Osmaston, 2002). As these glaciers retreated, lakes frequently formed where ice existed previously. The number of glacial lakes in the Cordillera Blanca has risen dramatically from 223 in 1953, when scientists completed the first glacial lake inventory (Fernández Concha and Hoempler, 1953), to 374 in 1997 (Electroperú, 1997). Unstable terminal moraines dam many of these newly formed glacial lakes. However, when avalanches or landslides crash into these lakes, the ensuing waves can rapidly erode moraine dams and trigger outburst floods.

Because of the massive scale of the 1941 Huaraz outburst flood (and continuous threats from lakes thereafter), the Peruvian government has worked for decades to prevent additional glacier-related disasters in the Cordillera Blanca. During the 1940s and early 1950s, the Peruvian government and independent scientists conducted a host of studies and aerial photography surveys that allowed completion of the first Cordillera Blanca glacial lake inventory in 1953 (Broggi, 1942; Torres Vargas, 1942; Ghiglino, 1947; Spann and Concha, 1950; Fernández Concha and Hoempler, 1953). In 1951, after an outburst flood in the Los Cedros Canyon devastated a nearly completed hydroelectric station, the Peruvian government established a permanent lakes security office, called the Control Commission for Cordillera Blanca Lakes (CCLCB).

By 1953, this office had developed an important index for determining glacial lake stability. The index classified the type of lake dam (moraine, bedrock, debris, or mixed) and the slope of the dam (steep or gradual) to determine lake stability. Of the 223 lakes identified in 1953, researchers classified 25 with steeply sloped, moraine dams—the characteristics most likely to produce outburst floods (Fernández Concha and Hoempler, 1953; Track, 1953; Fernández Concha, 1957). This classification system remains in use in Peru today and provides insights for glacial lake analyses elsewhere in the world (Clague and Evans, 2000; Richardson and Reynolds, 2000a).

In addition to lake studies, the State also conducted "lakes security projects." These projects involved, first, the lowering of lake levels to remove water and reduce pressure on moraine dams. Engineers and workers removed water with open drainage canals, drainage tunnels, or water pumps. Second, they constructed artificial dams to strengthen moraine dams and to prevent their erosion if waves caused by icefalls washed over the moraine. By 1962, the CCLCB had conducted lakes security projects at 13 lakes and had three more in progress (Pizarro, 1962b).

