

Impacts of Climate Change in the Ecuadorian Andes

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III. Abstract

The Ecuadorian Andes is a region more susceptible to the impacts of climate change. However, there is a lack of data detailing the specific effects of climate change in the Ecuadorian Andes. Numerous studies discuss individual factors that display the impacts of climate change within this region, but most studies only analyze one component at a time. More data detailing the individual elements connected to climate change in the Ecuadorian Andes is needed. Additionally, these elements need to be analyzed as a group to understand their combined impact. It is clear from studies on glacier retreat that warming trends are impacting the Andes. Over time elements such as UV exposure, declining moisture content, and the introduction of Eucalyptus will, similarly to glacier retreat, have a significant negative impact on the water supply within the region.

IV. Introduction

The country Ecuador is smaller than the size of the state of Texas yet has three distinctly different environments. The Coast, the Amazon, and the Andes mountains compose the country's three distinct regions. The country's varying climate conditions within these regions allow for many species to thrive within one small country. Ecuador is famous for being a biodiversity hotspot. Not only does Ecuador have a large number of native species, but 15.6% of the species found on the mainland of Ecuador are endemic (Continental Ecuador).

Throughout history, humans have been responsible for changes to the planet's environment. Currently, one of the most significant threats to the environment is climate change. In countless scientific studies, it has been proven that humans are the main contributors to the Earth's rapidly changing climate. However, climate change does not affect the planet in one uniform way. Different natural environments are subject to varying impacts of climate change based on factors such as spatial location and weather patterns. Climate change not only impacts the environment but humans as well. New climate change prevention and mitigation techniques need to be implemented to protect these species and the people that live within Ecuador's Andes. However, before making recommendations for protection against the impacts of climate change; one must understand all of the factors that contribute to the effects within the Andes.

V. History of the Elements Linked to Climate Change Impacts in the Andes

The Andes mountain range within Ecuador is assumed to be more susceptible to the effects of climate change. However, there is a significant lack of research detailing what the specific impacts are that this region will face. One impact that we have been able to observe better than most is the rapid recession of glaciers present in the Andes within recent years. The recession of the glaciers is often attributed to climate change. However, glacier recession is just one indicator. More studies need to be completed on the impact of climate change on the Andean region of Ecuador due to other factors that make this region more susceptible to harmful effects. Factors that are likely to magnify the impacts of climate change within the area include increased exposure to ultraviolet rays (UV rays), weather events such as El Nino, and the recent introduction of Eucalyptus.

i. UV Exposure

UV exposure and elevation have a positive correlation. Although temperatures may decrease at high elevation, the effects of the sun's UV rays increase due to a thinner atmosphere. Additionally, proximity to the equator increases the susceptibility of a region to UV rays. While vegetation in the Andes has evolved to be more resilient to UV rays, there are still human health impacts to consider. Studies have shown that skin cancer is the second most common form of cancer for both men and women in the Ecuador Andean region (Harari Arjona et al. 2016). However, even though UV exposure has adverse effects on the human population, there is little

research within the Andean region on the impacts of increasing UV exposure on outdoor laborers and vegetation.

ii. ENSO

El Nino Southern Oscillation (ENSO) is a "climate phenomena" that impacts atmospheric conditions by causing a shift in low-level surface winds called "easterly winds." El Nino affects the atmospheric conditions by causing easterly winds to blow in the opposite direction or become significantly weaker (L'Heureux, 2014). In the Andes, El Nino events are associated with warmer climate conditions and reduced cloud coverage (Burke, Erin, et al.). Since El Nino events in the Andes have warming effects, precipitation is more likely to be rain instead of snow. Precipitation state is influenced by climate change events and may have an impact on glacier retreat and vegetation in the Andes as well. Precipitation occurring less frequently has been reported in recent years. Less rainfall could have a devastating effect on the water supply in the region. However, there is a lack of meteorological data to fully understand the impacts of change in precipitation for the region (Rabatel et al. 2013). Overall, unlike UV ray impacts, there are numerous studies that pertain to the impacts of more frequent El Nino events occurring within the Ecuadorian Andes. Glacier retreat attributed to the warming effects of El Nino events will be discussed further.

iii. Humidity & Moisture

The effects of increasing atmospheric temperatures due to climate change and ENSO has been hard to gauge in the Ecuadorian Andes due to a lack of long term studies. In 2003, a study showed that over the span of ten years, Ecuador experienced a 2.5% increase in humidity, and

other studies have speculated about increased humidity within the Andes (Rabatel et al. 2013). An increase in humidity indicates an increase in atmospheric and sea surface temperatures. Humidity is linked to these two factors because higher temperatures cause more frequent evaporation, which then increases humidity. However, high humidity does not mean that there is always consistent precipitation. Since the data that researchers have on ground moisture content is typically only a few years old, some scientists have been combining short term studies and the views of locals to produce comprehensive data. One study that pertains to the climate change effects on the region stated that local farmers have reported "ground moisture dries more quickly than in the past and that the sun is 'stronger,' and this, too, is consistent with a warming atmosphere" (La Frenierre, J., & Mark, B. 2017). More research needs to be conducted on moisture content. A decrease in in-ground moisture content due to increasing atmospheric temperatures will, over time, have a negative impact on vegetation and crops.

iv. Eucalyptus

Eucalyptus was introduced to Ecuador from Australia in the 1800s as a part of an initiative to reduce erosion of exploited land. In recent decades especially, Eucalyptus has been a significant part of reforestation efforts throughout the country, including the Andes. Eucalyptus grows quickly and also acts as a source of revenue for some locals who sell it. However, the introduction of this non-native species has had many negative impacts on Ecuador's environment, specifically the water supply. One region with an abundance of Eucalyptus is the tree plantation on the Nasiche River water basin. This plantation also contains pine trees, which are invasive as well. A news article about this plantation states that these trees (Eucalyptus and

Pine) each take up about 5-10 gallons of water a day from the ground and reduce soil quality (Magdaleno, 2017). This amount of water retention severely threatens local water supplies. More studies in the Ecuadorian Andes are needed to understand the introduction of this tree species further.

