The Glaciers of the Andes are Melting: Indigenous and Anthropological Knowledge Merge in Restoring Water Resources

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Cultural anthropologists have known for years that climate change is a reality and not merely the opinion of paranoid physical scientists. Unlike other social scientists, cultural anthropologist study and live with those populations that are the first to experience the negative consequences of climate change. Because these small-scale societies (such as pastoralists, hunters, fishers, and subsistence farmers) live close to the earth, they are sensitive to minute changes in animal behavior, water temperatures, amounts of rainfall, planting cycles, climate changes, and soil conditions. In fact, this accumulated knowledge about their ecology has enabled them to make the appropriate cultural changes needed to successfully adapt to their changing environments over the past millennia. Owing to their close relationship with their natural environments, these small-scale societies are the first to pick up the early warning signs of climate change and, unfortunately, are the first to experience the negative consequences.

In this selection Inge Bolin introduces us to the Quechua people of the high Peruvian Andes, who are facing severe water shortages brought about by the rapidly retreating glaciers. Bolin discusses how the Quechua are reinstating, in the twenty-first century, certain ancient Incan practices of water conservation, such as garden terracing and the revitalization of ancient irrigation canals and reservoirs used in earlier times. While anthropologists such as Bolin have served as liaisons between the Quechua people and local and regional officials, much more needs to be done by global organizations to prevent these rapidly occurring water shortages from becoming catastrophic. And, as Bolin reminds us, this is not a problem facing just the Quechua people of Peru. Rather, more than one-sixth of the world's population depends on glaciers and seasonal snow packs for its basic water supply.

The indigenous Quechua people of the high Peruvian Andes are worried as they look at their mountain peaks. Never in their lifetimes have they witnessed environmental changes of such drastic dimensions. One village elder expressed his concern by telling me: "Our Aput (sacred mountain
The glaciers of the Andes are melting. Deities have always had sparkling white ponchos. Now some of their ponchos have brown stripes. Other peaks have shed their ponchos altogether (Bolin 2001, 25). His feelings resonate throughout the hills and valleys where one often hears people say, “When all the snow is gone from the mountain tops the end of the world as we know it is near, because there is no life without water” (Bolin 2003).

I first encountered the problem of melting glaciers in 1984–85 when I researched the organization of irrigation along the Vilcanota/Urubamba valleys (Bolin 1987, 1990, 1992, 1994). At that time Peruvian geologist Dr. Carlos Kalofatovich told me that the Chicon glacier above the Urubamba Valley had receded sixty meters in fifty years (personal communication). During the next two decades I continued to observe how glaciers melted in this and other adjacent regions. This process became much more visible starting in the mid-1990s, at which time my research and applied work among high-altitude pastoralists was focused on ritual activities (Bolin 1998), environmental issues (Bolin 1999, 2002; Bolin and Bolin 2006) and child rearing (Bolin 2006). Starting in 2004 when glacial retreat and water shortages had reached serious proportions, I shifted my research focus more directly to the problems of climate change, concentrating on melting glaciers, water shortages, and solutions that could improve the chances for the survival of the indigenous peoples and their cultures.

In this chapter I discuss glacial retreat in the high Andes with focus on the provinces of Quispicanchis and Urubamba in the Cusco region of southeast Peru (Figure 16.1). The people living in these areas deal with a rainy season that lasts from roughly October to the end of March, and a dry season from April to the end of September. During the dry season almost all the water that people and animals use throughout the Andes is derived from the glaciers in the mountains' high peaks.
indigenous people who reside along the hillsides of these provinces, between 3,000 and 5,000 meters above sea level, live primarily from working the land and pasturing their animals. I will describe how the melting process affects the natural environment, the livelihood of agriculturists and high-altitude pastoralists, and the impact it has on their culture and religious beliefs. The discussion will center on my role as a collaborative researcher and mediator between the local and the global by describing my interactions with the indigenous people as climate change intensified and we were forced to seek ways to mitigate the impending crisis caused by glacial retreat and water shortage. Together we started to consider local adaptive strategies and globally devised methods to preserve, capture, recycle, purify, and distribute water, and adjust irrigation and agricultural practices in ways that may allow the Andean people to remain in their homeland instead of migrating to overcrowded cities. As a collaborative researcher I have helped with such projects in the past; some are being implemented at the present time as discussed below; others will follow.

