AN EXPLORATION OF THE IMPACTS OF CLIMATE CHANGE ON
HEALTH AND WELL BEING AMONG INDIGENOUS GROUPS IN THE
ANDES REGION

By

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Integrated Studies Project
submitted to Dr. Leslie Johnson
in partial fulfillment of the requirements for the degree of
Master of Arts – Integrated Studies

Athabasca, Alberta

June, 2010
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Abstract

The Andean areas of Peru, South America are declared to be extremely vulnerable to global warming and these regions are facing major challenges in coping with climate change. One native group from this area, in particular, the Quechua, is the focus of this paper. The Quechua communities include Huanca, Chanka, Q’ero, Taquile, and Amantani, but, for the purposes of my analysis, all of these groups will be dealt with together as they share similar use of natural resources for food and medicine (Wilson, 1999). The Andean plant and animal species are a significant source of nutritious food and medicine for the Quechua people. Temperature warming is posing a serious risk to these resources and consequently to the lifestyle of the Quechua Natives. By examining several studies that focus on the environmental effects of temperature changes, the correlations to health can be viewed. I argue and provide evidence that the impact of climate change on the health and well being of the Quechua people is a serious issue that needs to be addressed.

In the first section of this paper, an historical perspective of the Quechua Natives is given, as well as an overview of their traditional way of life. This also includes reference to their effort to live sustainably within their natural surroundings. In the second section, scientific proof of environmental changes in the Peruvian Andes is presented. Section three deals with the environmental stress of alpine plants due to climate change. Part four emphasizes on the impact of climate change on the natural resources. This section looks at the nutritional and medicinal value of various plant sources, and how the Native people depend on these resources for their health and well being. The issue of micro-financing as a means to assist the Quechua people, is presented in section four. Micro-financing is one component of this group's specific environmental issues, and thus some of their health-related concerns. Suggested solutions to the problems resulting from the impact of climate change on the health of the Quechua people are stated in the last two sections. The important role of the Peruvian government, both nationally and locally, as well as the potential contributions from private industry, Non Governmental Organizations (NGOs), and various citizen groups, is emphasized as part of the solution.
Introduction

Indigenous people have a close relation with the environment, and they suffer the consequences of global warming due to society's careless attitude towards the environment. Health officials from the Pan America Health Organization, Harvard School of Public Health, and Johns Hopkins School of Public Health believe that temperature warming is responsible for negative impacts on health among the indigenous people in South America. There are patterns that show global warming correlated with diseases and other illnesses among the indigenous people (Fraser, 2009). Climatologists feel that there is a linkage between infectious diseases, hunger, malnutrition, and global warming among the indigenous people (Fraser, 2009). The indigenous people need to find alternative ways of earning a living and, at the same time, protecting their resources.

The Andean Natives live in the Andean mountains in Argentina and Peru in an area that is more than 7000 km long with an average altitude of about 4000 m (Bolin, 1999), but I will focus on Andean Native communities in Peru, particularly the Quechua groups. The Quechua groups include Huanca, Chanka, Q’ero, Taquile, and Amantani, and all these Native groups will be dealt with as one culture that shares similar uses of plant and animal sources for food and medicine (Wilson, 1999).
Mean annual temperature in the Andes has increased by approximately 0.1 Celsius/decade. Greenhouse gases are responsible for temperature warming, and carbon dioxide is the main greenhouse gas. A primary cause of carbon dioxide in the atmosphere comes from burning coal. The other causes are widespread fossil fuel use, land use, and deforestation (Houghton, 2004). The government and industries generally sacrifice the environment in favour of economic benefits. These negative impacts of climate change are a form of violence against the indigenous people. The health impacts of climate change will be discussed in detail further in the paper.

Temperature warming affects the population, and the Native Andeans may not be able to access adequate sources of the plant and animal resources they have traditionally used for food and medicine. Over many centuries, plant species in the highlands have made adaptations that enable them to survive harsh conditions (Korner, 2003). Temperature warming due to climate change adds a high level of stress to the Andean plants, many of which are intolerant of high temperatures (Korner, 2003). The plants can die of overheating and can become extinct (Korner, 2003).

Another adaptation response is that plant species migrate to higher altitudes, which have conditions that they are used to. When the Native people farm at these higher altitudes, they have to clear land. This leads to another environmental problem, deforestation (Hellin, 2005). Deforestation can lead to erosion of the fragile soil of these high altitudes.
Climate change in the Andes will also cause a reduction in precipitation and glaciers, and increase droughts, glacial retreats, and glacier lakes outburst floods. These hazards will threaten the natural resources in the region (Hellin, 2005).

The Native people have depended on these resources for many centuries (Wilson, 1999). Their knowledge of animal and plant sources used for food and medicine was extensive and was passed down from generation to generation (Wilson, 1999). They always had a close relation with their natural surroundings and they continue to practice sustainable methods in order not to deplete the resources. The paper will review the impact climate change has on Quechua people: the resources they depend on for food and medicine. This allows the reader to have a greater understanding of how temperature warming affects their way of life. It will review the biophysical and environmental change in the region and future projection of change, focusing on the pressure brought upon the ecosystem. Many health experts believe that there is a strong connection between diseases and nutritional inadequacy and Global Warming, and fear that health conditions may worsen among the Quechua people as temperatures continue to increase (Fraser, 2009). The paper will then describe the impact climate change has on food security and other natural resources in the Andes region, and the way environmental degradation affects the Quechua Natives’ well being. It concludes with an exploration of how microfinance can develop and implement strategies to assist the Quechua Natives to improve their problems that relate with Global Warming. The poverty of the majority of Quechua people negatively affects their health conditions. Assisting the Quechua people by financial means may allow them to improve their health. If the Quechua Natives contribute economically to society, the Peruvian government may realize the economic value of the natural resources, and implement stricter environmental laws.
Thus, the Quechua may continue to live in harmony with their natural surroundings and resolve their challenges that deal with climate change.

**Solutions to Protect the Natural Resources**

In addition to medicinal purposes, the Native people depend on other plants, such as wheat, corn, potato, and indigenous tubers, to provide the calories and other essential nutrients for an adequate diet. Livestock, such as llama, vicuña, and sheep, remains central to the livelihoods of a large portion of the Quechua indigenous people, providing nutritious food and fiber for clothing. Environmental change caused by global warming poses risks to plant species upon which livestock depend.

Through its impact on sustainability of local economies, climate change is linked with economic vulnerability. Climate change has thus moved beyond being an environmental challenge to one that creates poverty and hinders development around the world (Fairbanks, 1997). It creates problems especially for those in more marginal environments with fewer resources, increasing global inequities. In order to change this situation, societies must respond by decreasing the level of greenhouse gases in the atmosphere. Developing countries do not tend to have as strong environmental regulations as the developed world does because they are mainly concerned with economic development. They do not implement environmental regulations, because they fear this will add an economic burden that they cannot afford.

Microfinance is one initiative that may help the Quechua people with the environmental problems. Microfinance, the delivery of small loans, insurance, and other financial services to
the poor, helps them engage in productive activities (Fairbanks, 1997), such as establishing small businesses where they can sell local items, such as food and clothes, to tourists and neighbouring communities. The Native people have a long tradition of making clothes from specific livestock and cooking different types of food from plants and animals. If the Native people establish small businesses and sell their items to tourists and neighbouring communities, this may allow the Andean people to become economically independent by harvesting resources in a sustainable manner.

Many Quechua Natives endure poverty and their social-economic background is strongly connected to their poor health conditions (Kern, 2001). Assisting Native people economically may allow them to improve their overall health conditions and nutritional levels. If the Native people contribute financially to society, the Peruvian government may realize that these alpine plants have value in the economy, and they may implement stricter environmental laws.

The Quechua Natives can practice sustainable methods, but they alone cannot prevent global warming. People from different backgrounds have to work together to protect the Native people from suffering from health risks due to climate change.

