DISASTERS, DEVELOPMENT, AND GLACIAL LAKE CONTROL IN TWENTIETH-CENTURY PERU*

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Abstract: During the past 65 years, glacier melting in Peru's Cordillera Blanca mountain range has caused some of the world's most deadly glacial lake outburst floods and glacier avalanches. Since the onset of these catastrophes in 1941, various groups have understood glacier hazards in distinct ways. Scientists and engineers saw them as technical problems. Economic developers and government officials believed glacier hazards threatened vital hydroelectric, irrigation, and tourism projects. And local residents feared glaciers and glacial lakes, though they ranked natural disasters among other social, political, and economic risks. Despite these marked differences in defining glacier hazards, local residents, authorities, developers, and scientific experts generally sought the same solution to Cordillera Blanca glacier disasters: draining glacial lakes to avoid outburst floods. Thus, risk perception varied, but each group proposed similar strategies to prevent glacier disasters. This chapter also suggests that development interests can help reduce the risk of natural disasters for local people and that local, marginalized populations can influence their degree of vulnerability to natural disasters.

Keywords: glacier retreat, natural disasters, history, risk, Cordillera Blanca

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1. INTRODUCTION

During the past 65 years, glacier melting in Peru's Cordillera Blanca mountain range has caused some of the world's most deadly glacier disasters. In 1941, a glacial lake outburst flood claimed 5,000 lives and demolished a third of the Ancash Department capital city of Huaraz. A 1945 outburst flood in Chavín killed approximately 500 people, devastated much of the town, and destroyed ruins and artifacts from one of Peru's oldest organized societies. In 1950, the Los Cedros outburst flood left 200 people dead and destroyed the nearly completed Cañón del Pato hydroelectric station. Beyond the floods, glacier retreat also triggered deadly avalanches in 1962 (4,000 deaths in Ranrahirca) and 1970 (15,000 deaths in Yungay). No society in the world has experienced such devastation as a result of melting glaciers (Carey 2005).

Since the onset of these catastrophes in 1941, various groups have understood glacier hazards in distinct ways. First, experts (scientists and engineers) saw a technical problem that required scientific studies, glacier monitoring, and engineering projects that used technology to contain unstable glacial lakes. Second, economic developers and government officials believed disaster mitigation was necessary to protect vital infrastructure; but they also recognized that disaster mitigation programs created an opportunity to bolster modernizing projects in hydroelectricity, irrigation, and tourism. Third, local residents' fear of additional catastrophes—and their concerns with a series of additional risks only tangenttially related to natural disasters—led them to demand immediate draining of dangerous Cordillera Blanca glacial lakes.

Scholars have recognized discrepancies among groups in both perceiving risks and proposing solutions to natural hazards (see Dacey, this volume). These differences have become increasingly clear in recent years as analysts now understand that natural disasters often result from social factors that force marginalized segments of the population into those areas or situations most vulnerable to natural disasters (Cannon 1994; Hewitt 1997; Oliver-Smith and Hoffman 1999; Wisner et al. 2004). To understand these distinct forces influencing vulnerability, researchers often divide local and expert perceptions of risk into two paradigms (Maskrey 1994). On the one hand, experts comprehend natural hazards through a single focus on an environmental problem—a view that generally neglects the social dimensions of natural disaster. On the other hand, local people face a host of risks, and they rank potential natural disasters far below other, more immediate risks to their survival. Not simply differences, these variations in risk perception are embedded in power structures whereby dominant social groups, governments, developers, and experts exert significantly greater power over most marginalized, vulnerable populations (Davis 1998; Steinberg 2000). Nevertheless, while recognizing that poor, marginalized people do suffer disproportionately from natural disasters, this view can both victimize local residents and assume that local people's demands for disaster mitigation differ from those of experts, authorities, and developers. However, by recognizing the historical agency of vulnerable populations and understanding their perceptions and demands, this tendency to victimize vulnerable populations can be avoided.

This essay suggests that while distinct groups may perceive risk differently, they can agree about the solutions to natural hazards. Local residents living beneath unstable Cordillera Blanca glacial lakes faced a host of risks that transcended the threat of natural disaster. Yet the most vulnerable population—the urban and wealthiest people in the Cordillera Blanca region—believed that the best way to protect themselves was to drain glacial lakes. They thus chose a scientific-engineering solution that failed to account for their vulnerability to natural disasters (their habitation of flood zones). Despite different understandings and worldviews, the experts, developers, policymakers, and local residents thus agreed that the best strategy for disaster mitigation was the draining and damming of Cordillera Blanca glacial lakes.