CHANGES IN ANDEAN GLACIAL TOPOGRAPHY AND ITS REPERCUSSIONS

What can science tell us about the changes that have occurred within the Andean glacial topography? At 7,250 kilometers in length, the Andean Cordillera is the longest mountain chain in the world. Within it, Peru’s glaciers alone account for 70 percent of the tropical mountain glaciers of the planet (González 2003). Given their tropical latitudes, these glaciers are very close to the melting point and are therefore extremely sensitive to changes in the earth’s temperature. Since climate change is greatest at high altitudes, it makes them prime indicators of global warming (Vásquez Ruesta et al. 2002). In the last twenty years the ice of the Peruvian Andes has been reduced by 20 percent, and this process is accelerating (González 2003). Renowned glaciologist Lonnie Thompson found that the Qori Kalis glacier, the largest glacier of the Quelccaya ice cap in the southern Andes mountains, which had been retreating an average of six meters per year between 1963 and 1978, has since retreated on average sixty meters a year (personal communication, 2007; see also Thompson et al. 2006). In a 2007 CBC News report, he and a team of scientists relayed evidence that Qori Kalis could be gone in five years (CBC News, February 16, 2007).

The Quelccaya ice cap, the world’s largest tropical ice mass, covers 44 square kilometers and is located about 125 miles north-northeast of Lake Titicaca (Bowen 2005, 166). Thompson warns that it is the unprecedented rate of ice loss that concerns him most in the Andes and in other parts of the world where he and his crew have been working. Other leading scientists of the Intergovernmental Panel on Climate Change (IPCC) reported in 2007 that “warming of the climate system is unequivocal given increases in average air and ocean temperatures, widespread melting of snow and ice and rising sea levels” (CTV News, March 26, 2007).

The smaller glaciers that make up 80 percent of the glaciers within the Andean Cordillera may vanish in ten to fifteen years as predicted by Francou (2001) and Francou et al. (2003). But many of these small glaciers have already melted or are melting at a much faster rate than ever predicted. The forecast for rainfall, which is hoped to makeup for at least part of the water loss from glaciers, is equally alarming. According to the fourth assessment report of the IPCC, the annual precipitation is likely to decrease in the southern Andes (Matthews 2007). More scientists now join indigenous peoples in their concern about glacial retreat and its consequences. During November and December of 2007 I discussed the issue of melting glaciers and water scarcity in the Andes with directors and scientists of environmental agencies in Cuzco, Peru, among them IMA (Instituto del Manejo de Agua), CONAM (Consejo Nacional del Ambiente), ANDES (Asociación para la Naturaleza y el Desarrollo Sostenible), Plan MERISS (International Irrigation), and Ayllus Ecológicos del Cusco. They unanimously agree that the
situation is very serious and that steps must be taken at once to slow down the disastrous consequences of global warming.

**IMPACT OF GLACIAL RETREAT ON THE LOCAL POPULATIONS**

Since virtually all the water available to Andean peasant farmers and pastoralists in the dry season comes from the snow and ice fields of their high mountains, the repercussions of melting glaciers are immense for local communities. Melting glaciers may provide added water in the short run, but they also cause rock falls, landslides, and floods. As snow masses diminish, however, mountain lakes and creeks shrink or disappear, and rivers no longer receive enough water from the glaciers to irrigate fields and meadows, which require 70 percent of the water supply, or to generate hydroelectric power. Water scarcity, combined with extreme weather conditions, result in bad or lost harvests. In addition, increasingly higher temperatures require that tender new plants be irrigated more frequently, though not enough irrigation water is available. To make matters worse, multinationals are building luxury hotels that use much of the precious water in the province of Urubamba, while international mining companies destroy the glaciers of many sacred mountains in the Andes and elsewhere to extract minerals, thereby poisoning water and land. The smaller mountain glaciers above the Urubamba Valley, which had receded slightly more than one meter in 1985, are now receding twelve meters each year (Tupayachi Herrera, personal communication, 2007); the last ones will soon be gone.