The Non Governmental Organizations (NGOs) that deal with microfinance sometimes include an educational component. This approach would educate local peoples about their rights to communicate to the Government and industries about the severe impacts economic development has on their livelihoods. If they are educated about their rights to protect their resources, the Native people can use non-violent pressure on governments to implement environmental laws.
Microfinance organizations can also find ways to educate the people outside the Native communities about the environmental problems in the Andean region, enabling them to be aware of the need for environmental protection.

**Andean Native Traditional Way of Life**

**Historical-Cultural Perspective**

According to anthropologists, the first human settlers of the Americas crossed the land bridge between the Old and New Worlds around fifteen thousand to seventy thousand years ago. Over countless generations, they slowly made their way from Alaska south across the Isthmus of Panama to the continent of South America (Wilson, 1999).

These migrating groups adapted to every possible inhabitable environment throughout the continent, including the frigid straits and coniferous forests of the far south, the grassy pampas of modern day Argentina, the rugged seasonally arid Brazilian uplands south of the Amazon River, the vast green sweep of the Amazon rain forest, and the Andes mountain chain on the western edge of the continent along its entire 7700 kilometer length (Wilson, 1999).

As their ancestors in North America had done, the first inhabitants of the southern New World became experts in collecting and hunting the wild flora and fauna that flourished in astonishing diversity across the length and breadth of the vast area in the Andes (Wilson, 1999). Prior to 2500 B.C., anthropologists agree that the economy in the sierra regions in Peru was based on hunting and gathering. Afterwards there was a gradual spread of agriculture. The Andean indigenous groups continued to adapt to the great diversity of the environment as their ancestors
had done, using methods such as hunting and gathering, horticulture, and small scale agriculture (Wilson, 1999).

Archeologists found lithic raw materials, large grinding stones, and various flora and fauna in several sites in the Peruvian Andes that indicates that the Andean Natives have harvested their resources in a sustainable manner for several centuries (Dillehay, 2004). Regional variations in stone tools suggest seasonal movement between high and low elevations (Dillehay, 2004). These archeologists believed that these remaining materials show evidence that the Native people used sustainable methods for hunting, fishing, and gathering plants.

After the Spanish Conquest in the sixteenth century, a massive resettlement of the indigenous population drastically changed the settlement patterns of the whole Andes region, including the Vilcanota Valley of Peru, near the Puno region (Gade, 1975). From the dispersed and semi-dispersed settlements of Inca times, the Native people were moved into clustered settlements where they could be easily managed by the civil and religious authorities (Gade, 1975). In the process, the Andean communities were forced to settle in mountain areas that had poor agricultural land and harsh environmental conditions (Gade, 1975). As they have done in the past, the Native people have learned to survive these difficulties and find strategies to sustain the resources for food and medicine over centuries. The Native people continue to depend on these resources, and climate change is likely to have a negative impact on their health and well being.
**Quechua Natives**

Indigenous people make up 45% of Peru’s population, while 52% are of European descent or Mestizos of mixed Hispanic and Indigenous descent (Albo, 1999). The remaining segments of the population are of African, Japanese, or Chinese descent (Albo, 1999).

Quechua indigenous groups of South America are the largest of any indigenous group in the New World (Wilson, 1999) and they make up one third of Peru's 24.5 million residents (Albo, 1999). The Quechua peoples have migrated south along the ridges and valleys of the Andes Mountains and east into the rainforest of the Amazon Basin (Wilson, 1999). Their different living conditions have led to two distinct cultures and identities: The mountain and the rainforest Quechua. This paper will focus on the social and health impacts on the mountain Quechua groups.

Around 1000 AD, a group known as the Inca, arose and gradually extended leadership over many peoples (Gade, 1975). The Incan Empire, known as Quechua, occupied 45% of the land of present day Peru (Gade, 1975). Currently, the majority of the Quechua people are marginalized in society and limited to being laborers or farmers. Power and wealth have been monopolized by the inhabitants of European descent.

**Spiritual Connection to the Land**

Resource loss has not only a negative health and nutritional impact on the local people, but also a spiritual one. The Quechua Indians have a deep belief in the existence of a supernatural and powerful Earth Mother, Pachamama, who supports the value of the land by overseeing the well
being of nature and the improvement of farming by soil fertility and climate (Gade, 1975). The faithful Quechua people practice sustainable strategies to show respect to the Earth Mother.

Figure 1: Map of Peru

The dark grey shades indicate the Andean region in Peru, Bolivia and northern Chile.

(from Vuille, 2008, p.81).

Environmental Change in the Andean Region

Climate Change

The tropical Andes are often declared to be one of the most vulnerable regions to global warming worldwide and this region is facing major challenges in coping with climate change (Salzmann, 2009). Many alpine regions are biodiversity hotspots with many plant and animal species (Korner, 2003).
Human activities of all kinds, such as the burning of fossil fuel and deforestation, have led to increases in the atmospheric concentration of greenhouse gases, particularly carbon dioxide (Houghton, 2004). Every year greenhouse gas emissions add a further seven thousand million tonnes to the atmospheric carbon dioxide already present and most of it will remain there for a period of a hundred years or more (Houghton, 2004). Health experts from the Pan America Health Organization, Harvard School of Public Health, and Johns Hopkins School of Public Health believe that Global warming is causing several health problems among the Quechua Natives in Peru, as will be elaborated below.

Carbon dioxide concentrations have risen from a pre-industrial level of approximately 270-280 parts per million (ppm) to the current concentration of over 370 ppm (Houghton, 2004). During the past hundred years, the earth’s climate has experienced an average warming of approximately 0.8 degree Celsius, with an increase of 0.6 degree Celsius in the past thirty years alone (Houghton, 2004). The 1990s have been the warmest decade in that century (Houghton, 2004). The increased temperature will cause the amount of water vapour in the atmosphere to increase, causing the earth to be even warmer (Houghton, 2004).

Stresses on the climate are not only causing many impacts on Earth’s surface temperatures, but also altered rainfall patterns; a rise in the sea level; and floods and increased frequency and severity of storm surges, heat waves, drought, and changes in the natural ecosystems, such as shifts in the distribution of several species (Houghton, 2004). In return, climate change has affected many communities globally through agriculture-related economic losses, increased
incidences of vector- and water-borne diseases, difficulties in access to clean water, and loss of livelihoods. Andean Indigenous people are at risk of loss of resources to sustain their traditional livelihoods. This will be mentioned in greater detail later in the paper.

The Quechua people have recently noticed that late blight (*Phytophthora infestans*), a fungus, is destroying their potato crops (Fresh Plaza, 2008). According to Cesar Portocarrero, a civil engineer who has been studying the effects of climate change on the Peruvian Andes, global warming is bringing many diseases, including late blight, which is spreading and damaging the potatoes (Fresh Plaza, 2008). If this continues, the Native people will be forced to plant potatoes at higher and higher altitudes (Salazar, 2008).

This could lead to another environmental problem, deforestation if the Native people have to clear land, so they can grow their crops at these higher altitudes. This deforestation will affect the local climate by removing a portion of the carbon dioxide absorption process, which will cause more destruction of the land and natural resources. The Quechua people fear that eventually there will be no place to grow the potato and this crop may face extinction. The varieties of potatoes grown in the Peruvian Andes contain high levels of nutrients, such as vitamins C, and B, potassium, magnesium, and phosphorous (Salazar, 2008).

Dr. Larry Laughlin, Dean of the School of Medicine at the Uniformed Services University, compared disease statistics with climate data in the Peruvian Andes (Fraser, 2009). The Doctor found that disease outbreaks were strongly linked with higher temperatures and rainfalls in the
region (Fraser, 2009). Other researchers in Lima found similar correlation with hospital admission for diarrheal illnesses and temperature warming (Fraser, 2009).

Farming accounts for 35% of the land (Mateo, 1990). The soil in the Andean region is shallow and fragile. The Native people need to practice proper soil management systems that enable them to grow crops in the harsh environmental conditions. Terracing allows the Native people to cultivate steep slope without the risk of soil erosion (Mateo, 1990).

Crop diversity enables the Native people to reduce the risk of losing plants to climate change. For example, twelve different species of potatoes are found in a small potato plot in the highland (Mateo, 1990). Many crops have been selected in different mountain elevations and ecological niches. The Native people have fields that extend across an altitudinal range of more than 1,000 meters (Wilson, 1999).