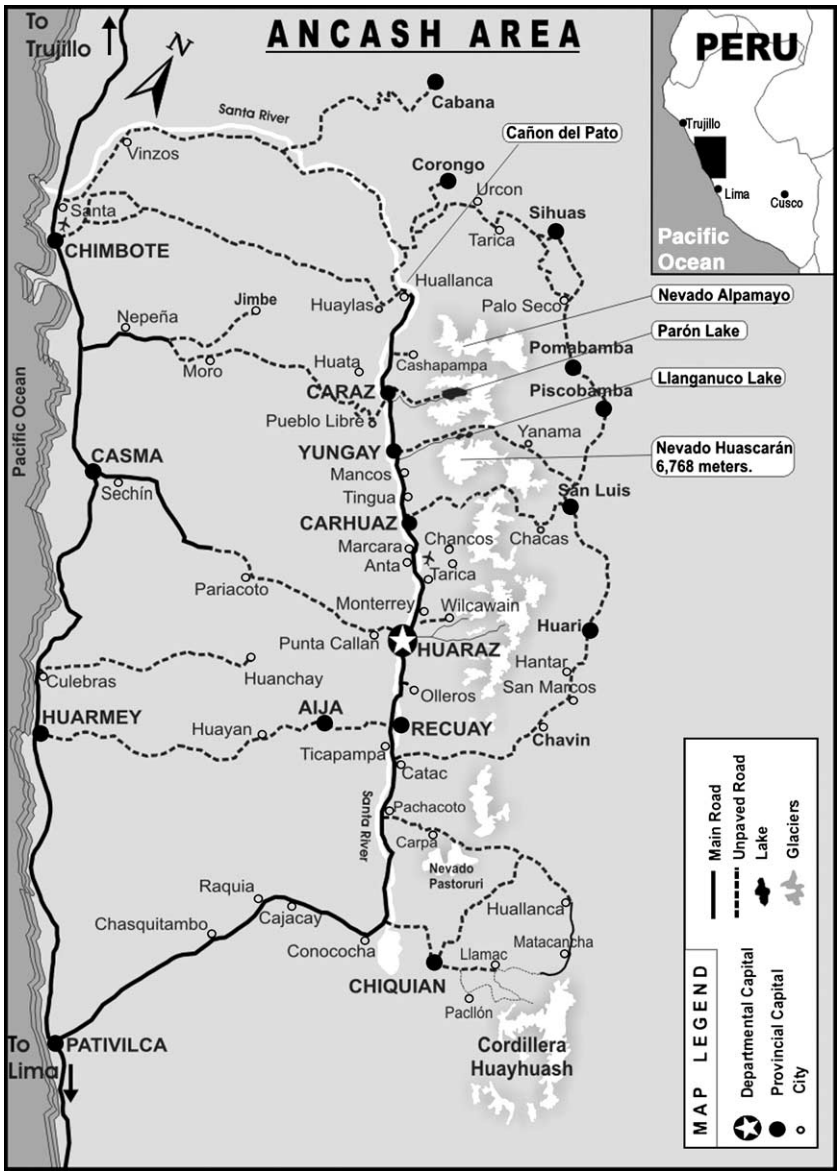
Although the State funded the CCLCB only sporadically during the 1950s and early 1960s, by the late 1960s, the Peruvian Corporation of the Santa (CPS), which ran the hydroelectric station at Cañón del Pato, devoted considerable funds toward the control of glacial lakes. In 1967, the CPS began working with French glaciologists and engineers from the Paris firm, Coyne et Bellier, to plan lakes security projects at two large and dangerous Cordillera Blanca lakes, Safuna and Parón. Then, on May 31, 1970, a 7.7 (Richter Scale) earthquake devastated the Santa River valley and Cordillera Blanca region. This catastrophe was one of the most deadly natural disasters ever in the western hemisphere, killing 70,000 people, including 18,000 in the earthquake-triggered avalanche from Mt. Huascarán. Thereafter, the Peruvian government invested heavily in disaster prevention, and the Glaciology and Lakes Security Division (formerly the CCLCB) conducted 10 lake security projects between 1970 and 1977 (Electroperú, 1984). Although this Division underwent dramatic budget cuts in the 1980s and disappeared completely in the late 1990s, by 2004, the government had completed a total of 35 lakes security projects in the Cordillera Blanca. Today, although now with a limited staff of five, the (newly renamed) Glaciology and Hydrological Resources Unit continues to monitor glaciers and glacial lakes.

Clearly, the State's glaciology and lakes security office has helped prevent outburst floods and contributed to glacial lake control worldwide. But because of the agency's historical instability, bureaucratic centralization, inadequate funding, and limited dissemination of information to the public, the lakes security office has not always soothed local fears about glacier-related disasters or boosted local confidence in the government's ability to protect people.

4. Society and history: a brief overview

A half million people live directly below Cordillera Blanca glaciers and glacial lakes. Most of these

residents live in the Santa River Valley (called the Callejón de Huaylas) on the western slope of the Cordillera Blanca; the largest towns along the Santa River are Huaraz, Carhuaz, Yungay, and Caraz (see Map 1). People also inhabit the Marañón watershed (Callejón de Conchucos) on the eastern slope above Amazonia. The population consists, in broadest terms, of rural indigenous people who speak Quechua and urban Spanish-speaking *mestizos* (of mixed Spanish-indigenous descent). Outburst floods and avalanches have affected both populations, but because indigenous people are more dispersed and, until recently, did not build population centers along riverbanks, the greatest destruction and the most deaths from glacier-related disasters have occurred among urban mestizos. The 24 outburst floods and six avalanches since the mid-1800s have caused varying degrees of damage, from killing livestock and destroying crops, to



Map 1. Department of Ancash and Cordillera Blanca, Peru. Map by Tito Olaza.

Table 1
Five most deadly 20th century glacier-related disasters in Peru's Cordillera Blanca

Date	Principal area affected	Disaster type	Number deaths
13 December 1941	Huaraz	Outburst flood	5000
17 January 1945	Chavín	Outburst flood	500
20 October 1950	Los Cedros Canyon	Outburst flood	200
10 January 1962	Ranrahirca	Avalanche	4000
31 May 1970	Yungay	Avalanche	18,000

devastating cities and killing thousands of people (Track, 1953; Fernández Concha, 1957; Lliboutry, 1977; Portocarrero, 1995; Ames, 1998; Kaser and Osmaston, 2002; Zapata Luyo, 2002). Table 1 shows the five most deadly glacier-related disasters in recent Cordillera Blanca history.