The unprecedented melting of the Andean glaciers is also posing serious drinking water problems for local inhabitants. Drinking water becomes scarce where springs dry up, and lower water levels in lakes and rivers are causing disease vectors from animal feces to increase. This requires that water be thoroughly boiled, but firewood is scarce. As a result, many people drink raw water, putting themselves at risk of contracting gastrointestinal ailments. These, in turn, require natural medicines that must be derived from plants that are increasingly scarce due to the uncertain water regime.

Furthermore, weather patterns in the Andes now tend to reverse, a trend also found in other climate-sensitive areas of the world. The absence of rain during part of the rainy season has interfered with the growing of food plants, while rains during the dry season have barely allowed for the freeze-drying of potatoes, the staple of the herders’ diet. Hunger, combined with extreme temperatures, has caused much sickness, and led to new diseases (e.g., *Verruga peruana*) and new pests. Until a few years ago potatoes and other high-altitude tuber crops (*oqa, ulluku*, and *maswa*) were free from pests. Recently, however, some high-altitude communities have been forced to spray their potato crop, which has caused financial hardships for most families.

**VIEWS EXPRESSED BY INDIGENOUS ANDEAN PEOPLE**

Inhabitants of the Andean Cordilleras have been concerned about water scarcity for a long time. Myths and legends tell about courageous young people who dared to face severe obstacles to bring much-needed water from snowfields and high mountain lakes to villages in the valley. Water was sacred to pre-Columbian civilizations as it is to many indigenous people today. Pre-Columbian religions and the beliefs of today’s indigenous societies have been based on the benevolence of Mother Earth, and the sacred Apus, those mountains whose snow and ice fields provide the life-giving waters, and on the mountain lakes that retain it. As the snowfields melt due to global climate change, these deities lose their powers. Eventually Andean religion may erode and these legends will become meaningless. Some indigenous people have wondered what they have done wrong to deserve the wrath of the gods who began to restrict the
water that flows from their mountainsides. Although elders are often aware of the effects of El Niño that can cause havoc in the weather patterns, few know of the problems underlying global climate change and of those responsible for causing such a devastating process. Yet, the local knowledge of the Quechua people of the high Andes is invaluable to their survival. The slightest changes in the environment tell them when something goes wrong. Thus, for example, the people living along the hillsides above the Vilcanota and Urubamba valleys observed already in the mid-1980s (and perhaps earlier) that important medicinal plants became increasingly hard to find, and even where they persisted, their growth was stunted, usually because of water scarcity during at least part of the year. The Andean mountains that contain the most extreme range of landscape types, climates, and vegetation communities in the world are rapidly losing their biodiversity (Brack, Egg, and Noriega 2000). Since biodiversity is highest at high altitudes, indigenous knowledge in this area is paramount in our struggle to help preserve these plants (Gade 1975; Tupayachi Herrera 1997, 2005).

With the same degree of precision as with medicinal plants, the Quechua people’s local knowledge tells about past weather patterns, either seen in their own lifetimes or learned through oral history. They know whether a change that is happening now has occurred before or in such an extreme form within living memory. When it comes to rainfall, for example, the Andean people refer to veranillos, which are dry periods that can last for three weeks and have occurred mainly during the height of the rainy season in January and February. Within recent years, however, veranillos have also appeared earlier. I experienced two veranillos within six weeks in November and December 2007. Abnormalities such as torrential rains, snow, and hail falling during the dry season have occurred increasingly within the last decade or two. These weather anomalies seriously affect the herds and crops, mainly the preservation of potatoes, the staple of high Andeans’ diet. The freeze-drying process of potatoes can only take place between May and July when the days are sunny and the nights are frosty. Now this weather pattern can no longer be relied on. The rains that fall in the rainy season also tend to be stronger now, washing the potatoes out of their steep beds into the rivers. These situations have caused several years of hunger in high-altitude regions (Bolin 1999; see also Winterhalder 1994 on rainfall patterns). Also, during drought conditions high-altitude pastoralists often point to grasses that are of such weak texture that they break apart and even pulverize when grazed by llamas and alpacas. Melting glaciers and drying creeks and mountain lakes all add to the problems caused by drought.