The Native people also have developed expertise in intercropping, a way of combining a variety of plants that enhances the growth of each type of plant. Maize extends from 3,100 to 3,400 masl (meters above sea level) and is intercropped with quinoa, peas, or squash (Mateo, 1990). Potatoes are located between 3,600 and 3,800 masl, where the mean temperature ranges from 8 to 10 degrees Celsius (Mateo, 1990). The crops associated with potatoes are faba beans and quinoa (Mateo, 1990).

As discussed above, livestock farming plays a vital role in the Andean people’s livelihood. As with different types of plants, the Andean Natives have found that different types of animals are
suited to different elevations. At around 3,600 to 3,750 masl, the most common activity is animal production. Animals, such as guinea pigs, are located from 3,800 to 4,100 masl and the llama and alpaca graze at an altitude of up to 5,000 meters (Mateo, 1990).

In areas with limited livestock, the domestication of crops with high levels of protein, such as quinoa (*Chenopodium quinoa*), kaniwa (*Chenopodium pallidicaule*), tarwi (*Lupinus mutabilis*), oca (*Oxalis tuberose*), ulluca (*Ullucus tuberosus*), and mashua (*Tropaeolum tuberosus*), provide a nutritious diet for the Andean Natives (Wilson, 1999).

Living at such high altitudes, the Andean Natives have been isolated from the rest of the Peruvian population, but have strong trade relationships with Andean Natives in other parts of the mountains. Since a variety of crops is grown in different areas of the mountains, and livestock reside in higher altitudes, their trade links allow the Native people to be self-reliant.

The tropical Andes contains around one-sixth of all known plant life in less than one percent of the world’s surface area; climate change may pose a risk of extinction to these valuable plant sources (Richter, 2009). Temperature warming is pushing valuable plants to higher elevations and many of these plants may disappear, because of overcrowding. The plants that remain in the lower elevations may not able to adapt to the warming temperatures, as they are used to growing in cold environments. The Native people may face hunger and nutritional inadequacy if the plants disappear. The topic will be discussed in detail later in the paper.
Andean Countries in Terms of Climate Change

With a negligible share of 0.59% of the industrialized countries’ greenhouse gas emissions, Peru contributes exceedingly little to man-made global climate change (Jeschke, 2009). Deforestation activities in the tropical lowlands are responsible for Bolivia's carbon emissions, and it is possible that Peru faces a similar situation (Jeschke, 2009).

Given the Andes' fragile climate and ecosystem, Peru is prone to the negative impacts of climate change (Jeschke, 2009). The Andes is at high risk of climate-generated dangers. According to the University of Louvain’s emergency database (EM-DAT*), 68% of all emergencies in Andean Countries, including Peru, are said to have been caused by dangers of floods, debris, and mud floods (Jeschke, 2009).

Unfortunately, climate changes in the Andes regions have not been properly documented, and there are no clear scientific records. However, some significant long-term trends in Andean countries have been estimated over the last decades (Jeschke, 2009).

Near Surface Temperature

Vuille and his co-workers (2008) conducted a study of information from 279 meteorological stations between the parallels 1°N to 23°S and 0 to 5000 masl, as well as interpolated climate data sets. The tools of the study were a linear trend analyses of the observational data combined with model diagnostics from an atmospheric general circulation model (Vuille, 2008). The authors aimed to discover potential mechanisms related to the observed glacial retreat in the tropical Andes in the years between 1950 and 1998 (Vuille, 2008).
Scientists discovered that air temperature has significantly increased over the last seventy years (Vuille, 2008). Climate in the Andes has increased by approximately 0.1 Celsius/decade, with only two of the last twenty years (1996 and 1999) being below the 1961-1990 average (Vuille, 2008). Scientists have observed a trend of accelerated temperature increases of 0.34 Celsius/decade from 1974 to 2006 (Jeschke, 2009). In another study based on 29 low and high elevation stations, Mark and Seltzer (2005) found a temperature increase of 0.35-039 Celsius/decade between 1951 and 1999 in central Peru (Vuille, 2008).

The model projections of climate change in the 21st century in the tropical Andes predict a continued warming of the tropical troposphere with a temperature increase that especially affects the higher altitudes (Vuille, 2008). Following the SRES A2 (Special Report on Emission Scenarios), the tropical Andes may experience a massive warming on the order of 5 degrees Celsius by the end of the 21st century (Vuille, 2008).

Alpine plants are not able to survive in warmer temperatures if temperatures continue to rise and may face extinction. Livestock will also be affected, because they depend on these plants for food. Food plants and medicinal plants used by Quechua may also be affected and may become less available to the population.
Figure 2: Surface Air Temperature at tropical Andes between 1939 and 2006

Data was collected based on a compilation of 279 record stations. The graph shows that there was an increase of warming over several decades. (from Vuille, 2008, p84).

**Humidity and Precipitation**

Due to improved remote sensing techniques, data sets of troposphere water vapour have been available to measure humidity changes in the Andes region (Vuille, 2008). In the assessment of near-surface humidity changes in the Andes, Vuille and his colleagues (2008) relied on CRUF05 data, which is based on station observations, spatially interpolated on a regular 0.5 X 0.5 grid. However, Vuille and colleagues (2008) noted the CRUF05 data need to be evaluated carefully and further data may have to be collected in this area.
During the last forty-five years, there have been significant changes in atmospheric humidity and temperature. The temperature increase in the Andean region has been up to 2.5 Celsius/decade (Jeschke, 2009), while the atmospheric humidity increased at a moderate rate in Southern Peru by 0.5% to 1% Celsius/decade (Jeschke, 2009).

Given the significant increase in temperature and rising relative humidity level, it is believed that vapour pressure has also increased significantly throughout the Andes (Vuille, 2008). Due to temperature change and the rising level of humidity, there is an increased risk of glaciers melting, leading to an increased risk of flooding in the region.

According to the IPCC (International Panel on Climate Change), the temperature in the Andes could increase by one degree Celsius over the next century, and the precipitation may be reduced by about twenty percent (Bush, 2002). Health experts from the Pan American Health Organization, Johns Hopkins School of Public Health, and Harvard School of Public Health predict that temperature increases can alter the way diseases occur in the regions (Fraser, 2009). More Quechua people may be at risk of diseases, such as malaria and dengue. Collateral effects of climate change will cause floods in the regions, and this will destroy the plant and animal sources. As mentioned previously, the lack of natural resources may cause the Native people to suffer from hunger, malnutrition, and other health conditions.

**Atmospheric Circulation**

Warming induced by climate change is occurring rapidly in the Peru Andean region; glaciers have lost between 11 to 30% of the mass in the past forty years (Vuille, 2008). In the latter half
of the century a number of glaciers have even vanished completely (Bury, 2008). Leading scientific research has indicated that global greenhouse emissions are growing faster than expected and the recession rates of tropical glaciers will likely continue to increase in the near future (Bury, 2008). Scientists also predict that climate change may occur over a shorter time period than previously predicted (Bury, 2008).

Glacier-fed discharges currently provide a continual supply of melt water that serves as a buffer during the tropical dry season and in drought years (Bury, 2008). Accelerating glacial recession and its impacts on water resources are predicted to lead to significantly diminished water supplies during the dry periods, thus causing severe consequences for the indigenous people in the Andean region (Bury, 2008). Quechua people fear that as the water disappears, the plants and livestock will disappear, and there will be lack of food and medicine in the area (Fraser, 2009). These fears, according to a statement by Dr Pamela Anderson, the director of the International Potato Center, have been proven accurate: diminishing water supply in the Peruvian Andes is affecting the potato crops (Uenuma, 2009).

According to Vuille and colleagues’ research (2008) on glacial length and area variations, glaciers in Peru and Bolivia started to retreat after the Little Ice Age with a major recession occurring in the late 19th century, and an even more rapid recession after 1940.