2. THE ONSET OF GLACIAL LAKE DISASTERS

The Cordillera Blanca mountain range runs approximately 180 km north-south through the Department of Ancash (see Figure 1). Approximately 600 glaciers cover the range and account for about one quarter of the world's tropical glaciers (Georges 2004). Large valleys—called the Callejón de Huaylas along the west side and the Callejón de Conchucos to the east—run parallel to the Cordillera Blanca. Varying between 2,000 and 3,500 m above sea level, these two valleys are densely populated with nearly a half million people; the majority inhabit the Callejón de Huaylas. The largest towns in the Callejón de Huaylas—such as Huaraz, Carhuaz, Yungay, and Caraz—cling to the banks of the Santa River, which flows through the bottom of the valley. The river descends from above 4,000 m to the Pacific Ocean, carrying 70 percent of Cordillera Blanca runoff through the Callejón de Huaylas and then through the steep, narrow gorge at Cañón del Pato, where a 260 megawatt hydroelectric station exists today.

People living around the Cordillera Blanca—like Peruvians throughout the country—have historically divided their society into geo-racial binaries

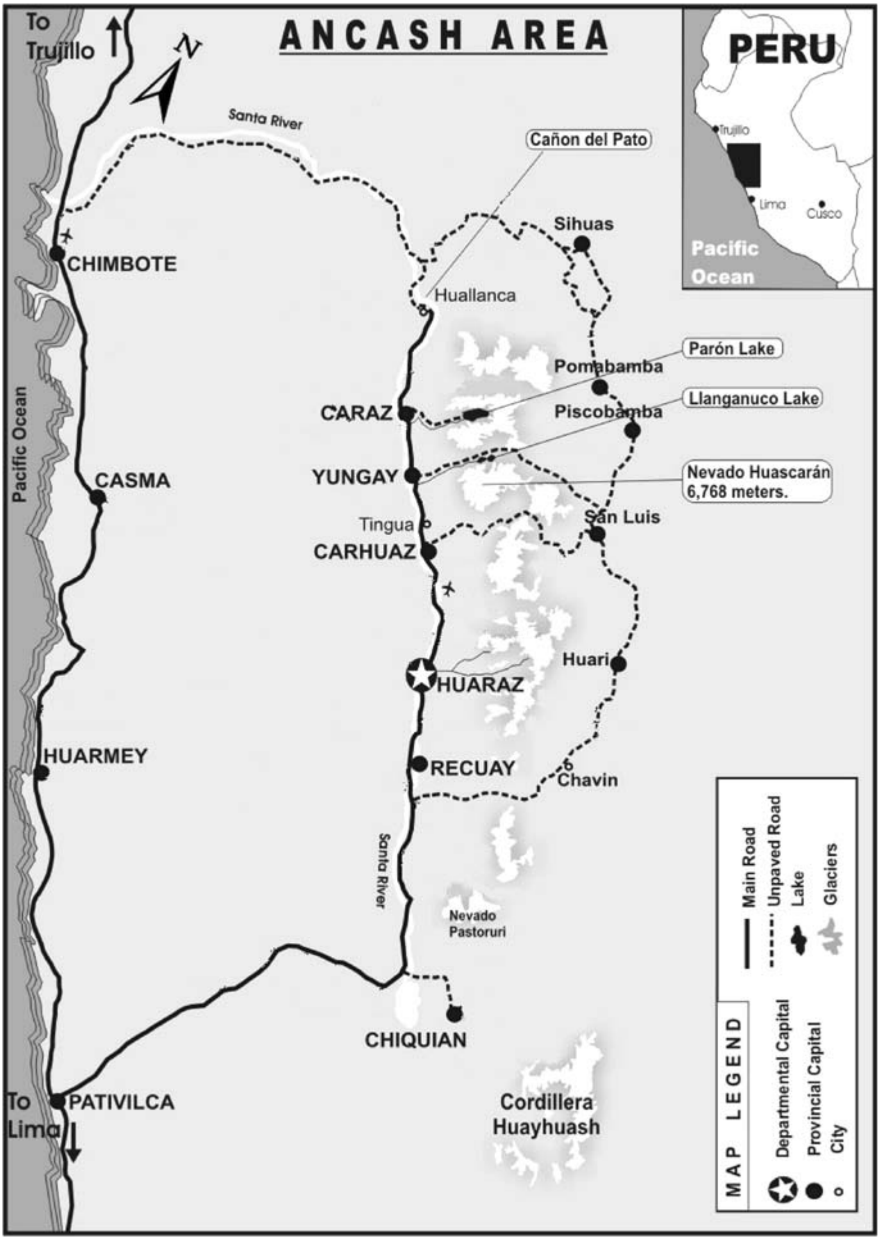

Figure 1: Ancash Area and Location in Peru (map drawn by Tito Olaza).

that separated indigenous people from *mestizos* (of mixed Spanish-indigenous descent). Although literacy, education, language, and dress have always distinguished these groups, most Peruvians have since the nineteenth century equated indigenous people with rural and highland areas; on the other hand, they associated mestizos with urban and lowland areas. Peruvians have generally identified a third group, called *cholos*, of indigenous people who exhibit mestizo customs and behavior, such as formal education or residence in urban areas (Mangin 1955; Stein 1974; Oliver-Smith 1977). A continuum has thus existed in Peru: moving inland from the coast to the highland Andes, society becomes more rural and thus more indigenous, regardless of phenotype (Orlove 1993).