Peruvian environmental organizations and village leaders are becoming increasingly concerned about the local and regional impacts of global climate change and in some cases have taken action. Attempts to slow down glacial retreat started several years ago along Peru’s Sinakara mountain range. Here tens of thousands of pilgrims flock from high-altitude regions of Peru and Bolivia to celebrate at the sanctuary of Qoyllur Rit’i with ancient Andean and Christian rituals. Hundreds of ukukus who represent spiritual figures dressed in shaggy alpaca robes with masks of alpaca wool ascend to the glaciers under the full moon for initiation and other ceremonies. They leave a few drops of blood in the snow as a sacrifice to the mountain. In return, they used to chop off large chunks of ice and bring this potent medicine to the people in their villages (see Figure 16.2). Beginning in the year 2000, as the melting of glaciers became a frightening reality for many, the indigenous leaders who organized this great pilgrimage announced that the ancient custom of collecting ice from the glaciers must be abandoned. Since 2003 this law has been strictly enforced. Now each ukuku is allowed to fill only a tiny bottle with snow or water to bring to the valley.

### LOCAL RESPONSES

Indigenous peoples live in close association with their land. In the high Andes the Quechua revere Pachamama or Mother Earth, the sacred mountains
FIGURE 16.2 Ukukus (bear men) bring ice, believed to be medicine, from the glacier to their villages in 1991. This age-old custom was abandoned in 2000 because of alarming glacial retreat. © Inge Bolin.

they call Apus, and lakes and meadows. These are omnipresent deities. Yet, in places where water became too scarce to make a living, families were forced to move to find a better environment in which to plant their crops or herd their animals. But few have been successful, relocating only to find similar issues with water or lack of land. Those who sold or abandoned their land and moved to the overcrowded cities were for the most part equally disappointed. Without extended families and compadrazgo, networks of fictive kinship ties, they found no support when they most needed it in an unknown environment.

Yet, Andean peasants and herders have been very resourceful throughout history in adapting to environmental changes. In order to defend themselves against the vagaries of the weather, for example, they have always used small parcels of land at different altitudes and within different microenvironments to ensure that at least part of a year's potato harvest can be saved. Now, with much greater changes in the weather pattern, with hotter summers and colder winters, with more variable precipitation, and with less or no water flowing from their mountain peaks, they contemplate growing drought-resistant species of food plants and think about methods of storing water. But the manifold effects of climate change, the activities that contribute to it, and governments that are not responding to the policy challenges are all too distant for most local people to comprehend. It is here that the role of an anthropologist or other professional as mediator between the local, national, and global levels becomes important.
COLLABORATION BETWEEN INDIGENOUS PEOPLES AND ANTHROPOLOGISTS

Just as many anthropologists have learned the strategies of survival in marginal environments from indigenous and other local peoples, indigenous peoples now need information from anthropologists about global climate change, the way it affects humanity, how future trends are detected and forecast, and new coping strategies. We all must understand, for example, that the disappearance of glaciers is not only felt locally, but also at the national and worldwide levels. Glacial retreat in the Andes causes mountain lakes and creeks to dry up, becoming unable to provide water to fill the rivers that make their way throughout the country to the dry, rainless coast or to the jungle regions. As aquifers also drop, even drinking water can become scarce during the dry season or whenever the rains do not arrive on time.

During more than two decades of research and applied work in the Andes, it became clear to me that migration to the cities or other parts of Peru is not the answer for people who want to get a better chance at survival. Andean people are attached to their land, lifeways, and religious beliefs, and it is here where efforts must begin. Since most of the world's leaders are doing little to curb climate change through implementing policies that restrict emissions from vehicles, factories, and billions of animals kept under atrocious conditions, local people must become innovative and self-empowered to implement both short-term emergency projects to survive and projects that are sustainable in the long term. In most cases, indigenous inhabitants have a wealth of knowledge already available to them based on how their ancestors dealt with and adapted to weather extremes, like the scarcity of water.