The Peruvian Andes contain around seventy percent of all tropical glaciers, and glaciers in Peru are among the best studied in the tropical Andes (Vuille, 2008). As mentioned above, temperatures in the Andes have significantly increased over the last seventy years (Vuille, 2008).
Temperatures in the Andes have increased by approximately 0.1 degree Celsius, with only the last twenty years being below the 1961-1990 average and an overall temperature increase of 0.68 degree Celsius since 1939 (Vuille, 2008).

A comprehensive overview of the entire Cordillera Blanca in the Peru Andes, based on the SPOT satellite image and digitalized maps, implies an overall reduction in glacier areas from 850 km square during the Little Ice Age to 800-850 km square in 1930, 600 to 680 km square in 1970, and 620 km square in 1990 (Vuille, 2008). Based on different IPCC (International Panel on Climate Change) scenarios for 2050 and 2080, the projected changes in climate and simulations with a tropical glacier-climate model indicate that glaciers will continue to retreat (Vuille, 2008).

The global retreat of glaciers is anticipated to have severe environmental impacts among the Andean Natives. Flooding caused by glacier retreats will damage the agricultural resources and over time there will be limited water supplies, leading to drought. Health experts from Pan American Health Organization, Harvard School of Public Health, and Johns Hopkins School of Public Health note that the Native people may store water in containers if clean water sources dry up. This will create breeding grounds for disease-bearing mosquitoes, and the Native people will be at risk of mosquito borne diseases (Fraser, 2009).
Distribution and supply of water for pasturage

Figure 3: Change in length of ten tropical Andean glaciers from Ecuador, Peru, and Bolivia between 1930-2005

The graph shows that there has been a decrease of glaciers over seventy years. Climate change is considered to contribute to the declining level of glaciers.

(reproduced from Vuille, 2008, p82).

Environmental Stress of Alpine Plants

Alpine plants are adapted to live in cold environment, because these plants have lower photosynthetic temperature optima and higher photosynthetic capacity per leaf area than low altitude plants (2003). These plants cope with the low temperatures by enhancing their photosynthetic systems by increasing their leaf thickness (2003).
Although temperature warming can increase productivity in many plants, alpine plants are not able to survive in warm weather and even small increases in temperature can have a negative impact on their growth and reproduction (Pieper, 2009). Most plants respond to warming by increased net photosynthesis, which leads to an increase in growth and yields. One reason many botanists believe alpine plants may face extinction due to climate change is that increased temperatures can cause respiration rates to increase relative to photosynthesis (Email from Dr Pauli, May 17, 2010). This process results in no net gain in biomass production, and these plants eventually become a potential source of carbon dioxide (Email from Dr Pauli, May 17, 2010).

Another Andes plant, Queen of the Andes (Puya raimondii), a bromeliad which grows in Peru and Bolivia, may also be at risk of extinction due to Global Warming (Red List, 2009). The plant is only able to survive in a harsh environment, and lacks sufficient variability in its genome to allow the plant to adapt to temperature warming (Red List, 2009). Climate change may prevent the Queen of the Andes from germinating, preventing reproduction (Red List, 2009). The Andean Natives continue use the plant as nutritious food (Benzing, 2000). If the plant faces extinction, the Native people will be deprived of consuming a traditional food.
Temperature warming causes the growth of other types of plants, such as evergreen shrubs and canopy species, and this leaves limited space for alpine plants. As more shrubs and canopy species occupy the highland regions alpine plants may face extinction. As mentioned previously, temperature warming will force plants to migrate to higher altitudes as invading plants occupy their original regions. As these plants migrate upwards, they will face limited areas of appropriate habitat or may completely disappear (Pieper, 2009). These issues of movement of altitudinal vegetation zones have been demonstrated in other regions.

In the Alps, a high elevation region in Europe, the FAO (Food and Agriculture Organization) of the United Nations report that alpine plant species have migrated to higher altitudes at rates
ranging from less than one meter to close to four meters per year over the last century, due to a warming by 0.7 degrees Celsius (WMO, 2009). Similar changes may be expected in the Andes. If the Quechua people have to farm at these higher altitudes, they will have to clear land for their farming. As mentioned previously, this will lead to another environmental problem, deforestation (Hellin, 2005).

Careful crop rotation is practiced by the Quechua Natives to allow them to grow crops in cold environments. Potatoes are grown the first year, ocas the second, barley the third, and back to potatoes in the fourth (Wilson, 1999). This procedure ensures the continued use of the Native people’s land over the longer term.

As mentioned above, crops have been selected in different mountain elevations and ecological niches. Maize is grown from 3,100 to 3,400 masl and intercropped with quinoa, peas, or squash (Mateo, 1990). Potato and barley are located from 3,400 to 3,800 masl and associated with faba beans and quinoa (Mateo, 1990). Alfalfa is found from 3,600 to 3,750 masl and rotations include faba beans-barley and potato-faba beans (Mateo, 1990).

Climate change has an environmental effect on livestock in the highlands as well. As mentioned above, plants are affected by climate change, and this may disrupt the diet of the livestock, such as llamas, alpacas, and sheep. Climate warming may also negatively impact the appetite of livestock, leading to lower weight gain (Adams, 1998). Overgrazing may further accelerate loss of good pasture. Quinoa is one example of a crop used as a high quality food for several livestock and pasture animals in the Peruvian Andes; it is also an important food for human.
The Quechua groups depend on this livestock for meat, wool, fertilizer, and fuel, and these communities at higher elevations may be particularly affected by the negative impact climate change may have on livestock populations. The livestock meat is an important staple among the people at higher elevations. In some areas, 40% of the meat produced is eaten by the local people (Mateo, 1990). The livestock meat contributes a high level of protein, which has a range of health benefits, such as maintaining healthy muscles, healing injuries and repairing tissues, providing energy for the body, helping the body fight off illnesses, and maintaining the immune system (Wilson, 1999).

The Quechua people in Amura noticed that the population of llama is decreasing (Fraser, 2009). In the past, families in the area owned dozens of llamas, and now they only own a handful (Fraser, 2009). The Native people believe that temperature warming may be responsible for the decline of their livestock as they noticed glacier retreats since 1970s (Fraser, 2009). The Native people worry that they will run out of food and endure hunger in the near future.

**Case Study**

In a study conducted in the European Alps Gottfried and colleagues (1999) presented an explicit model that draws scenarios of future species distribution patterns for special cases; they discovered genetic losses are typical in high mountain European Alps.

Based on the lapse rate and on definitions of topographical niches of species, a + 1 degree Celsius and + 2 degrees Celsius warming scenario altitudinal gradients, a predictive model and digital elevation are developed using a fine-scaled digital elevation model. (Gottfried, 1999, p 241).
Although the study was not conducted in the Peruvian Andes, the European Alps share some environmental similarities: both areas are extensive mountain regions of high biodiversity. The findings by Gottfried and colleagues (1999) show that mountain biota, which includes plant species in the Andes, may face extinction as a result of climate warming.

The Gloria programme has very little information about the warming driven migration of Andean plants (Email from Dr Pauli, May 21, 2010). The researchers at the Gloria Programme are at its initial stages in conducting studies in the Andes to determine the impact climate change has on plant migration (Email from Dr Pauli, May 21, 2010). According to Dr Pauli, a PhD in Botany, an upward movement of cultivation of papa and other tuber crops were reported and this may be due to temperature warming (Email from Dr Pauli, May 21, 2010).

Kenneth J. Feeley, a tropical ecologist at the Fairchild Tropical Botanical Garden, conducted research in the tropical forests of Peru on the migration of tree species due to Global Warming (Hance, 2009). He discovered that most plant species are migrating as predicted under climate change (Hance, 2009). Due to temperature warming, many trees may migrate to areas where the Andean farmers graze their livestock (Hance, 2009). Local residents can prevent the trees from migrating by cutting off the corridors between current and future habitat areas (Hance, 2009).

