16

Mama Cotacachi

HISTORY, LOCAL PERCEPTIONS, AND SOCIAL IMPACTS OF CLIMATE CHANGE AND GLACIER RETREAT IN THE ECUADORIAN ANDES

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Environmental journalists, activists, and scientists alike are voicing urgent concerns that tropical mountains are losing their glaciers at an alarming rate. Downstream impacts of melting snow and ice provide, they warn, an early glimpse of what might be in store for earth's densely populated lowlands unless action is taken against global warming. Among the negative effects for human society are devastating glacier lake outbreaks (Mool, Bajracharya, and Joshi 2001), loss of alpine biodiversity (EPA 2000), the demise of mountain farming (Price and Barry 1997), declining sources of freshwater for cities (FAO 2002), destruction of sacred mountain sites, and loss of tourism (BBC World News 2003). If only a few of these future scenarios come true, the economic, ecological, and social costs to humanity will be huge.

Despite convincing arguments in call-to-action Web postings, Internet bulletins, and popular articles, little systematic and empirically grounded information is available about the human responses to or societal impacts of diminishing glaciers in mountain regions. While advances have been made in the physical monitoring of mountain glaciers, limited research has been undertaken on the effects of climate change and glacier retreat on human populations. This gap in knowledge needs attention before action or policy aimed at minimizing human costs can be formulated. As a step in building informative case studies, we present research findings on the history, local perceptions, and social impacts of the recent loss of the glacier on Cotacachi, a volcanic peak 4,039 m in elevation situated 35 km north of the equator in Ecuador. Cotacachi is among the first Andean mountains in the past half-century to completely lose its glacier as a result of recent accelerated global warming. As an early example of what might ultimately be in store for mountain glaciers and communities around the world, it deserves careful scrutiny.

Cotacachi, the highest of the northernmost cluster of Ecuadorian volcanoes, exhibits many of the ecological and socioeconomic characteristics typical of the western cordillera of the

northern Andes. Covering only 15 km, the mountain rises rapidly from an inter-Andean valley floor at 2,080 m through sharp altitudinal gradients to almost 5,000 m and a zone of what was until recently permanent snow. Agroecological zones of maize, hardy grains, tubers, and high pasture reflect these gradients. Just to the south of Cotacachi is Cuicocha (3,063 m), a crater lake. The lake and the surrounding high-altitude grassland within the Cotacachi-Cayapas Ecological Reserve are the region's main tourist attractions. Indigenous communities are interspersed among remnants of former haciendas at higher and middle elevations while mestizo farms and towns are located in the lower zones. Agriculture is the main activity in indigenous communities, although many young adults work in nearby towns or the capital city of Quito. In the lower zones, the economy is based on commerce, tourism, and an emerging floriculture and agro-industrial greenhouse industry. All social groups depend on drinking and irrigation water derived from Cotacachi and Lake Cuicocha.

To document the demise of the glacier on Cotacachi and the human response to this change, we utilized several different research methods. As is typical of Andean countries, little systematic socioeconomic information is readily available in Ecuador on climate change or glacier retreat. To overcome this gap, we gathered information from historical documents, photographic archives, historical paintings, meteorological station records, and government publications. In addition, we conducted ethnographic interviews and collected oral histories with local people. We also held workshops in which we used photographs and three-dimensional physical models as technical aids to assist in the recall of knowledge that could delineate changes and impacts related to the glacier. Finally, we conducted field observations and monitoring of water availability in selected streams and springs and in Lake Cuicocha. While the information gathered from any single source was thin, we were able to construct a broader vision of the demise of Cotacachi's glacier and its meaning to the local population.

HISTORICAL SOURCES

Chroniclers, travelers, mountaineers, and scientists fascinated with Ecuador's mountains have provided detailed accounts of their glaciers from the sixteenth century to the present. While typically based on brief visits by outsiders and reflecting a Eurocentric natural-history viewpoint, these accounts provide our only long-term data on the Cotacachi glacier (Table 16.1).

The earlier observations place the terminus of the glacier between 4,400 and 4,500 m, while in recent years it was only 200 m below the peak. Many chroniclers included paintings and sketches of Cotacachi that provide visual verification of the glacier's extent around the turn of the twentieth century (Figure 16.1).