Residents of the Cordillera Blanca region have never had a favorable relationship with Peru's capital city, Lima, or its coast-oriented leadership. In fact, tension between coast and highlands extends back to 1536 when Spaniards founded Lima (on the Pacific coast) as capital of its Andean empire. Since 1821 when Peru declared independence from Spain, policy-makers in Lima have generally viewed the country's mountainous regions in generalized stereotypical fashion: the mountains, from their perspective, thwarted progress because of the inaccessible landscape and "backward" indigenous population. By the mid-20th century, little had changed in coastal elites' thinking. Inhabitants of the Andes have, in turn, felt snubbed and neglected by what they consider detrimental policies imposed by racist government officials from Lima (Mallon, 1992; Orlove, 1993; Poole, 1997).

5. Locals fail to trust government action

By the early 1940s, glacial lake outburst floods presented explicit and well-known dangers to residents of the region. Given the remoteness of the glacial lakes and the technical knowledge needed to analyze geological and geomorphologic conditions, most residents knew little about specific lake dangers. Local people therefore turned to the State and professional scientists to understand which lakes posed threats. Their demands—and fears—should not be surprising: between 1941 and 1950, three massive glacial lake outburst floods destroyed a handful of cities, devastated the nearly constructed hydroelectric station at Cañón del Pato, and killed roughly 6000 people in the region.

Even before the deadly outburst flood devastated Huaraz on December 13, 1941, local people wanted the government to eliminate potential threats from Cordillera Blanca lakes (Espejo Luna, 1941; Anonymous, 1941; Moreyra, 1941). The pleas for government action heightened exponentially after the Huaraz disaster in December 1941. Several scientists and engineers analyzed the glacial lakes above Huaraz in late 1941 and early 1942. But locals wanted more (Salazar, 1942). By July 1942, the national government representative in Huaraz, Prefect Lorenzo Sousa Iglesias (1942), expressed to Peruvian President Prado "the alarm that exists in this city as a result of rising water levels in lakes above Huaraz."

Local frustration continued through 1943 when the State practically abandoned its purported commitment to investigate and drain dangerous lakes and instead built retaining walls along the Quillcay River in Huaraz. Many Huaraz residents complained that the retaining walls were ineffective. Instead of a "flimsy wall," they wanted the lakes drained in order to prevent an outburst flood at the source, not to contain it once unleashed. Ironically, a government disaster mitigation project at Lake Cuchillacocha was responsible for destroying the retaining walls in November 1943. When engineers at the lake opened a floodgate to lower the water level and reduce the threat of an outburst flood, the influx of water into Huaraz demolished the retaining walls—as well as locals' confidence in government programs (Anonymous, 1943; Ochoa, 1943).

On January 17, 1945, another glacial lake outburst flood from the Cordillera Blanca destroyed the town of Chavín de Huantar, buried the ancient ruins of the Chavín culture (800–300 B.C.), and killed roughly 500 people. Local fear of disaster and disgust with the State's progress in lake drainage caused widespread indignation (Anonymous, 1945a,c). Although the Water Division of the Ministry of Foment and Public Works had conducted studies and partially drained a handful of glacial lakes during the 1940s, many local residents continued to insist on more government

action. As one resident wrote, "We do not want any more study commissions that do their studies and disappear within 24 hours, offering their studies that only lie dormant, unknown to the anxious public" (Anonymous, 1945d). Capturing the mood of people throughout the region, another exasperated resident complained:

This Huaraz population is living through hours of true distress; there is a general neurosis, a panic in every sector that is impossible to hide given the fear of another catastrophe for the people of Huaraz. This terrible threat continues today because the government has not carried out the planned projects to drain the lakes of the Cordillera Blanca.... Not only this city suffers from such a situation of uncontainable nerves, but rather all the cities found throughout the Callejón de Huaylas wait for the government to make effective its offer to drain the lakes (Anonymous, 1945b).

Part of the reason the government did not drain lakes immediately was because it wanted to utilize glacial lake water to generate hydroelectricity and irrigate crops. Prior to draining lakes for security and losing the water, scientists and engineers first wanted to study and understand Cordillera Blanca hydrology. By using glacial lakes as "natural reservoirs," these bodies of water could regulate water flow in the Santa River, which provides water for the Cañón del Pato hydroelectricity station and large-scale irrigation projects on Peru's coast (Broggi, 1942; Ghiglino, 1947). Unlike many scientists and government officials, local people generally did not see this broader importance of Cordillera Blanca water. They prioritized their own safety over hydroelectric and irrigation projects on the coast.