Within the highland Andes, people also maintain that populations on valley floors are more urban and mestizo than those inhabiting upland slopes. As one Callejón de Huaylas resident explained in the early 1950s, local urban residents believed that the "indigenous race" lives in "rural hamlets, ranches, and high-elevation plains (*punas*); mestizos, on the other hand, generally inhabit district capitals and the occasional hamlet of importance" (Carrillo Ramírez 1953). More than just racial divisions, the mestizo-indigenous distinction also characterized significant power divisions: lowland urban residents based their domination of highland rural populations on the racial hierarchy that gave mestizos higher social status than indigenous people.

Yet, strong as these geo-racial binaries were in people's minds, they always remained fictional in reality. Centuries of miscegenation, increased rural-to-urban migration during the twentieth century, constant movement of labor and commerce, and fluid connections between highland and lowland, between town and country, and even between indigenous and mestizo reveal the imprecision of these culturally constructed racial categories (de la Cadena 2000; Larson 2004). Nevertheless, the terms remain useful for describing the twentieth-century Callejón de Huaylas because they represent the ways in which the historical actors themselves viewed their world.

In the mountains above these human populations, Cordillera Blanca glaciers have been melting since the late nineteenth century (Kaser and Osmaston 2002; Georges 2004). Glacier retreat became deadly because, as glaciers melted, glacial lakes formed on top of glacial ice or immediately below glaciers. The dynamic process of glacier retreat in the Cordillera Blanca has led to a massive increase in the number of these glacial lakes: from 223 in 1950, to 314 in 1983, to 374 in 1997 (Fernández Concha and Hoempler 1953; Zamora Cobos 1983; Electroperu 1997). In many cases, terminal moraines dammed these swelling lakes. Heightened pressure on unstable moraine dams or wave action caused by icefalls into the lake could cause dams to rupture, thereby producing a glacial lake outburst flood (GLOF). As lakes discharged in a GLOF event, often in a matter of minutes, the water mixed with rock, soil, glacial ice, and other debris to produce slow moving but powerful outburst floods with a consistency of wet cement (Trask 1953; Fernández Concha 1957; Lliboutry et al. 1977).

On the morning of December 13, 1941, residents of the Ancash Department capital city of Huaraz awoke to one of these outburst floods descending violently from the Cordillera Blanca. The flood's thunderous howl sent the city's inhabitants running from their beds into the street. Moments later, a wall of water, mud, glacial ice, and rocks slammed into Huaraz, fanning out across one third of the city while overtaking bridges, houses, schools, hotels, streets, and families. Some residents managed to escape or avoid the outburst flood. Others, however, could not escape, like Olguita Ríos who stood confused at her second-story window when the flooding mass engulfed her, or Zoila Gonzáles de Huertas, who sprinted into her house from the street to rescue her children just when the flood swamped them (Zegarra 1941; Anonymous 1941b; Coral Miranda 1962). Eyewitness Reynoldo Coral Miranda (1962) later described that terrifying morning: "On December 13, 1941, the blinding force of nature unleashed its power, making the mountains shake; the avalanche came, killing and swallowing, destroying and demolishing everything in its path. It cut short the lives of thousands of innocent people who just happened to live or be located in this picturesque and beautiful land. [The flood] converted the city and its precious lands into a heaping pile of inert material." The flood destroyed approximately one-third of Huaraz and killed an estimated 5,000 people.

The 1941 Huaraz outburst flood originated from Lake Palcacocha, also known as Lake Cojup because it lies at the head of the Cojup Canyon. Palcacocha burst when an icefall from the retreating glacier above the lake crashed into the lake and triggered giant waves, which quickly eroded and ruptured the moraine dam. The quantity of flood water increased again when it flowed into Lake Jircacocha farther down Cojup Canyon and caused that lake to burst as well. By the time it reached Huaraz, 23 km below Lake Palcacocha, the flood contained 8 million m^3 of water and debris (Anonymous 1941a; Giesecke and Lowther 1941; Zegarra 1941). Not the world's largest outburst flood by volume, the 1941 Huaraz flood was nonetheless one of the most deadly (Carey 2004).