Repeat photography, which relies on a time series of photographs across several decades, is a useful method for documenting glacier change (Byers 1987). The first photographs of Cotacachi were likely taken in the last two decades of the nineteenth century (Figure 16.2). An anonymous photograph taken from Cotacachi's town plaza with a view of the eastern slope verifies Whymper's 1880 observation by showing a large glaciated area between the higher and lower peaks of Cotacachi. A 1978 photograph by B. Wuth (reproduced in Vacas 1978, 161) taken from the south shows Cotacachi as a snow-capped mountain; occasionally even today the mountain will receive a thin layer of seasonal snow. By 2002, a photograph by Rhoades taken of the east face shows no evidence of a glacier. Finally, our analysis of aerial photographs as part of a study of land use change from 1963 to 2000 verified what the historical sources and photographs revealed about glacier retreat. In 1963 the east glacier found in Whymper's 1880 sketch was still in place, while by 1993 only a small remnant remained and by 2000

TABLE 16.1

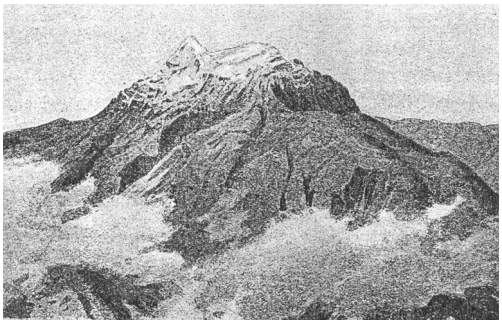
Selected Accounts of Cotacachi Glacier, Nineteenth and Twentieth Centuries

SOURCE	REPORT
von Humboldt (1853, 21), 1802	"Mount Pichincha is located in the same direction and axis as the snow capped mountains Illiniza, Corazón, and Cotacachi."
Wagner (1870, 627–28), 1858–59	"The permanent snow line of Cotacachi in May is 14,814 feet (4,515 m) above sea level."
Orton (1870), 1867	"Twenty-two summits are covered with permanent snow. . . . The snow limit at the equator is 15,800 feet (4,815 m). Cotacachi is always snow-clad."
Dressell (quoted in Hastenrath 1981, 99), 1877	Cotacachi summit is "covered with perpetual and compacted snow."
Whymper (2001 [1892], 260), 1880	"permanent snow, in large beds, as low as 14,500 feet (4,419 m). . . . It is not likely that a crater lies buried beneath the glacier which at present occupies the depression between its peaks."
Wolf (1892, 98)	"Cotacachi is the only snow-capped mountain that is found between the Guayllabamba Valley and the Mira River. It has a large glacier on the east side."
Bermeo (1987, 39–41, 126–29), Luis Bolanos, personal communication, 2004	"There has been an impressive decrease of glaciers on the [Cotacachi] mountain."
von Hillenbrandt (1989, 33)	"Cotacachi is the only mountain in the northern part that has glaciers. There are moraine deposits at the limit as low as 3,900 m."
Sustainable Agriculture and Natural Resource Management Project, 1997	Remnants of the glacier observed and photographed during a reconnaissance trek on the mountain.
Ekkehard and Hastenrath (1998)	Glacier has an area of 0.06 km,^{2} with the lowest glacier terminus at 4,750 m.
Eric Cadier and Bernard Francou, personal communication, 2004	Glacier nearing its ultimate demise.

permanent ice cover was no longer discernible (Zapata et al. 2006).

METEOROLOGICAL RECORDS

Climate data from private and state meteorological stations collected since the 1960s are limited but suggestive of temperature and precipitation trends (Ontaneda, García, and Arteaga 2002; Gutiérrez 2004, 26–27). Ecuador's (National Institute of Meteorology and Hydrology, or Instituto Nacional de Meteorología e Hidrología [INAMHI]) provides empirical data on changes in temperature and precipitation patterns throughout the country. Data from 15 INAMHI meteorological stations show an increase in the mean, maximum, and minimum annual temperatures and decreasing precipitation over the past century (Cáceres, Mejía, and Ontaneda 2001). INAMHI stations around Cotacachi show mean annual precipitation and mean annual temperature variation for a period of 40 years. While a mean annual temperature increase is clear, the results for