6. Locals fail to trust government information

For decades after the 1941 Huaraz disaster, local residents remained scared of glacial lakes and frustrated with the government for providing little or contradictory information. During the 1940s and 1950s, people demanded specific details about "the lakes that threaten the population" (Anonymous, 1945a,c). They also requested "a definitive report about the lake situation... demonstrating the impossibility or possibility of future catastrophes" (Anonymous, 1955). In July 1970, perplexed Huaraz residents hired three mountaineering guides to visit lakes, take photographs, and report about the state of six glacial lakes above the city (Anonymous, 1970a). The following year, Huaraz residents formed a group called the Front In Defense of Towns of the Callejón de Huaylas Against Dangers from Outburst Floods, which held public roundtable sessions with the newspaper *El Diario de Huaraz* to discuss lake conditions and ongoing lakes security projects (Anonymous, 1971b). Also, in 1971, approximately 200 Huaraz residents visited lakes above the city. Trudging more than 25 km and climbing 1500 m in elevation, they sought to "verify [the lakes'] true level of danger" and to "look for proof about how the State had invested funds" in disaster prevention projects (Anonymous, 1971a).

Contradictory information also confused many people such as Caraz residents wondering anxiously about the state of Lake Parón. Thirty kilometers above the town of Caraz, Parón is the largest Cordillera Blanca lake. In the 1940s, Lake Parón was nearly 4 km long and a half kilometer wide; it contained approximately 80 million cubic meters of water—10 times the quantity of water that destroyed Huaraz in the 1941 outburst flood. As early as 1942, Caraz residents learned that the lake could produce a gigantic outburst flood if its moraine dam failed (Lucar, 1942). Yet the State did not conduct a lakes security project at Lake Parón during the 1940s. Because scientists continued to note the lake's precarious condition, Caraz residents remained fearful (Ghiglino, 1947; Ghiglino and Stein, 1948).

Worse, in 1951, two glacial lake outburst floods from Lake Artesoncocha drained entirely into Lake Parón. Parón absorbed these floods, but the added water rose the lake level to within centimeters of its brim and heightened pressure on its moraine dam. In July 1951, after the first of these Artesoncocha outburst floods, scientists Luis Ghiglino and Hans Spann claimed that Lake Parón offered serious threats, not only for Caraz, but also for the entire riparian zone to the Pacific Ocean. They recommended several measures, including the immediate installation of a telegraph line from Lake Parón to Caraz to warn residents if an outburst flood occurred; the construc-

tion of a road from Caraz to Lake Parón in order to move workers and equipment to the lake; and the immediate lowering of Parón's water level (Ghiglino and Spann, 1951).

A few months following this report, the director of the CCLCB, J. Elias Torres, announced publicly that "there is no danger of a possible outburst flood" from Lake Parón (Anonymous, 1952a). At this point, confused Caraz residents decided they needed to see for themselves if Lake Parón threatened them. In early February 1952, at the height of the rainy season, 300 Caraz residents and local authorities trekked 30 km to the lake. Climbing nearly 2000 m in elevation, the group had to fight through dense vegetation, boulder fields, and landslide debris to navigate the steep, narrow canyon. First, they wanted to confirm whether the lake posed a danger because they doubted the veracity of the recent CCLCB announcement, which contradicted other scientific conclusions. Second, they performed their own disaster mitigation project. They carried a statue of the venerated patron saint of Caraz, the Virgin of Chiquiaquirá. They left the statue on the lake shore to calm Parón in the same way that "Christ calmed the sea at the request of his disciples" (Anonymous, 1952b). While scientists (then and now) may doubt the Virgin's power to prevent an outburst flood, the action by so many inhabitants of Caraz demonstrates their desire to acquire accurate information and control Lake Parón.