The Huaraz flood was neither the first nor the last Cordillera Blanca outburst flood (Ames Marquez and Francou 1995; Zapata Luyo 2002).

Several other glacial lakes had ruptured since the end of the Little Ice Age, though none caused major destruction or loss of life. In 1945, an outburst flood on the eastern slope of the Cordillera Blanca razed part of the town of Chavín, killed 500 people, and destroyed irreplaceable pre-Columbian indigenous artifacts at one of Peru's most important archeological sites (Trask 1953; Tello 1960). A 1950 GLOF in the Los Cedros Valley killed approximately 200 people and destroyed nearly a decade of construction progress at the Cañón del Pato hydroelectric station (Ghiglino 1950; Spann and Concha 1950; Trask 1953). Cordillera Blanca glacial lakes remain precarious today. A small outburst flood from glacial Lake Safuna destroyed agricultural lands, damaged roads and bridges, and killed livestock in 2002, while Lake Palcacocha (source of the 1941 flood) produced a mini-outburst flood in 2003 that partially destroyed one of the lake's security dams.

In addition to numerous GLOFs during the 1900s, Cordillera Blanca residents also experienced two catastrophic glacier avalanches (Zapata Luyo 2002). In 1962, Glacier 511 on the north peak of Mt. Huascarán (6,768 m—Peru's tallest mountain) unleashed a glacier slide that killed 4,000 people and buried the town of Ranrahirca. The same glacier triggered another avalanche in 1970—the most deadly in world history—that destroyed several towns and killed an estimated 15,000 people. Both of these glacier slides resulted from glacier retreat: the ice had thinned and fractured after decades of melting.

While glacier disasters triggered the most deadly natural disasters in Peru's Cordillera Blanca, GLOFs were neither a new phenomenon nor specific to the Peruvian Andes. In fact, Pleistocene glacial lake ruptures generated some of the largest floods known (Rudoy 2002; Snorrason et al. 2002; Clarke et al. 2003). During the Little Ice Age (~1350–1850), glacial lake outburst floods caused significant destruction and death in the European Alps (Le Roy Ladurie 1971; Grove 1987; Grove 1988; Fagan 2000). And in recent decades, glacier retreat in the Himalayas has led to the formation of precarious glacial lakes that have triggered nearly a dozen outburst floods since 1935 (Kattelmann 2003; Richardson and Reynolds 2000b; Mool 2001; Richardson and Reynolds 2000a). A recent inventory of 4,989 glacial lakes in Nepal and Bhutan revealed 26 potentially dangerous lakes in Nepal and 24 in Bhutan. Efforts are now underway to lower glacial lake water levels to protect inhabitants from outburst floods. The history of glacial lake control in Peru offers important considerations for those concerned with GLOFs in the Himalayas and elsewhere (Clague and Evans 2000).

3. GLOFs AS TECHNICAL PROBLEMS

Programs to study, monitor, and contain Cordillera Blanca glacial lakes began immediately following the 1941 Huaraz outburst flood. Scientists from the Peruvian Institute of Geology conducted several glacial lake studies during the 1940s, while the Peruvian Division of Water and Irrigation partially drained six glacial lakes between 1942 and 1950. Authorities also tried to prevent Huaraz residents from rebuilding in the flood zone, an effort that ultimately failed. Despite such cataclysmic destruction in Huaraz and Chavín, neither the 1940s projects at glacial lakes nor the attempts at urban hazard zoning represented a systematic or comprehensive program to reduce glacial lake hazards. Destruction of the Cañón del Pato hydroelectric facility by the 1950 Los Cedros outburst flood, however, shifted the national government's approach to disaster mitigation: after the Los Cedros catastrophe, the sluggish state responses of the 1940s gave way abruptly to glacial lake control.

On February 20, 1951, the Peruvian government created the Control Commission of Cordillera Blanca Lakes (CCLCB). Its enabling legislation (*Resolución Suprema* No. 70) charged the agency with carrying out studies and conducting disaster mitigation projects to avoid "repetition of those outburst floods that can damage the current and ongoing works of the Peruvian Corporation of the Santa, as well as those of the Chimbote-Huallanca Railroad avoiding at the same time damage to the populations of the Callejón de Huaylas." Although future CCLCB funding hinged on political circumstances and its objectives were justified in large part by the protection of infrastructure rather than humanitarian goals, the technical achievements of the agency (and its successors) have for more than a half century helped protect the region from glacial lake outburst floods.