**Physical Environment**

The Quechua zone in Peru is complex and consists of highly contrasting physical and human environments. The altitude of this long strip of land in the Andean mountains, on both the western and eastern slopes of the cordilleras, varies from 2300 to 3500 meters above sea level.
(Wilson, 1999). The environment in the Quechua zone is sub-humid with a distinct season of precipitation (Wilson, 1999). The average annual temperatures fluctuate fairly narrowly; the temperature variation between daytime and nighttime shows a difference of ten degrees Celsius (Wilson, 1999). The Andean plants that can be grown, include maize, squash, wheat, and other Andean crops, such as arracacha (*Arracacia xanthorriza*), cuigua (*Caihua*), and granadilla (*Passiflora ligularis*) (Wilson, 1999).

The Peruvian Sierra provides a far more extensive and productive setting than the other Andes regions for a combination of subsistence strategies.

These include (1) at higher elevations, a pastoralist adaptation focused on alpacas and llamas, the Andean camelid domesticates, and the cultivation of various tubers, including potatoes; (2) at middle elevations, the cultivation of quinoa, and maize, and (3) at lower evaluations, the cultivation of medicinal plants, various indigenous fruit-bearing trees, and coca (Wilson, 1999: 58).

This shows some of the reasons Quechua Natives have a close relation with their land.

**Impact of Climate Change on Natural Resources**

**Plants Used by Quechua Natives**

The variety of ways in which humans use plants sources in their environment depends on their tradition and culture (Gade, 1975). In some areas in the Peruvian Andes, at least ninety percent of the food eaten by local people is supplied by cultivated plants (Gade, 1975). The remainder of their diet comes from livestock and uncultivated plants (Gade, 1975).

The Andes is a complex region with different types of environmental conditions. In areas with high livestock populations, the Native people depend on meat as staple food. In contrast, areas
that contain mostly cultivated plants, the Native people have a limited amount of meat in their diet. Andean people who mainly depend on livestock products for food will have very high protein intakes but a low level of energy intake. However, if these Native people trade some of their animal sources for cultivated food that come from the lowlands and other Andean region, they are likely to have higher energy intakes along with adequate protein.

Table 1: The Diet of Nunoa Quechua Natives

This table indicates the nutrient value of plants and animals in the Nunoa region.

<table>
<thead>
<tr>
<th>Foods</th>
<th>Bulk (1,547 gm.)</th>
<th>Calories (2,170 cal.)</th>
<th>Protein (69 gm.)</th>
<th>Fat (16 gm.)</th>
<th>Carbohydrate (660 gm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuber</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chuno negro</td>
<td>30.4</td>
<td>49.5</td>
<td>27.2</td>
<td>5.8</td>
<td>54.0</td>
</tr>
<tr>
<td>Potatoes</td>
<td>47.9</td>
<td>35.5</td>
<td>31.5</td>
<td>16.9</td>
<td>24.0</td>
</tr>
<tr>
<td>Other tubers</td>
<td>1.8</td>
<td>1.2</td>
<td>0.7</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Subtotal</td>
<td>80.1</td>
<td>74.2</td>
<td>49.7</td>
<td>24.1</td>
<td>79.3</td>
</tr>
<tr>
<td>Cereals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>3.4</td>
<td>5.7</td>
<td>5.8</td>
<td>5.9</td>
<td>5.8</td>
</tr>
<tr>
<td>Maize</td>
<td>1.6</td>
<td>2.5</td>
<td>2.9</td>
<td>0.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.9</td>
<td>1.7</td>
<td>2.2</td>
<td>2.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5.9</td>
<td>9.9</td>
<td>10.9</td>
<td>8.5</td>
<td>9.9</td>
</tr>
<tr>
<td>Chenopodium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quinoa</td>
<td>2.0</td>
<td>5.1</td>
<td>7.9</td>
<td>13.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Chulku</td>
<td>2.9</td>
<td>4.9</td>
<td>9.1</td>
<td>12.5</td>
<td>4.2</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5.9</td>
<td>10.0</td>
<td>17.0</td>
<td>25.8</td>
<td>8.7</td>
</tr>
<tr>
<td>Animal foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>6.0</td>
<td>2.8</td>
<td>21.4</td>
<td>17.0</td>
<td></td>
</tr>
<tr>
<td>Coke, or fish</td>
<td>0.3</td>
<td>1.1</td>
<td>0.6</td>
<td>20.9</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>6.3</td>
<td>3.9</td>
<td>21.9</td>
<td>37.9</td>
<td></td>
</tr>
<tr>
<td>Others*</td>
<td>1.8</td>
<td>2.0</td>
<td>0.4</td>
<td>1.7</td>
<td>2.2</td>
</tr>
</tbody>
</table>

(From Mazess, 1964, p344).

At the time the Spanish conquerors arrived in the early sixteenth century, the Andes Natives cultivated as many as seventy crop species (Wilson, 1999). This is equivalent to nearly the same number of agricultural crops in all of Europe and Asia (Wilson, 1999). The European settlers did
not have any interest of any of the Andean Natives’ agricultural resources; they replaced many of these species with European plant domesticates. Even though the Europeans brought their own plants, the Native people continued to use their traditional resources as they have done for many centuries.

The Andes Natives still cultivate a wide range of plant species in remote areas in the Peruvian Andes. The Andean system of cultivators in its totality is estimated to have produced enough food to support around fifteen million people (Wilson, 1999). They use the resources to their limits and do not exceed or waste it. They want to sustain the resources so that they can continue to use and enjoy the resources, as well as so future generation can use the resources and enjoy the aesthetic beauty of their natural surroundings. However, with climate change and deforestation, many plants will be at risk of extinction.

Wild plant species are also beneficial to the Native people nutritionally and allow them to continue their cultural practices. The plants provide an important source of vitamins, minerals, and other nutrients that complement the staple foods eaten by the Andes Natives. Many of the indigenous people are cash poor and may not be able to buy food and mainstream medicine from the market. Harvesting the resources directly from the environment also allows them to benefit economically.

**Staple Plant Foods**

The majority of the food eaten by the Quechua Natives in normal years is supplied by cultivated plants (see Table 2). Seed and root crops are the staple foods of the Andes Native population
(Wilson, 1999). There are at least twenty-five species of root and tuber crops that are native to South America (Hermann, 1997). Root and tuber crop diversity is particularly common in the Andes region and plays a major role in the farming system. The diversity of crops leaves the Andean Natives with more than enough food for themselves and their communities.

Table 2: Nutritional Value of the Major Peruvian Andean Crops

The table shows the nutrient value of some plants grown in the Andes region. The table also indicates the elevation range of the crops.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Nutritional Facts</th>
<th>Parts Used</th>
<th>Elevations</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mashua (Tropaeolum tuberosus, Tropeolaceae)</td>
<td>High level of Vitamin C, Vitamin B1, Vitamin B2, lipids, high level of protein, and fiber</td>
<td>All parts are consumed, but tuber mostly consumed</td>
<td>2400-4300 m</td>
<td>Flores, 2003, p162</td>
</tr>
<tr>
<td>Ulluco (Ullucus tuberosus, Basellaceae)</td>
<td>Excellent source of protein, carbohydrates, and vitamin C</td>
<td>Tubers</td>
<td>3000-3800 m</td>
<td>Flores, 2003, p 162-163</td>
</tr>
<tr>
<td>Achira (Canna edulis, Cannaceae)</td>
<td>Very rich in carbohydrates and contains some glucose and sucrose.</td>
<td>Rhizomes</td>
<td>1000-2900 m</td>
<td>Flores, 2003, p163</td>
</tr>
<tr>
<td>Maca (Lepidium meyenii)</td>
<td>258 mg of calcium, 15.4 mg of iron, 59% carbohydrate, 10% protein, and 8.5% fiber.</td>
<td>All parts are used</td>
<td>3500-4500 m</td>
<td>Flores, 2003, p.163</td>
</tr>
</tbody>
</table>

The effects of climate change on crop and livestock can be complex. Large areas in South America, including the Andes, are affected by changes in climatic factors such as temperature and precipitation and frequency and severity of extreme events like floods and droughts (Wilson, 1999). Studies conducted in the region specifically assess the impact of global warming on agricultural yield production (Adams, 1998). These studies show a reduction in yield (Adams, 1998). The GISS general circulation model for several locations in South America predicted temperature increases of 3 to 4.5 degrees Celsius, and the implications of this climate change for four Latin American countries, including Argentina and Uruguay, indicated a ten to thirty percent yield reduction (Adams, 1998). Since this paper focuses on the Peruvian Andes, I included data found in neighboring countries, because the Andean regions in these countries have many environmental similarities.