The State also furnished ambiguous information during subsequent decades. During the first months after the May 31, 1970 earthquake and avalanche, the Glaciology and Lakes Security Division (formerly the CCLCB) announced publicly that lakes offered no imminent threats to residents surrounding the Cordillera Blanca (Anonymous, 1970b). At the same time, though, this Division hurriedly lowered the water level in upper Lake Llanganuco, which had filled steadily and dangerously after a May 31 avalanche blocked the lake's outlet. Over the following 7 years, the Glaciology and Lakes Security Division conducted 10 lake security projects at glacial lakes (Electroperú, 1984). The government undertook these projects because officials knew that glacial lakes posed serious dangers and that the 1970 earthquake had both damaged existing lakes security projects and altered geomorphologic conditions at many lakes (Ojeda, 1973). Thus, while the Glaciology and Lakes Security Division concluded in its internal reports—used to secure State funding—that glacial lakes threatened people, towns, and infrastructure, the Division told the public that danger was not imminent. Not surprisingly, local residents became confused in 1974 when the Division announced that the completion of a disaster mitigation project at Lake Palcacocha "signified the culmination of a project of such importance for the tranquility of Huaraz, that they have now eliminated a serious threat of an outburst flood from this lake, which was seriously affected by the May 1970 earthquake" (Anonymous, 1974).

Of course, scientists' opinions are never uniform, and State officials needed to calm survivors of the 1970 earthquake. Throughout the 1970s, the director of the Glaciology and Lakes Security Division, Benjamín Morales, sought to restore stability in the region. Lakes security projects coupled with a confident discourse about the region's security assuaged some fears. Nevertheless, to an anxious public all-too-familiar with the outburst floods and avalanches that devastated the region every few years, State claims about "no imminent danger" also confounded people.

7. Authorities fail to trust scientists

Beyond the breakdown of trust between locals and the State, government officials also failed to trust scientists who warned about a potential avalanche in the Cordillera Blanca. After the January 10, 1962 glacier avalanche from Mt. Huascarán killed 4000 people and buried the town of Ranrahirca, scientists David Bernays and Charles Sawyer from the Massachusetts Institute of Technology (MIT) spent 3 weeks on Huascarán to investigate glaciological and geological conditions. On September 27, 1962, the scientists announced their findings in *El Expreso*, a local newspaper. The upper mountain, they reported, contained badly fissured and weakened rock as well as glacial ice that could potentially crumble. They warned that, at any moment, an avalanche could occur two or three times larger than that of Ranrahirca, thereby endangering towns like Yungay and Mancos (Anonymous, 1962; Pajuelo Prieto, 2002).

A flurry of newspaper articles and town meetings followed the announcement, and the director of the

CCLCB, Miguel Elías Pizarro (1962a), declared the MIT scientists' statements to be outlandish, hurried, and uninformed. As he wrote in *El Departamento*, the principal newspaper of the region, "This office deplores one more time the dissemination of this false information without first obtaining proof from worthy or credible sources, thereby creating, for no reason whatsoever, unrest and intranquility for the populations that are not threatened" (Pizarro, 1962a). Just prior to Pizarro's announcement, which was not apparently based on scientific analysis, authorities in Yungay issued a warning for people spreading the MIT scientists' findings. "Return to your homes with your faith placed in God," the official statement read. It continued: anyone who speaks in favor of the scientists' conclusions will be charged under the Penal Code for "disrupting public tranquility" (Plaza, 1962). Ironically, and sadly, the 1970 earthquake triggered a massive avalanche from Glacier 511, just as Bernays and Sawyer had predicted. The avalanche erased Yungay from the map and left 18,000 people dead.

If the government had heeded the warning from Bernays and Sawyer or if the CCLCB had followed with scientific studies of Huascarán and Glacier 511, tragedy may have been averted. Instead, Peruvian authorities dismissed the scientists' findings as "alarmist." While burying the issue may have soothed public anxiety in late 1962, in the long run, the oversight and neglect of scientific results by Peruvian officials is tragic. As Lamberto Guzmán Tapia, a survivor of the 1970 avalanche, recently lamented, "the disaster was predicted, but the warning was not taken into account. Since they predicted it, thousands of lives could have been saved, and Yungay would not have disappeared" (Pajuelo Prieto, 2002).

8. Locals fail to trust Experts

Although people often complained about the nonexistent or contradictory government-distributed information, locals sometimes rejected or ignored the safety measures the State did enact. When engineers and planners tried to resettle inhabitants outside potential hazard zones, for example, many people protested angrily, calling it "State intervention" instead of disaster mitigation or safety precautions. Following the 1941 Huaraz disaster, some property owners despised the building codes that prohibited them from reconstructing their houses and businesses in the floodplain (Anonymous, 1951a,b). Their complaints may indicate short-term memory or reveal their disregard for safe planning. On the other hand, their annoyance is perhaps understandable because the State restricted access to their own property without compensating them for losses.