In its first decade alone, the CCLCB "contained" more than a dozen lakes through its "lakes security projects," which involved draining millions of cubic meters of water from Cordillera Blanca lakes and constructing cement dams to hold back these precarious lakes in the future. By the early 1950s, CCLCB researchers had established an effective system to categorize glacial lakes and their likelihood of producing GLOFs. They analyzed glacial lake dam types (rock, debris, or moraine), dam slopes, and location of glacier tongues in regard to lakes (tongues in contact with lakes were regarded as the most dangerous). They also learned—and explained to the world—what caused glacial lake outburst floods and how waves from icefalls eroded moraine dams (Fernández Concha 1957). Since the CCLCB laid the foundations for Cordillera Blanca glacial lake control during the 1950s, the government has contained thirty-five glacial lakes by lowering lake water levels and constructing erosion-resistant security dams at lake outlets. Moreover, CCLCB historical records of glaciers and glacial lakes provide some of the most complete data for tropical glaciology and glacial lake management.

After 1967, when the Peruvian Corporation of the Santa appointed Benjamín Morales Arnao as director of a new Glaciology and Lakes Security Division, Peruvian scientists and engineers devoted attention to glacier research as well as disaster mitigation. By the 1980s, the agency had completed a national inventory of glaciers, a project important both for Peru and for the World Glacier Inventory (Ames 1988). The long-term glacier research has allowed scientists to understand effects of climate change on mass balance (e.g., Kaser 1990; Hastenrath and Ames 1995; Kaser and Georges 1997), glacier tongue behavior (e.g., Ames 1998), and glacial lake dynamics (Fernández Concha 1957; Morales 1969; Lliboutry et al. 1977; Kaser and Osmaston 2002). As scientists increasingly rely on glaciers for historical climate records, and as other mountain societies struggle against GLOFs, the Cordillera Blanca scientific and engineering advances have become increasingly important, not only for Peruvians but for people worldwide.

4. THE POLITICAL ECONOMY OF GLACIAL LAKE CONTROL

Establishment of the CCLCB marked a decided shift in the state's disaster prevention agenda—and this transformation stemmed largely from development interests that sought protection of hydroelectric infrastructure and expansion of irrigation, tourism, conservation, and transportation. In particular, water developers pursued disaster mitigation as a way both to protect hydroelectricity and irrigation infrastructure and to bolster their development projects. Cordillera Blanca glaciers have always enriched the Department of Ancash with one of its most vital natural resources: water. Glacier runoff on the western slope of the Cordillera Blanca flows into the Santa River, one of Peru's largest rivers flowing into the Pacific Ocean. On its path to the ocean, the Santa River makes a precipitous fall through a narrow gorge at Cañón del Pato. Since 1913, when Santiago Antúnez Mayolo first outlined plans for generating hydroelectricity at Cañón del Pato, engineers and developers have dreamed of exploiting Cordillera Blanca water to help industrialize Peru (Antúnez de Mayolo 1941). It was not, however, until 1943 that the national government created the Peruvian Corporation of the Santa (CPS) to construct and manage the Cañón del Pato hydroelectric station (CPS 1944). The hydroelectric station was 80 percent completed in 1950, when the Los Cedros outburst flood devastated the facility. After this dramatic setback, Cañón del Pato did not begin its first stage of operation (generating 50 megawatts) until 1958. The CPS brought another 50 megawatts on line in 1967 and again increased capacity by 50 more megawatts in 1982 (Electroperu 1989). In 1998, Duke Energy Perú (2002), which bought the facility in 1996, expanded Cañón del Pato to its current capacity of 260 megawatts. While coastal residents and industries in Chimbote utilized the bulk of this energy, Callejón de Huaylas communities have also relied on Cañón del Pato electricity generated from glacier water (Reynolds 1993).

Hydroelectric interests—which were not affected by the 1945 Chavín flood and were not yet established when the 1941 Huaraz flood passed through Cañón del Pato—motivated creation of the CCLCB in 1951. Interestingly, the Huaraz outburst flood had previously stimulated scientists and engineers to analyze the importance of glacial lakes for hydroelectric power generation. Rather than believing that glacial lakes needed to be controlled to protect hydroelectric facilities, however, experts in the early 1940s believed disaster prevention (damming lakes, regulating water flow, etc.) could be combined with increased hydroelectric generation. In 1942, for example, when geologists examined glacial lakes above Huaraz for security purposes, they also noted hydrological resources, prospective dam sites for water storage, and, according to Jorge Broggi (1942), methods to "help regulate the flow of the Santa River, which the State plans to exploit exhaustively for energy and irrigation, and to sustain agriculture along the banks for the river."