These crops are nutritionally important to subsistence Andean farmers and communities, and are often used as substitutes for expensive fruits and vegetables that come from other areas outside the Andes. Roots and tubers are rich in carbohydrate and other nutrients, use less water, and grow on land that does not support other crops. The crops in the Andean region used by the local people as nutritious food, include Mashua *(Tropaeolum tuberosu)*, Ulluco *(Ullucus tuberosus, Basellaceae)*, and Maca *(Lepidium meyenii*, (see table 2), but here I will focus particularly on the health and nutritious benefits of achira *(Arracacia xanthorrhiza)* and quinoa *(Chenopodium quinoa)* among the Quechua groups in Peru.
Achira

The plant source achira (*Canna edulis*) is closely related to canna lilies grown in tropical and temperate regions outside South America (Wilson, 1999). Achira is important to the Quechua Natives because it survives when other plants are not able to, providing nutrition when other sources are limited. Achira is low in calcium and phosphorous, but high in potassium (Wilson, 1999). The leaves and shoots provide ten percent of the protein in the Native people’s diet (Wilson, 1999).

Potassium is a vital nutrient and is one of the seven major minerals our body requires to maintain normal function. The mineral helps in the transmission of nerve impulses, assists in allowing muscles to contract properly, regulates blood pressure, and maintains a regular heartbeat. Not only is potassium beneficial for our physical health, but also our emotional well being. Significant amounts of potassium in the diet helps in dealing with anxiety, stress, and irritability.

Protein contains the essential amino acids that are required in the daily diet. Essential amino acids are the building blocks for healthy muscles, nails, skins, hairs and other body tissues. (Wilson, 1999) Recent research shows that adequate protein helps prevent or control chronic illnesses, such as cardiovascular diseases, cancers, and diabetes (Wilson, 1999).

Many Quechua people living in areas with small numbers of livestock must rely on plant sources for protein. Plants, such as quinoa, ocu, and kaniwa have high levels of protein. Most of the Quechua people are cash poor, have limited livestock, and thus depend heavily on plant sources for protein (Wilson, 1999). Many of the plants in the Andes, in addition to achira and quinoa (discussed below), contain high level of protein and substitute for the meat products that are
limited in some regions. Although many of these plants alone have high levels of protein, they do not contain all the essential amino acids, and need to be combined with other plant foods to get a complete protein.

**Quinoa**

Quinoa (*Chenopodium quinoa*) is a pseudocereal that has been a cultivated and important food grain source since 3000 BC; it has been a staple part of the diet among millions of indigenous people, including the Quechua communities in Peru (Bhargava, 2005).

Quinoa is high in nutritional value and it is high in protein (Bhargava, 2005). Since it is rich in omega-3 fatty acids, quinoa is nutritionally beneficial to the heart and digestive system. Quinoa has an average of sixteen percent of protein (Wilson, 1999). It provides all essential amino acids, including lysine, cystine, and methionine (Wilson, 1999). As mentioned previously, essential amino acids aid in tissue growth and repair. They are also effective in preventing arthrosclerosis.

Quinoa falls in the group of complex carbohydrates, which allows the food to digest slowly into our body. The complex carbohydrate allows us to feel full longer and helps balance blood sugar in our body. The crop also has high levels of potassium. Due to its high nutrient content, quinoa plays an important health role among the Andes Natives, and climate change poses a risk to the crop, as I will detail below.

Quinoa is grown at 3,100 masl, but the crop can also be easily cultivated up to 3,800 meters (Mateo, 1990). Quinoa can survive in harsh environmental conditions, but despite its hardiness it
is vulnerable to a variety of pest and disease problems. These problems may occur when quinoa is introduced to a new production area (Oelke, 1992). Viruses have been found in quinoa fields in the Andes, yet there needs to be further research to determine the damage caused by these viruses (Oelke, 1992).

Quinoa has a chemical defense, saponins, against insects. But rainy weather can easily wash out saponins, which allows insects to damage the crop during seed germination, harvest, and seed storage (Oelke, 1992).

**Photoperiod-sensitive development phases in quinoa**

Bertero and colleges (1998) conducted an experiment of the effect of photoperiod on seed growth and examined a photoperiod times temperatures interactions on seed growth in one cultivator. The cultivars were from the Andean plateau in southern Peru and from the tropical valley of central Peru (Bertero, 1998). The objective of this experiment was to establish which development phases are sensitive to photoperiod and whether conditions during a particular phase had delayed effects on subsequent development (Bertero, 1998). Plants were grown in naturally lit growth cabinets under controlled conditions and photoperiods were given as ten hours of natural daylight followed by extensions with low intensity artificial light giving either a short day (SD) of 10.25 hours or a long day (LD) of 14 to 16 hours (Bertero, 1998). In the experiment, the treatments were kept constant between SD or LD photoperiods or they involved transfers between photoperiods at different development stages (Bertero, 1998). Though photoperiod will not change with climatic change, plants that were grown SD and in LD both responded to increased temperature with smaller seeds.
For plants that were grown in SD until anthesis and shifted to various environments, seed size was measured twenty-one days after anthesis. Seeds were larger under the SD, cool temperature treatment. Hot temperature and long photoperiods have decreased the seed sizes (Bertero, 1998). Under the LD and hot temperature treatment, seed size was reduced by fourteen percent in the SD hot day and seventy-three percent in the LD hot temperature (Bertero, 1998).

The study shows that climate change will likely have a negative impact on the development and seed growth of quinoa, which is the source of the food “grain”. Other crops in the Andes may show similar effects. This reduction in yield will reduce food security and nutritional adequacy of local diets, and thus likely will impact overall health. Although the study does not focus on anthropogenic climate change, it is relevant, because it shows that temperature warming will affect the Andean people’s valuable crops that they depend on their livelihood.

**Medicinal Plants**

The Peruvian Andes has a variety of medicinal plants that are used by the Quechua people to treat all sorts of diseases and illness ranging from colds to cancer (Hammond, 1998). They have used these medicinal plants for centuries and the knowledge was passed down by generation after generation from their ancestors. Climate change may pose the threat of extinction to the medicinal plants in the near future as these plants may not be able to survive in warm temperatures. If medicinal plants disappear, the Native people may suffer further health wise, as they may lack treatment of various types of illnesses. Traditional healers in the Andes have started to notice some loss of medicinal plants, and ethnobotanists at the American Botanical
Council believe that climate change may be responsible for the decline of these plants (Cavaliere, 2009).

**Therapeutic Effects of Medicinal Plants**

Hammond and colleagues (1998) carried out field work in different villages throughout the Callejon de Huaylas. The region is located at the northeastern flank of the Peruvian Andes and is in between two mountain ranges that form part of the Andes Cordillera (Hammond, 1998). The majority of the inhabitants are Quechua Natives. Data were collected through informal conversations with traditional doctors and herbalists, as well as with local elders (Hammond, 1998). A total of thirty-three medicinal plants were surveyed in the region (Hammond, 1998). The table below gives a few examples of therapeutic effects of medicinal plants used by the Quechua Natives in Peru.

Table 3: Uses of Medicinal Plants from the Callejon de Huaylas

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Uses</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molle</td>
<td>Treats colds, coughs, and asthma</td>
<td>Hammond, 1998, p20</td>
</tr>
<tr>
<td>(<em>Anicadiaceae schinus mulle</em> L.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Llanchuasa</td>
<td>Heal wounds</td>
<td>Hammond, 1998, p20</td>
</tr>
<tr>
<td>(<em>Senecio rhizomatosus Rusby</em>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anis Serrano</td>
<td>Treats stomach ache and intestinal pain</td>
<td>Hammond, 1998, p20</td>
</tr>
<tr>
<td>(<em>Tagetes filifolia Lag</em>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(<em>Werneria nubigena</em>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lengua de perro</td>
<td>Health tonic for liver</td>
<td>Hammond, 1998, p20</td>
</tr>
<tr>
<td>(<em>Gamochaeta spicata Lamarck</em>)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The data from Hammond’s (1998) study shows that medicinal plants are still used by the Quechua groups in Peru to treat all types of illnesses and diseases. There are many other medicinal plants, too numerous to mention, that are used by Quechua Natives (see Bastien, 1987 for further discussion of medicinal plants in the Andes).