In 1984–85, the villages along the hillsides above the Sacred Valley of the Incas in the province of Urubamba suffered from a serious water shortage that resulted in conflicts over the last few drops of water during the dry season. Given this emergency, the indigenous population asked for international cooperation to improve irrigation canals and reconstruct small Inca reservoirs. At various occasions the local people told me that their Inca ancestors knew the most stable regions along the mountainsides, where remnants of ancient canals and reservoirs could still be seen. Since many of these structures had for centuries been trampled on by animals, they were no longer functional.

The elders of the village of Yanahuara along the hillsides of the Sacred Valley of the Incas, where I studied the ways by which they organized their irrigation activities, approached me to assist them in writing a proposal to the international developers who were working in the Vilcanota Valley, 400 kilometers away. The elders requested that their broken ancient canals and reservoirs be repaired. Together with the local population, I wrote a proposal to get the necessary funding, which I took to the GTZ (Gesellschaft für Technische Zusammenarbeit, German International Development Corporation) in Germany who discussed the issues with their Peruvian counterparts.

The people of Yanahuara and adjacent regions rejoiced when in 1986 the international development agency Plan MERIS II (now Plan MERISS) in Cuzco, through which Peru and Germany cooperate, accepted our proposal to improve canals and reservoirs to provide enough water year round, and to also add complementary projects (e.g., a school building). Yet, within the last five years, with the glaciers along the Cordillera de Urubamba melting much faster and retreating at an average of twelve meters a year (Tupayachi Herrera, personal communication), water scarcity has again been sorely

1. The suffering of billions of animals in animal factories is a disgrace to humanity and also a major contributor to our environmental dilemma. In a groundbreaking 2006 report, the UN declared that raising animals for food generates more greenhouse gases than all the cars and trucks in the world combined. Senior UN Food and Agriculture Organization official Henning Steinfeld reported that the meat industry is "one of the most significant contributors to today's most serious environment problems." Yet, this most significant issue is seldom, if ever, discussed at environmental conferences or elsewhere. Should we close our eyes to an issue that is at the very heart of global warming? Should we continue to waste 2,500 gallons of water required to produce one pound of beef?

2. For a summary of how the Incas systematically preserved water, see the following reference (Pollock 2001).
felt by the local people, especially during planting time. Within the last decade, climatic extremes here and elsewhere in the Andes have contributed to floods, catastrophic droughts, heat waves, and cold spells as never seen before. Among other drastic events, in 1998 and 1999 harvests were destroyed by extreme weather conditions throughout large parts of the Andes (Bolin 1999). In 2005 an immense avalanche of snow and ice, estimated at about two hundred tons, tumbled from Mount Veronica, destroying everything in its path and finally obstructing the train tracks in the valley leading to Machu Picchu (Tupayachi Herrera, personal communication). The recent cold spell in May 2007 was more extreme than any previous one experienced by the Quechua people, killing some of the very old and very young. (See also Suarez 2008.) Yet, as soon as this natural catastrophe was over, glacial melting continued as before.

With some peaks now free of ice and snow and others losing their glaciers at a rapid rate, major efforts are necessary to curb further destruction. Together with the volunteer organization Yachaq Runa, which I founded in 1992 in Cuzco, we have embarked on a program to help stop local environmental degradation and, hopefully, reverse it. The indigenous Quechua people along the hillsides of the Vilcanota and Urubamba Valleys have been eager to revert to Inca ways of managing the environment by planting native trees, recreating small forests on the hillsides and around their homesteads, and by planting bushes alongside irrigation canals to keep water evaporation low (see also Bolin 1987). Although Australian eucalyptus trees grow fastest and continue growing after being cut, they need much water, and their enormous roots destroy plants and buildings in their close proximity. Therefore reforestation with indigenous trees, such as Q’euña (Polylepis incana) and Quiswar (Buddleja incana), and indigenous shrubs, such as Tayanka (Baccharis odorata) and Chilika (Baccharis latifolia), is environmentally much more beneficial. These reforestation projects were started by the villagers of Chilihuani, in the province of Quispicanchis, in cooperation with the Yachaq Runa volunteer group and with international funding.2 Reforestation in Challwaqocha and five other villages in the province of Urubamba is now underway. As soil and waterways are stabilized through reforestation, the simultaneous planting of the highly nutritious Maca tuber and other food plants is becoming more successful.