An explicit link between water use (hydroelectricity and irrigation) and disaster mitigation did not emerge until after the 1950 Los Cedros outburst flood. The late start for systematic glacial lake monitoring, research, and engineering projects suggests that the destruction of a major hydroelectric facility proved more compelling to the national government than the deaths of more than 5,000 Huaraz and Chavín residents. Through time, hydroelectric and irrigation interests have increasingly guided the state agency charged with disaster mitigation at Cordillera Blanca glacial lakes. Hydroelectric developers benefited from glaciological and hydrological research conducted under the auspices of glacial lakes security, and they utilized access roads and dams that were constructed originally for GLOF prevention. By the 1970s, the office explicitly "oriented its studies toward an evaluation of the hydrological potential of glacial watersheds for use in energy and agriculture" (Electroperu 1975; INGEMMET 1979). Hydroelectric power generation and irrigation became principal objectives of glaciological research and lakes control projects after the 1980s. Increasingly, the office studied glacial lakes for their potential to store water and boost flow of the Santa River during the dry season (UGH 1990). In the 1990s, the office proposed damming sixteen glacial lakes, not for security alone, but for exploitation of the water (Electroperu 1995). Glacial lakes Parón, Cullicocha, Aguascocha, and Rajucolta are now utilized for water storage and streamflow regulation (Duke Energy Perú 2002). Although hydroelectric interests sometimes eclipsed disaster prevention programs, the CCLCB and its successors nonetheless contributed enormously to the safety of the regional population, the protection of infrastructure, the development of CPS initiatives, the expansion of economic activity in Ancash, and the extension of public services into people's homes.

Tourism has also been part of policymakers' and developers' understanding of glacial lake control projects. Since the early twentieth century, the Cordillera Blanca has attracted mountaineers to its majestic peaks, especially Mt. Huascarán (Morales Arnao 2001). By the 1950s, advocates of tourism also promoted Lake Llanganuco, one of Peru's most famous lakes, as a tourist center and, thus, an economic resource for local communities to exploit (Carrión Vergara 1959). As Isaías Izaguirre (1954) noted, the beauty of Lake Llanganuco "has always instilled spiritual grandeur in all people. With Llanganuco, we can convert our towns into paradises of a thousand successes." Llanganuco had by 1954 become the centerpiece of the Automobile Circuit of the Callejón de Huaylas. And in 1964, the Automobile Association of Peru featured Lake Llanganuco on its national tourist guidebook, noting the lake's "unforgettable views" and opportunities for boating and trout fishing (Asociación Automotriz del Perú 1963).

Conservation efforts linked to tourism also helped justify both the control of glacial lakes and the CCLCB's construction of labor camps at glacial lakes and access trails to remote parts of the Cordillera Blanca. Conservation initiatives in the Cordillera Blanca paralleled not only the glacial lake control projects, but also the earliest national park movements in Peru. A year before Cutervo National Park became the country's first national park in 1961, Ancash Senator Augusto Guzmán Robles presented a bill to the national congress to create Huascarán National Park in the Cordillera Blanca. Interest in this park continued and in 1967 two United States Peace Corps volunteers also made formal proposals to create Huascarán National Park. Describing the tourist potential as well as conservation issues, they identified Lakes Llanganuco and Parón as ideal cites for Cordillera Blanca tourism (Slaymaker and Albrecht 1967). The national government officially created Huascarán National Park in 1975, and it became a World Natural Heritage Site in 1985. Glaciers and glacial lakes have become increasingly popular destinations for tourists who now flock to the Cordillera Blanca in the tens of thousands each year (Barker 1980; Bartle 1985; Byers 2000).

Tourism and conservation have been part of glacial lake control projects since disaster mitigation initiatives began in the Cordillera Blanca. As early as 1942, scientists argued that glacial lakes security projects could bolster tourism: access roads and trails would open areas of the Cordillera Blanca to tourists, while the labor camps built for disaster mitigation project workers would later serve as climbing huts for mountaineers (Broggi 1942). When César Morales Arnao founded the nationally and internationally recognized Cordillera Blanca Mountaineering Club in 1952, many of the original thirteen members were scientists who had worked on glacier studies and disaster mitigation at glacial lakes (Grupo Andinista Cordillera Blanca 1952). Through the following decades, the disaster mitigation managers continually noted tourist advantages that stemmed from their projects. As one official explained in 1975, “It is important to note that, indirectly through access routes to these [glacial lakes security] projects, we are providing the initial steps for the region’s tourist infrastructure, the fundamental pillar for its future development. We have constructed ten labor camps at our lakes, and these will serve as bases for future high mountain tourist lodges” (Electroperu 1975). Today tourists do not use most of these labor camps, but the trails and roads remain vital for tourism, one of the region’s principal industries.