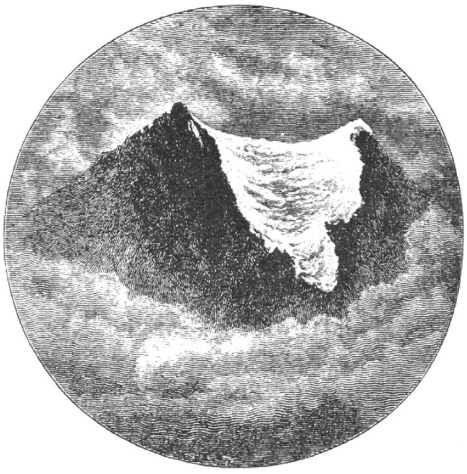


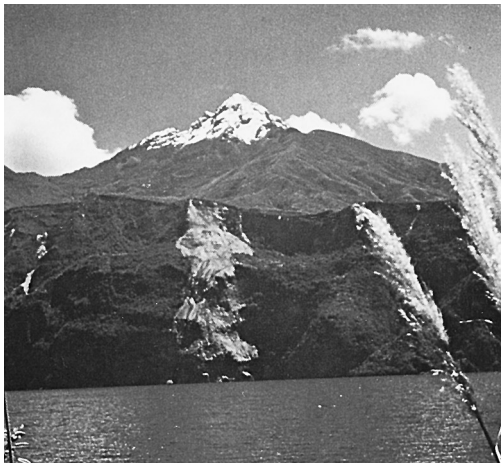
FIGURE 16.1. Images of Cotacachi from Wolf (1892), Whymper (2001 [1892]), and Troya (1913).

precipitation do not always show systematic trends. However, two stations near Cotacachi—San Pablo and Hacienda Maria—recorded a clear decrease in precipitation. Although the few climate stations around Cotacachi are dispersed and generalizations are difficult, the available data point strongly to a climate that is growing warmer and drier—changes that underlie the glacier's retreat.

ORAL HISTORIES AND LOCAL PERCEPTIONS

Although outside visitors and secondary sources provide useful insights and measurements of the physical nature of the glaciers on Cotacachi, these observations are devoid of cultural or social context. Therefore, we elicited local people's observations and responses to climate change and glacier retreat through ethnographic research focused on agriculture, plants, folklore, and communities' histories (Rhoades 2006).

The volcano plays a key mythological and religious role for indigenous Cotacacheños. Following an Andean pattern, they personify and describe Cotacachi with metaphors drawn from the human body and social relations. The volcano is feminine, a *mama* or "mother," and is described as having a body and a head. Indigenous people say that they live on her broad "skirt." (The metaphor of "skirts" of a mountain is widely used in Spain as well.) Local people described Cotacachi as constantly interacting with other features in the landscape and told of her intimate sexual relations with Tayta [father] Imbabura, a volcano located directly across the valley to the east. She has relations with her human inhabitants as well, expressing anger and disappointment with them and at times interfering in the life of the community, especially when social conflict and behavior meet with her disapproval (for similar indigenous North American accounts, see Cruikshank 2005).



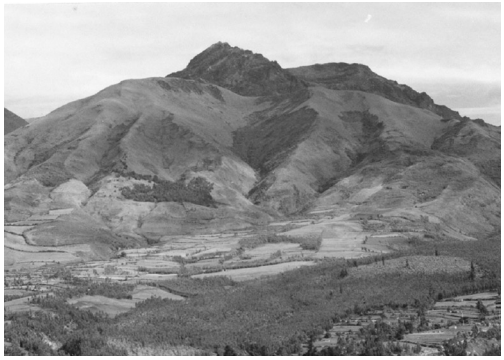


FIGURE 16.2. Cotacachi's east (*left and below*) and south faces in 1890, 1978, and 2002. (Photos anonymous, B. Wuth, and R. E. Rhoades, respectively.)

Etched in the collective memories of the people and handed down through their oral histories is an awareness of the volcano's enormous destructive force (Nazarea et al. 2004). Stories and folktales tell of mayhem and death from earthquakes, landslides, rockfalls, volcanic eruptions, and other calamities. The volcano figures strongly in indigenous oral traditions (Nazarea et al. 2004). One local folktale relates how Tayta Imbabura and Mama Cotacachi fell in love. Cotacachi was a beautiful young girl who owned a large hacienda. Tayta Imbabura, an aging womanizer, tired of chasing after other females, Cayambe and Tungurahua (also glaciated peaks), decided to remain with Mama Cotacachi. From their union came a child, a smaller volcano beneath Cotacachi called Yana Urcu. Imbabura became sick and wrapped his head with a white cloth. This, it is said, is why Imbabura is covered with snow only in winter while Mama Cotacachi has permanent snow. Another folktale tells that when Mama Cotacachi has new snow on her peak in the morning, it is a sign that her lover, Tayta Imbabura, has visited her during the night. In yet another, Tayta Imbabura falls in love with the volcano Cayambe, higher and more glaciated than Cotacachi, and Cotacachi stares darkly at him. We were unable to determine the age of this folktale, which seems to take Cotacachi's recent fate into consideration.