Since increasing water scarcity is already starting to affect the potential of hydroelectric plants, indigenous people in several of my study communities are happy as we cooperate to provide solar cookers, photovoltaic lights, and solar hot water to the health stations, schools, shower houses, and other facilities we help to build and equip. Yet, many more efforts are necessary to assure the survival of the Andean people should global climate change continue at the present rate. Unless precipitation patterns change to become more beneficial to agriculture and pastoralism, much more must be done to provide the amount and quality of water necessary for survival. We must consider primarily indigenous Andean knowledge—known in some areas, but forgotten in others—as waterways are restored, agricultural practices are adapted to prevailing climatic conditions, and new methods are devised to collect water and use it sparingly throughout the dry season. In cooperation with the indigenous population, and based largely on their ancestral knowledge system, we arrived at the following priorities: a) the reconstitution of ancient and building of new terraces, b) the use of conservation tillage, and, c) the rejuvenation of ancient irrigation systems.

Irrigation uses around 70 percent of the available water. Water is saved and erosion largely prevented when peasant farmers use terraces built by their forefathers and/or construct new ones. Where slopes are not terraced, fields must be leveled in such a way that water seeps to the root system without eroding the soil. The Incas did this masterfully, as seen on ancient fields. Secondly, to prevent runoff and erosion and keep soil and plants from drying out, contour drenches must be dug. Conservation tillage, used in pre-Columbian times and sometimes today,
leaves the soil undisturbed and moist, as seeds are placed into narrow slits.

Above all, changes must be made in the way water is transported. The ancient Andeans used a variety of methods, including subterranean water channels, to bring water from the mountains to the dry, rainless coast. The ancient and venerated site of Tipon, 20 kilometers south of Cuzco, consists of a network of narrow irrigation canals that crisscross the region, providing the fields with small amounts of water throughout extended periods of time, causing no erosion and little evaporation. Modern drip irrigation systems are ideal, but still too expensive for most peasant communities (see also Schreier, Brown, and MacDonald 2006).

CONCLUSION

Anthropologists working with indigenous and other place-based peoples have a critical role in the issue of climate change, working as research collaborators and mediators between the local and the global. In this chapter I have shown how, in collaboration with the Andean people and in the context of Yachaq Runa, we continue to look into both old and new ways of collecting, using, and transporting as well as recycling and purifying water. Increasingly more reservoirs will have to be built to store water collected in the rainy season. Individuals and national and international nongovernmental organizations, those mentioned above and others, have been cooperating successfully with indigenous and other local people. Yet, much more help is required in the Andes and worldwide to guarantee survival. The situation is extremely serious (see also Hansen 2007) and it is unimaginable what will happen in the Andes and other parts of this planet if governments do not begin to act quickly: “With more than one-sixth of the Earth’s population relying on glaciers and seasonal snow packs for their water supply, the consequences of these hydrological changes for future water availability are likely to be severe” (Barnett, Adam, and Lettenmaier 2005). For example, “Up to three billion people live from the food and energy produced by the Himalayan rivers” (Schild 2007). In the Andes, “glaciers feed the rivers that feed the sprawling cities and shantytowns on Peru’s bone-dry Pacific coast. Two-thirds of Peru’s 27 million people live on the coast where just 1.8 percent of the nation’s water supply is found” (CBS News 2007/02/17). The people of the high Andes have no choice but to remain in their mountains, keeping them moist, planting trees, digging trenches, collecting rain water, and hoping that the world’s leaders will finally wake up and give all they have to help avert the worst disaster humankind ever had to face.

REFERENCES