To protect and expand modernizing projects and infrastructure, the Peruvian state developed a specific approach to disaster mitigation: draining and damming glacial lakes rather than reducing people’s vulnerability to floods through hazard zoning. On first glance, this could suggest neglect of the local people, cooperation with developers, an over-reliance on science and technology to resolve social issues (vulnerability), and pursuit of political goals rather than the safety of the population (Cannon 1994). Analysis of local people’s perceptions of risks and proposed solutions to glacial lake hazards, however, indicates agreement and cooperation instead of government abandonment or deceit.

5. GLOFs AND THE SOCIAL CONSTRUCTION OF RISK

In the wake of the glacier disasters that occurred periodically after 1941, local residents developed a profound awareness of Cordillera Blanca natural hazards. The most vulnerable populations—those in towns and cities along the rivers that descended from the Cordillera Blanca—demanded state action to prevent additional outburst floods. Like populations worldwide, however, Callejón de Huaylas inhabitants ranked various risks that influenced their lives. Fear of glacial lake outburst floods existed alongside a number of other concerns: adequate food and shelter, education, access to public services, crime, social control, and other issues related to people's everyday livelihoods. Safety from outburst floods was not their only, or even their most pressing, concern. Nevertheless, urban residents were traumatized by the glacial lakes and they persistently advocated for disaster mitigation programs.

Although natural disaster scholars argue that the poorest, most marginalized populations are usually the most vulnerable to natural disasters, in the Cordillera Blanca the situation was the reverse. Spanish colonizers' decisions to construct towns along the Santa River and its tributaries led to the establishment of urban areas in flood zones. Indigenous settlements before the sixteenth-century Spanish conquest had been more dispersed and at higher (and thus safer) elevations (Oliver-Smith 1999). Further, Peru's geo-racial binary put the wealthiest people and the dominant socio-racial class in urban areas on the valley floor. Consequently, the dominant classes of urban residents suffered the vast majority of death and destruction from glacial lake outburst floods. Most indigenous residents in the mid-1900s lived on upland slopes, though urbanization, jobs, and fluid urban-rural connections had brought some rural residents to flood zones within regional towns. It was thus the urban population—the wealthiest segment of the population—that was most vulnerable to glacial lake hazards and most concerned about disaster mitigation projects.

The constant threat of catastrophic GLOFs caused these urban residents to vilify glacial lakes and fed their anxieties about impending disaster. Songs, books, poems, literature, and stories depicted glaciers and glacial lakes as both beautiful and villainous. In 1954, a local resident called Lake Palcacocha, source of the 1941 Huaraz flood, a traitor and an assassin that took on a new course of punishing local people (Neogodo 1954). Some residents considered glacial lakes treacherous and secretive, capable of destroying the valleys. Others believed the glacial lakes could suck people in if they got too close (Yauri Montero 1961; Bode 1990). Despite such negative perceptions of the glacial lakes, most Cordillera Blanca inhabitants continued to see the lakes and mountains as defining characteristics of the region. This landscape, according to many residents, makes the region more beautiful—and thus better—than other areas of Peru (Ibérico 1954; Villón 1959; Yauri Montero 2000). This dual view that simultaneously celebrated and vilified glacial lakes became common after the 1940s.

Glacial lake instability has also made people live in fear of impending disaster. Worried that more GLOFs would inundate Cordillera Blanca communities after the 1941 Huaraz and 1945 Chavín outburst floods, a poet (Montes 1945) penned his frustrations with recently formed glacial Lake Cuchillacocha:

> . . . look at the cruel Andean lakes
> that have tormented us
> be careful Cuchillacocha, don't kill me
> like the traitor [Lake] Cojup
> that killed our brave brothers [in Huaraz]. . . .

In 1955 a local newspaper reporter, fearful of heavy rains and rising water levels in lakes, complained that "these hydrological phenomenon that happen much too frequently provoke an anxious restlessness among the Huaraz populations" (Anonymous 1955). Anxieties over glacial lake outburst floods remained high enough that amidst the violent earthquake of May 31, 1970 (7.7 on the Richter Scale), some people feared a GLOF more than the trembling earth itself. Residents of Huaraz, for example, stared intently at the Cojup Canyon, watching and listening for an outburst flood. People in Caraz below Lake Parón, the Cordillera Blanca's largest glacial lake, ran directly for the hills screaming "Here comes Parón!" (Pajuelo Prieto 2002). Fear of glacial lakes has continued in recent years. In 1998 the Quillcay River in Huaraz rose dramatically during a rainstorm, creating a panic in the city that sent many residents running to the hills for safety. In March 2003, Huaraz residents again became alarmed when they learned that Lake Palcacocha had overflowed due to a landslide into the lake.