To gain insight into present-day perceptions of climate change and the glacier, we organized workshops with farmers representing various Cotacachi communities. To facilitate discussion, we used a three-dimensional physical model with a scale of 1:10,000 to encourage people to discuss the locations of rivers, flows of springs, and the extent of the glacier

FIGURE 16.3. Researchers listen to indigenous farmers explaining climate change using the model. (Photo Jenny Aragundy.)

through time (Figure 16.3). We also used aerial and historical photographs from various years to encourage informants to recall the past.

Previous surveys conducted in the area showed that local farmers listed climate change more frequently than other factors as the most important cause of agricultural change (Campbell 2006). The comments of workshop participants supported these findings, though their accounts of the causes and consequences of this change varied considerably. Elderly people and those from more remote villages believed that it was due to Mama Cotacachi's punishment, while younger people with formal education and contacts with local nongovernmental organizations pinpointed global climate change. Workshop comments focused on three themes: seasons and rain patterns, the glacier and snow on Cotacachi, and water availability.

ORAL ACCOUNTS OF ENVIRONMENTAL CHANGE

Though the demise of the glacier is the most visible impact of climate change at Cotacachi, seasonal rain patterns were more frequently mentioned as a day-to-day concern by participants. They stressed that rainfall had decreased and become more irregular in its timing. Farmers noted greater difficulty in planning field preparation and planting. They reported that lower and midzone crops (e.g., maize) are today being produced in the higher zones. Many referred to the rain as "playing" with people. A female farmer's response was typical: "It doesn't rain as much anymore. It seems the weather is changing so that there is only a drizzle today. It used to be more abundant. The climate seems to be playing. The rains were harder and longer. Today the clouds are polluted and there are only strong winds and everything is dry." Participants noted that 30 years ago Cotacachi was permanently snow-capped and ice was harvested and transported to cities such as Ibarra, where it was used in food preparation and for medicinal purposes. In a representative comment, a farmer said, "There was more snow on Cotacachi; it was whiter when it rained. They say that when there is snow you can see animal figures like there are on Imbabura. There are figures of a rooster and of cattle lying down." Another woman said,

"What I remember of Cotacachi is that it had more snow that came down to near the road to Intag." Another recalled that "snow was used to make ice cream with crushed ice. The mestizos went to fetch it with donkeys." Finally, one farmer from Morales Chupa noted that Cotacachi today is "black" compared with the "white" of Cotapaxi and Chimborazo: "I remember that Cotacachi had snow in the past, but in contrast it has hardly any. These days what we see is black. We used to climb to the *páramo* and observe that there was snow, but now there is none. What I remember of the mountain is that it had snow and looked white. The whole corridor of Cotacachi now looks black."

While there is a universal local awareness that Mama Cotacachi is losing her snow and ice, the community seems unwilling to remove the historic image from its memory. As an exercise, we left the model in the indigenous headquarters for locals to complete by painting it with their own conceptions of landscape features (e.g., communities, sacred places, water bodies). We later learned that they had painted Mama Cotacachi's peak bright white. The mountain continues to be portrayed as snow-capped on billboards, brochures, and tapestries. In the minds and memories of local people, it is still a snow-capped volcano. It is interesting to speculate about the reasons for painting the model: Did that reflect the wish of adults to show younger generations what the mountain looked like, to remind themselves, or perhaps even to show the mountain herself their hope that she would return to her earlier state?

Elderly workshop participants recalled that during their youth earthquakes were more frequent than today and more water flowed in rivers and springs. Today, they say, the rivers are more like irrigation canals. A 49-year-old woman from the community of Turuco said, "Rivers such as Pichavi and Yanayacu were wider 40 years ago. Some people and animals died because they were swept away [by the river when it was at peak flow]." Another indigenous woman recalled that the Pichavi River was once about 8 m wide and would sometimes carry away people and houses. The river has been dry for about 20 years. Other participants pointed to springs where they once drew household water but that are dry today.

FIELD OBSERVATIONS AND WATER MONITORING

In an effort to cross-check the observations of local people, we conducted direct field observations and monitoring of selected water sources. Three rivers (the Pichavi, the Yanayacu, and the Pichanviche), several creeks, springs, and Lake Cuicocha were the main water sources at the beginning of the twentieth century. Today all these sources are experiencing declining water flows. For example, Chumavi Creek, which starts at Chumavi Falls 3,780 m above Lake Cuicocha, once carried water that flowed into the lake. Although the streambed is 30 m wide, it is dry today except for a small spring at approximately 3,600 m. This is the only source for the Chumavi and San Nicolas water systems, which supply nine communities, including 487 families (Mayorga 2004). The Alambi River, with a streambed 30 m wide, is located on the east side of Cotacachi directly under the now-vanished glacier. Thirty years ago, the Alambi ran full of water and was used to irrigate the northern part of the Cotacachi landscape, as is evidenced by an abandoned intake structure located at 2,800 m. Field observations reveal that the now dry Alambi and Chumavi riverbeds extend directly from the glacier.