Traditional Healthcare

In neighbouring Bolivia, Vandebroek and colleagues (2008) conducted a study of illnesses treated with traditional and biomedical health care. This study reveals the widespread and continuing importance of medicinal plant use in highland Quechua communities. Vandebroek and her colleagues found patterns and demonstrate similarities and differences in the treatment of health conditions in a Quechua community. Their study was based on plant use data from traditional healers and patient data from primary health care services. While my primary focus is on the Quechua groups in Peru, the similarity of culture and medicinal plant use makes the results applicable throughout the highland Quechua area.

Vandebroek et al. carried out a secondary analysis of plant use based on data from semi-structured interviews with eight healers and diagnostic data was collected from 324 patients in the community primary health care (PHC) service (Vandebroek, 2008). Health conditions were ranked according to the percentage of patients in the PHC service diagnosed with these conditions, and the citation frequency of plant use reports to treat these conditions by healers (Vandebroek, 2008). Plant use reports from healers provided 1166 responses about 181 medicinal plant species most frequently used to treat different types of illnesses: wounds and bruises, respiratory infections, fever, arthritis, pain, biliary colic, and rupture (Vandebroek,
The range of conditions treated shows the widespread importance of traditional medicine to treat all type of illnesses and diseases.

According to the UN Development Program, in 2000, 15% of the Peruvian population lived in extreme poverty (Kristjanson, 2004). Almost half of the people facing ‘extreme poverty’ live in highland rural areas (Kristjanson, 2004). The term ‘extreme poverty’ is associated with low levels of income, low levels of consumption, lack of access to basic services, such as health, education, water sanitation, and low levels of ownership (Tauhid, 2007).

Temperature warming may pose a risk of extinction of plants and livestock, and this will worsen their socio-economic conditions and leave them to continue to endure poverty, facing hunger and related illnesses (WFP, 2010). Microfinance is one initiative that can reduce poverty among the Quechua Natives, as well as assist in adaptation to climate change and develop of new economic bases.

**Microfinance**

Because the Andean Natives do not have the type of collateral that the banks require, they are not able to get loans from traditional banks. Microfinance organizations can help resolve these problems by providing the Quechua people with small loans that enable them to run small businesses, and at the same allow them to sustain their natural resources.

In 1974, Muhammad Yunus, a Bangladeshi economics professor, started the concept of microfinance by lending small amounts of money to impoverished basket weavers (Khan, 2006).
The professor was successful with his plans, and over time the grants of very small loans to the poorest people worldwide enabled them to run small businesses that allowed them to escape poverty (Khan, 2006).

By lending money to Quechua Natives to establish small businesses where they can combine sustainable resource management with related value added to income generating activities, microfinance loans allow the Quechua people to gain economically (Hammill, 2008). The Quechua people have a long tradition of making clothes from specific livestock and cooking different types of food from plants and animals. If the Native people establish small businesses and sell their items to tourists and neighbouring communities, this may allow the Andean people to become economically independent and enable harvesting resources in a sustainable method. Many Quechua Natives live in poverty and their social-economic background is strongly connected to their poor health conditions (Kern, 2001). Assisting Native people economically may allow them to improve their overall health conditions and nutritional levels.

Environmental issues are not a top priority for the Peruvian government as compared to economic issues. The Government and industries continue to impact the environment, which threatens the Native people’s way of life. Alan Garcia, the president of Peru, did not attend the recent Copenhagen meeting on global warming. Some NGOs believe that Garcia did not attend because he feared he would scare investors away and many of these investors are responsible for environmental problems in Peru (Bo, 2009).
Recently Garcia issued a series of decrees to encourage foreign companies to extract oil and gas extracts in the Amazon (Bo, 2009). The extraction will cause many environmental problems, such as pollution in the rivers, decline in fish and other natural resources, landscape disturbances, and risk of certain diseases. Many indigenous people also see the decrees as a threat to their ancestral land and way of life (Bo, 2009).

Peruvian Government statistics do not place any value on natural resources in the Andes, yet Andean plant species play an important role economically in the highlands. Although resources obtained directly from the environment provide the Native Andeans their basic needs for survival, these resources bring little transactional value to the economy. The Andean Natives from different areas currently have trade relationships with one another for the exchange of food. In some cases, the Andean people sell their resources to the market in order to earn an income (Kristjanson, 2004). In the Puno communities, three quarters of total income comes from livestock sales (Kristjanson, 2004).

**Establishing Businesses**

Kristjanson and colleagues (2004), carried out a household survey, using a combination of qualitative and quantitative methods. The authors examined 40 rural communities in the Andean regions of Peru, in Puno and Cajamarca Departments and the four Provinces within each of these regions, to determine how households have moved out of poverty in the last 10 and 25 years (Kristjanson, 2004). The method used to measure poverty is based on incomes or consumption level (Kristjanson, 2004). A person is considered poor if his or her income or consumption level is below the minimum level necessary to meet basic needs (Kristjanson, 2004). According to
Kristjanson and colleagues’ findings: “The odds of escaping poverty are 13 and 16 times greater than living in poverty in Puno and Cajamarca, for households who opened up their own businesses” (Kristjanson, 2004, p 12). Establishing businesses that use the natural resources to make valuable products is one way to help the Native people escape poverty.

A lot of non Native people, including American and European tourists and Hispanic Peruvians, appreciate Andean food and clothes, and by selling these products, the Andean people can have the opportunity to gain economically and manage their resources in a sustainable manner. One approach is that the Native people can open restaurants in different parts of the highlands and these restaurants can serve different types of traditional meals using plant species and livestock from their land that may attract non Native groups. As mentioned previously, a proportion of income comes from livestock in some communities in the Andes. Llamas and alpacas are used to make wool and fiber to sell in the market (Kristjanson, 2004). Microfinance organizations can also help the Native people to start small clothing businesses to sell their traditional clothes to tourists and other communities around the Andes.

BIOANDES, an NGO based in Cusco and funded by the Swiss Agency for Development and Cooperation, is one successful case that allows the Quechua people to sustain their resources and culture, while enabling them to be economically independent. BIOANDES is involved in several projects that assist Andean Natives with commercializing their products. In one project, the staff at BIOANDES helped the Quechua women in Cusco to commercialize textiles made by spinning alpaca and sheep wool, and which use plants to dye the materials to design traditional indigenous iconography (Mathez-Stiefel,
These textiles were sold to tourists outside the Andean regions and these women generated income by using sustainable methods to harvest their resources (Mathez-Stiefel, http://www.mnhn.fr/colloque/localiserlesproduits/25_Paper_GIANNELLA_MALCA_C.pdf). This eventually enhanced their status in the Peruvian society.

According to a telephone interview with Sarah-Lan Mathez at the Centre for Development and Environment (May 26, 2010), she stated that BIOANDES is implemented by several local NGOs and one might deal with microfinance. She also stated that Aldo Tezerina, a researcher at BIOANDES, is conducting a study on the integration of the indigenous economic system and the market economy in Bolivia (Phone conversation with Sarah-Lan Mathez, May 26, 2010). When the article is published, it will provide NGOs that deal with microfinance with some models for assisting the Andean Natives to contribute economically to society.

NGOs that use microfinance can also follow BIOANDES’ example by lending the Native people to start small businesses to sell items made out of natural resources. These NGOs can also get involved in commercializing products, so the Andean Natives can continue to use their traditional knowledge to harvest their resources in sustainable manner and gain economically. FINCA, a microfinance organization in Peru, is one example that helped over 9,000 Andean Natives, especially women, to start small businesses by using their natural resources (Downing, 2010). Many Quechua entrepreneurs worked as market vendors, small store owners, artisans, and other family income generation activities (Downing, 2010). The organization helped many Native people escape poverty. There are other Microfinance organizations in Peru that help
Quechua Natives to start businesses by using natural resources. If more Quechua people contribute to the economy by using sustainable methods to harvest their resources, the Peruvian government may recognize the importance of these resources, and be encouraged to implement stricter laws to protect the environment.