Similar discontent emerged following the 1970 earthquake and avalanche. When President Juan Velasco created the Reconstruction and Rehabilitation Commission of the Affected Zone (CRYRZA) to oversee all aspects of aid and reconstruction, people around the Cordillera Blanca protested that the true villain was not the avalanche or earthquake, but rather CRYRZA. Because Lima bureaucrats and military officials controlled CRYRZA, many locals complained about centralization. As one resident grumbled, technicians from Lima lacked "profound knowledge of the region, love for it, or the will for service" (Anonymous, 1970c).

In particular, survivors resented government attempts to relocate cities in safe areas or to restrict building in hazard zones. The reconstruction of Yungay, for example, involved building a new community. Engineers designated a new market area that would be out of danger from future avalanches and outburst floods. But survivors had already constructed some lean-tos and straw huts in the proposed market area. After the engineer explained to these survivors that the government would assign them new plots of land, higher up and out of danger, a woman piped back: "The avalanche has taken my home and family and now the engineer wants to take my place from me again." Ultimately, the people moved because engineers leveled their makeshift homes with bulldozers and earthmovers. Eyewitness anthropologist Oliver-Smith (1986) observed that "The little shacks had represented a beginning, a new start after the horror of the avalanche. The sight of similar destruction, this time at the hands of man, was still another blow."

Clearly then, just as government officials sometimes appeared contradictory, so too did locals. Local perspectives emerged from different experiences than those of the engineers, planners, and scientists.

Residents surrounding the Cordillera Blanca had witnessed many disasters, lost friends and family, been dispossessed from their homelands, and felt pressure to relocate from unknown "experts." Most people's unwillingness to relocate outside of hazard zones was not based not on a whimsical rejection of scientific evidence; rather, it stemmed from the deeply rooted historical resentment of nonlocal experts and officials, especially those from Lima (like the directors of CRYRZA).

At root was the issue of trust. Residents of this region had heard what was "best" for their livelihoods for centuries; yet they remained in extreme poverty and condemned within Peruvian society simply because of their geographical location, their customs, or the color of their skin. Why all of a sudden in the 1940s or 1970s, even if outburst floods and avalanches had occurred, would local people decide to take Lima experts' advice when it had not apparently ever worked in the past?

9. Conclusions

Peruvians have experienced direct and far-reaching impacts of global climate change, glacier retreat, and the ensuing outburst floods and avalanches. In addition to widespread destruction and nearly 30,000 deaths, local society has undergone a series of other less-visible transformations. The objective of this study is not to determine whose assertions, beliefs, and actions were "correct." To be sure, the State did eliminate many threats from glacial lakes in the Cordillera Blanca. In fact, no major outburst floods or avalanches have occurred since 1970, despite continued glacier retreat and lake formation. And some local people did, in fact, appreciate the lakes security projects, which made them safer, provided jobs, and boosted tourism through the construction of roads and trails to remote parts of the Cordillera Blanca. Yet, in most cases, the government could have taken action more promptly to prevent outburst floods. A more stable, well-funded glaciology and lake security program would have made the region safer. Inclusion of locals in decision-making processes could have empowered locals and informed them of potential risks. And the distribution of accurate, detailed information may have calmed locals and built faith in the national government.

The State's failure to achieve these measures has as much to do with shortsighted or uninformed policymakers as with Peru being a developing nation. An unstable economy, debt, changing governments, dictatorships, and a decade of violence and war against the Shining Path meant that State agencies emerged and evaporated quickly, sometimes within months. Those that remained never had consistent budgets. Additionally, 500 years of Peruvian history, the marginalized socioeconomic position of residents living around the Cordillera Blanca, and locals' deep-rooted distrust of national government officials could not be completely overcome by any glaciology and lakes security office—no matter how large its annual budget was.

This case study from the Peruvian Andes is important not only because melting glaciers and dangerous glacial lakes threaten people worldwide but also because this case forecasts how future climate change may disproportionately—and even brutally—impact local societies confronting sea level rise, heat waves, flooding, droughts, hurricanes, water shortages, increased El Niño frequency, and other predicted consequences of global warming. To smooth the process by which populations adapt to climate change, researchers and government officials should take care to build solid relations with local communities. Just as local people can learn from scientists and policymakers, so too can scientists learn from locals. Increased trust and sharing may make science and policy more effective, while inclusion of locals in decision-making may minimize local rejection of beneficial projects and ideas. These guidelines apply worldwide, although Peru's socio-historical context is unique.

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