Lake Cuicocha is also experiencing a lowering of the water level. Since the construction of a hotel on the lake's edge eight years ago, the water level is reported to have dropped about 5 m. Sensors in the lake show that from October 2003 until December 2005 the water level fell some 90 cm.

WATER AND CONFLICT IN COTACACHI

Water availability and use in the Cotacachi area are tied to dramatic social changes since the early 1960s, when a national agrarian reform

program began to break up the area's large haciendas. Previously, indigenous people had no title to their lands. They had to work for the owners of the haciendas to obtain usufruct rights to small parcels and access to irrigation water. The agrarian reform divided up the large private estates but did not adequately address issues of water rights. The hacienda owners relinquished to indigenous people the land that had the worst conditions for agriculture, including poor topography and little access to water. When the indigenous communities obtained land, they asked for water concessions from the state, which has formal title to all water resources in Ecuador. Water concessions are obtained from the Consejo Nacional de Recursos Hídricos (National Council of Hydrological Resources [CNRH]). The decisions made often favor the economically and politically powerful. This injustice has angered indigenous communities, and they have filed formal complaints in Quito against the local authorities. As a form of protest, they have blockaded roads and even shut down the nation's major road, the Pan-American Highway (*Diario El Hoy*, July 5, 2005).

The difficulty of the farmers' situation is compounded by the fact that present-day water concessions are based on outdated flow figures. Despite a realization that less water is available, concession holders want to claim the same volume as before. At the same time, demand for water has increased dramatically. Development projects have installed new household potable water and irrigation systems in the growing indigenous communities. Moreover, the number of water users has increased as average plot size has declined as a result of the land fragmentation that follows the division of plots among many heirs in indigenous families.

New activities and users place additional demands on these shrinking water supplies. The owners of several large haciendas have planted water-demanding eucalyptus to demonstrate their active use of the land to government authorities who might expropriate it or otherwise challenge them and to rural activists who might otherwise encourage the poor and landless to occupy their lands (Carse 2006). Simultaneously, an expansion of the lower urban municipality and the growth of floriculture have increased the demand for water. While a partial solution would involve revision of the concessions and their more equitable distribution, the basic problem of insufficient water remains. Local authorities predict that conflict will increase dramatically in the coming years if nothing is done about it.

CONCLUSIONS

While social science researchers in tropical mountains may be disappointed by the scarcity of readily available data on glacier retreat, we have demonstrated that the use of multiple methods can generate significant information. We need to refine these methodologies further and to integrate the study of environmental phenomena with elicitation of human perceptions and responses. Our assumption is that by understanding local people's awareness of glacier retreat and its consequences, we can better understand their decision making and local adaptations to global change. One question that needs further investigation is the relation between present indigenous knowledge of the environment and global climate change as manifested locally. Logically, farmers' local knowledge forms the basis of their decision making and should be incorporated into any strategy meant to mitigate the impact of climate change (Vedwan and Rhoades 2001, 117). However, it should be recognized that the demise of the Cotacachi glacier and its consequences for water availability are entirely new phenomena for Cotacacheños. Local people—young or old—have no previous history with the disappearance of a physical and spiritual feature that has always dominated their cultural landscape. In their collective memories, the glacier has always been present and Mama Cotacachi has always supplied abundant water. The anthropological

literature on indigenous knowledge largely draws on local people's long-term experiences with past and ongoing patterns in their environment (Bricker, Sillitoe, and Pottier 2004). On the basis of our study, we suggest that local knowledge is inadequate in the face of external global change that produces unprecedented events. Determining whether long-term adaptive strategies of mountain people (e.g., economic diversification and expansion, agricultural intensification, the development of new regulations) will help mitigate negative impacts will require more in-depth and comparative research at the local level (Netting 1976). While farmers are intensely aware that their climate is changing in ways they do not understand, the novelty of these changes—especially in relation to water availability—may signal that local indigenous knowledge of plant and animal behavior is less secure than in the past.

It is critical that we understand what is happening concretely in communities that have historically depended on glacier resources. This calls for a vigorous social science linked with the natural sciences and for cross-fertilization between local understanding and scientific analysis. Only with a strong interdisciplinary approach that involves the participation of the people directly affected can we hope to achieve solutions to what may become major disruptions of ancient cultures deeply rooted in glacier-fed mountain landscapes.

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