Using these strategies, the Native people may be able to produce enough resources for themselves and sell the surplus to tourists and neighbouring communities. The NGOs can commercialize local products in the national economy and continue to make sure the Quechua people sustain their resources. In this process, they need to have control of their businesses and maintain knowledge of their recipes and ways of designing clothes without the government interfering. The NGOs can keep a vigilant eye on preventing government policies from pushing commercial production and discarding old-fashioned methods (Mathez-Stiefel, http://www.mnhn.fr/colloque/localiserlesproduits/25_Paper_GIANNELLA_MALCA_C.pdf).

Climate change may have a negative impact on the NGOs plans to help the Native people economically. If the temperatures continue to increase, these resources may become endangered or even extinct, and the Native people will not be able to combine sustainable resource management with income generation activities.

**Reaching out to Remote Areas**

Microfinance organizations face difficulties in remote areas, due to poor road infrastructure, scattered housing, and long distances from urban areas (Lee, 2006). Some Andean regions have microfinance organizations, but some communities in the highlands are located at much higher
altitudes, and are isolated further away from microfinance organizations. The people in these remote areas may have difficulty traveling to another village in order to access NGOs that deal with microfinance (Kristjanson, 2004).

Microfinance organizations in rural environments include electronic loans, such as e-banking and micro-leasing. Many Andeans in extremely remote areas will be deprived of access to loans, also because they lack reliable electricity and phone services. Microfinance organizations need to create more offices in rural and remote areas in the Andean regions. Although there are challenges in opening offices in these areas, it is still possible. Self-help groups, community based organizations, which are promoted by International NGOs can help microfinance organizations reach remote areas. As more businesses are established in isolated regions in the Andes, more tourists and residents from other villages will be attracted to remote areas. This will have a positive economic impact in remote regions.

**Microfinance and Environmental Education**

Access to financial services is one factor that assists the poor in escaping poverty, but there are other development services in combination with microfinance that can help the impoverished. By using microfinance as a tool in climate change adaptations, it is important for NGOs to implement an environmental education program. Environmental education is a process that brings awareness and knowledge to learners about the environment, including the relationship of humans to the natural world (CEGN, 2006). It also promotes the development of the skills, attitudes, and motivations to enable learners to make informed environmental decisions. Environmental education teaches powerless groups of people strategies to peacefully demand
their rights to live in harmony with their natural surroundings and pressure the government to implement stricter environmental laws.

The socio-economic and ethnic background of the Andean Native people should not force them to be victims of environmental degradation while the Government and industries abuse the environment. Volunteers and staff members, in the NGOs that deal with microfinance, can educate the Quechua people about their rights to live sustainably on their land and to effectively tell the government and industries that their careless attitude on the environment is destroying the indigenous people's livelihood. Educating the Quechua Natives about Gandhi in India and his peaceful approach to fight against injustice upon the poor and marginalized groups may empower the Quechua people to demand their rights to protect their land.

Staff members in the NGO can also develop environmental education programs that can teach the non-Native people about the severe environmental issues in the highlands. One way of addressing the severe environmental problems in the Peruvian Andes is for the NGOs that deal with microfinance to mandate meaningful environmental education programs in primary, secondary, and post secondary institutions across Peru. Although the paper focuses on the impact climate change has on the natural resources in the Andes, the highland regions also face a number of other environmental issues, such as soil erosion, water pollution, deforestation, and wastes from mining activities (National Research Council, 1989). Bringing awareness to Non Native people, and even younger generation Native groups in academic settings, will allow them to gain necessary education about environmental issues in the highlands. Once they are aware of the reality of the Andes and how environmental degradation will impact the country
economically will motivate many non-Native people to take the necessary measure to protect the environment. Environmental education would allow the integration of many different subjects, such as social science, science, and history, thus providing students’ knowledge in all aspects of the environment and expanding their horizons. It would give the youth a basic understanding of human impacts on the local ecosystem, as well as the biosphere.

**Ecotourism**

Due to increased awareness of climate change, ecotourism has gained popularity among the tourism sector. Ecotourism is tourism to threatened ecosystems and shows ways to prevent extinction of natural resources. Since the Peruvian government is not too concerned with protecting the environment, ecotourism may be another option to assist the Quechua Natives to protect their resources from environmental degradation.

The Sikkim Ecotourisms and Biodiversity Project in the Himalayan state of India is a successful example of ecotourism that enhanced indigenous capacity and generated economic incentives to conserve natural resources (The Mountain Institute, 1996). With many domestic and international tourists visiting the site, this generated economic benefits for the Sikkimese people, as well as protected their resources (The Mountain Institute, 1996). One of the project’s initiatives is to increase awareness of resource conservation to tourists, so they will have a greater understanding of the importance of protecting the environment. Since the ecotourism project benefited the country’s economy, the Indian government is eager to embrace policies to minimize the environmental problems that would destroy the resources which attract tourists (The Mountain Institute, 1996).
The success of the ecotourism project in the Himalayans shows that it is possible that the same methods can apply in the Peruvian Andes. Ecotourism may also benefit the Andean Natives. The Quechua people aim to develop agro ecotourism site as well. The Potato Park (Parque de la Papa) is an example. Many tourists from other parts of Peru and worldwide visit the Potato Park to have a better understanding of the Quechua Native’s close connection with their land. The Potato Park is indigenous-run and it is being implemented in south of Pisac that aims to conserve natural resources in the Peruvian Andes (Colchester, 2003). The park grows more than 1,300 varieties of potato and the Quechua Natives put these potatoes on display for visitors to view (Colchester, 2003).

Although the park is popular among many visitors, the management still has to persuade the Peruvian government to recognize that the park needs to be part of the country’s protected area system (Colchester, 2003). The government is not implementing environmental laws to protect the park (Colchester, 2003). If the park develops into an ecotourism site that attracts many tourists similar to the Sikkim project and benefits Peru’s economy, then the government may be more enthusiastic in implementing stricter environmental laws to prevent the damages to the resources in the Andean regions.

NGOs that deal with microfinance can work with Native people to develop programs that educate tourists about their natural resources. They can help them set up a display of potato and other natural resources that is a similar but smaller version of the Potato Park. As the government notices tourists visiting the site and the positive impact they have on the economy, they may be
enthusiastic to implement laws to protect these natural resources. If the Quechua Natives live in better environmental conditions, they will continue to have the opportunity to sustain their resources and not be deprived of nutritious food and treatment from medicinal plants.

**Conclusion**

Throughout their history, the Quechua communities in the Peruvian Andes always have depended on the natural resources from their land for their livelihood. The Andean plant and animal species provide the Native people with nutritious food and medicine for their health and well being. The knowledge about the use of these resources was passed down from generation to generation. Unfortunately, Global Warming is posing a risk to these resources. Although the Native people may be able to adapt to changing environmental conditions, these changes pose cultural and health risks which are difficult to respond to with limited economic resources.

Microfinance is one way to help the Andean Natives sustain their resources and at the same time gain economically. If the government sees the economic value of these resources, they may be willing to implement stricter environmental laws that will protect the natural resources. At the moment, the government is turning a blind eye towards the environmental consequences of economic activities and focusing mainly on financial gain. Education programs from these NGOs that deal with microfinance can teach the Native people peaceful strategies to pressure the government for their rights and assist the indigenous people to maintain an environmentally and socially sustainable way of life in the face of global environmental and economic change. These
education programs can also teach the society outside the Native groups about the importance of protecting the environment.
References


the Native Peoples of the Americas: Volume 111 South America, Part 2. (pp. 765-870).


Fraser, B. (2009). Climate change is hitting South America with a triple whammy: More water stress, more migration, more disease. The Daily Climate.