VI. Glacier Retreat

Scientists in the past decade have been making more efforts to monitor the impacts of climate change in the Ecuadorian Andes. However, climate change impacts multiple elements of the environment in different ways, which makes the impacts of climate change difficult to observe. A lack of consistent meteorological data also contributes to an incomplete view. One of the most well-documented and visible effects of climate change in the Ecuadorian Andes is the glacier recession. Aerial view images taken years apart are one method scientists have used to confirm that the Andes are significantly impacted by climate change. Aerial photographs showed that Cotopaxi's ice cap experienced a 30% reduction in mass between 1976 to 1997. The Anastasia glacier on Anastasia volcano has experienced a reduction of 8% in ice coverage between 1996 to 1998 (Burke, Erin, et al.). These rapidly increasing ice recession rates indicate that if warming trends continue, glaciers on volcanoes in the Ecuadorian Andes may recede so drastically that they disappear by the year 2080. However, volcanic activity could accelerate this process (Lopez et al., 2017).

Glaciers in the Andean region have experienced accelerated glacier mass reduction. The accelerated mass reduction is mainly due to the geographical location and UV exposure. Equator regions typically do not fluctuate in temperature. However, weather events like ENSO can result in significant temperature changes. El Nino events cause the Andes to experience warmer air

temperatures, which reduces the chance of potential snowfall. Low wind speeds and less cloud coverage, which increases snowmelt, are also associated with El Nino events. Due to these warming effects, El Nino events have been shown to influence glacier recession (Rabatel et al. 2013; Burke, Erin, et al).

i. Impacts of Glacier Retreat on Water Supply

The recession of glacier mass within the Ecuadorian Andes directly affects the water supply within the region. As the ice caps melt, they replenish water supplies for the mountains and highland regions. A slow and steady melt is not problematic if snow production continues. However, warming trends indicate that glacier mass is rapidly receding and not being replenished. Glacier melt, lakes, and precipitation are the main sources of water for the region. A reduction in water supply will not only affect the animal and plant life within the region but also humans. People who reside within the Andes are typically farmers who require drinking water and a steady source of water for crop production (Córdova, 2018). Additionally, people who reside in cities below mountains still use the water from glaciers for both drinking and hydroelectric power (Harari et al., 2016).

The recession of glaciers, combined with other factors, needs to be researched. For example, data has shown that El Nino events accelerate glacier melt, but to what extent still needs to be determined. Another example is the connection between lakes and glacier runoff. The Paramo region contains many of the region's lakes. The deep lakes within the area have experienced a trophic level shift due to warming trends, but the shallow lakes have remained consistent. Overall, a majority of lakes in the Paramo region have yet to be dramatically

impacted by climate change (Labaj et al. 2018). To help mitigate the impacts of climate change more research about these lakes should be conducted. If glacier runoff is a primary contributor to these water sources, the sustainability of the lakes should be researched.

Glacier mass reduction has a negative impact on the water supply for the region. While many research papers acknowledge the reduction of water supply that will occur, they neglect to also account for other elements that will magnify the impacts of climate change within Ecuador's Andean region. Increasing UV exposure, increasing El Nino events, a reduction in moisture content, and the introduction of Eucalyptus are all elements which will increase climate impacts within the region. Eucalyptus will accelerate the reduction of the water supply. A reduced water supply combined with increasing UV may result in stunted plant growth. Over time the ecosystem of the Andes may be dramatically altered. The livelihoods of farmers would be put at great risk as well, which would ultimately disrupt Ecuador's economy.

VII. Conclusion

Many of the potential factors that contribute to or magnify climate change in the Andes impact the country's water supply. While rising temperatures may not seem important to a region that is accustomed to high temperatures, human life can not be sustained without a reliable water supply. This paper briefly discusses the many factors that affect climate change impacts within the Ecuadorian Andes; all of these components could benefit from additional studies. For example, the environmental impacts of Eucalyptus has been mentioned often in news articles and a few studies completed in other countries. However, even though Eucalyptus is an invasive species in Ecuador, there is a severe lack of scientific information that specifically pertains to the

effects of Eucalyptus in the Ecuadorian Andes. How this species will continue to impact Ecuador's environment, specifically the water supply is unknown.

A potential solution to understanding the impacts of climate change in the Ecuadorian Andes region would be more research. Eucalyptus, precipitation, and effects of UV exposure are the topics that are the most lacking in available data. Since climate change is a time-sensitive issue, finding research pertaining to similar Andean regions is necessary as well. Those living within the Ecuadorian Andes will likely have to make changes to their lifestyle to cope with the effects of climate change. Those who live in cities at lower elevations will also be affected since their water supply is under threat. Water is a vital resource that adds urgency to the need for further research on the impacts of climate change in the Ecuadorian Andes.

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