The mounting social anxieties that accompanied this history of relentless glacier disasters led people to demand the Peruvian government to protect them from glacial lake hazards. After the 1945 Chavín flood, for example, residents criticized the government for wasting time on scientific studies while not acting to eliminate societal threats from glacial lakes: "What we want is that [the government] listens to the voice of the people, which is the voice of God, and drains the lakes without waiting until the rainy season passes and without doing more studies" (Anonymous 1945c). Ten years later, a Huaraz newspaper revealed public fear of floods and frustration with the CCLCB, especially for not preventing the 1950 Los Cedros GLOF and for not investing more in the reconstruction of Huaraz after 1941. Additionally, the newspaper urged the agency to publish its studies so that Huaraz residents would know whether "future catastrophes were possible or impossible" (Ayllón Lozano 1955; Anonymous 1955; Anonymous 1954). Local authorities also demanded that the national government do more to protect their communities from GLOFs. In Caraz, for example, municipal leaders in 1942 requested immediate disaster mitigation work at Lake Parón (Subprefecto Lucar 1942). Although work had begun by the early 1950s, Caraz authorities still complained about slow government response and the continued threat of hydrological catastrophes from Parón (CCLCB 1951–1954). When glacier disasters occurred, many local people blamed the government for withholding glaciological information and thus hiding the true dangers to Cordillera Blanca towns (Oliver-Smith 1986).

Huaraz residents also rejected hazard zoning that would have helped reduce their vulnerability to outburst floods. Instead of complying with building codes that sought long-term disaster prevention, many people re-colonized the floodplain to recover their lost property (Anonymous 1945b, 1956c). During the 1950s, Huaraz residents actively fought against the building restriction and defied the law by constructing homes and buildings on the floodplain, in what many considered the true heart of Huaraz. Residents wrote newspaper editorials that complained about the economic losses from hazard zoning. Others asserted their right to rebuild Huaraz and the "need" to rebuild the city in its previous location. And some simply did not care about restrictions or dangers because the floodplain offered vacant land (Anonymous 1951; Irving 1952; Anonymous 1956b). In 1956, urban residents even formed the Association of Flood Zone Property Owners to "restore the urbanization of this important sector of the city". They argued that recuperating their land and re-urbanizing such an "important sector of the city" was vital not only to their own interests but also to the general recovery from the 1941 disaster (Anonymous 1956a).

Reconstruction of the city was critical to Huaraz residents because it symbolized modernity, civilization, and the social standing of mestizos over indigenous people (Fernández 1942; Anonymous 1945a; Coral Miranda 1962). In a society where geo-racial binaries dictated social status, urban residents of the Callejón de Huaylas sought to preserve the status quo of the class–race hierarchy. Maintaining their cities in the lowest possible sites, which were hazard zones, ranked as a more important risk than the possibility of another glacial lake outburst flood. This was particularly true during the second half of the twentieth century, when rural to urban migration rose steadily in Peru and eroded rigidly defined categories of race, class, and social standing. As Huaraz and other Callejón de Huaylas residents refused to move to less vulnerable locations, they clung to their towns along the Santa River floodplains and demanded that the government drain and dam glacial lakes (e.g., Anonymous 1959a, b; Anonymous 1970; Salazar Bondy 1970). Authorities abandoned the

Huaraz hazard zoning soon after mandating it, thus indicating their preference for glacial lake control rather than the reduction of human vulnerability.

6. CONCLUSION

The most vulnerable Callejón de Huaylas inhabitants believed—as did government officials, developers, and experts—that science, engineering, and technology could effectively protect them from the melting glaciers that periodically unleashed avalanches and outburst floods. Of course, the Peruvian government did respond much more energetically and systematically to economic losses at Cañón del Pato in 1950 than to catastrophic loss of human life in 1941 Huaraz, thereby suggesting the political-economic nature of disaster mitigation rather than a primarily humanitarian endeavor. Unlike some development interests that put people in danger (Steinberg 2000), however, the CCLCB and its successors engaged in significant (and successful) disaster mitigation projects for more than a half century. Thus, it was *because of* development projects—not in spite of them—that disaster mitigation blossomed during and after the 1950s.

Local complaints of government projects have focused on the *speed* of the scientific studies and lake control projects, not on the government's general approach to disaster mitigation. The only disaster mitigation plans that locals rejected were those expert and government initiatives that sought to reduce local residents' vulnerability to future natural disasters. Given their overall agreements—and locals' willingness to reconstruct their destroyed city in a vulnerable hazard zone—it is clear that local people's continued vulnerability to glacier hazards stemmed from their social constructions of risk. Perceptions of risk and understandings of glacier hazards thus differed among distinct groups. But local urban residents, authorities, developers, and experts generally sought the same solution to natural hazards: draining glacial lakes to avoid outburst floods.