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THE LOS OLMOS PROJECT: BENEFITS FOR TODAY, COSTS FOR TOMORROW

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(ABSTRACT)

Peru's population is primarily located on the west side of the Andes Mountains. Unfortunately, the vast majority of the water is located on the opposite side of the Andes. Efforts are being made to bring the bounty from the East to the West within Peru. The Los Olmos Project is a massive irrigation project that is drilling 12.5 miles through the heart of the Andes Mountain range. The objective of this investigation is to take a closer look at the country of Peru and how this project will provide many benefits to the region. However, I also hypothesize that over time, like many other attempts in history to manipulate nature, consequences will arise and changes in the landscape of Peru will drastically come about. It is my intention to find other irrigation projects in history that have similar constants and examine their effects on their respective environments. Using historical data to buttress claims of how the Los Olmos Project will be beneficial in the short run, I also anticipate findings that will predict long-term negative costs.

Consideration of other major engineering/works projects throughout recent history will provide insight as to where the country of Peru is heading with the completion of this irrigation effort. Those who fail to learn from history are doomed to repeat it. I feel that with enough collected data, I may provide a sound prediction of how the landscape will change in Peru, and how these changes will touch the lives of the Peruvians, both in the short and long term.

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I. INTRODUCTION

"Water is life." Those three simple words have had a profound impact on me. It was not so much that I had never been taught the value of safe, clean water, or to not waste water, however, while travelling near one of the planet's largest desert regions two summers ago, that simple, powerful statement really hit home in my mind.

I heard the words "water is life" while travelling through the dirty, hot, West-African city of Accra. I was just getting ready to sit down and grab a bite to eat. I ordered a "Star," the country's most popular beer, but was surprised when the garçon brought me a bottle of water and, with a smile, spoke those three words. It was at this point for some reason, unbeknownst to me, I had a mini revelation—he was right.

Water is and forever will be life, yet as Americans, little do we stop to give thanks for our blessing. Little do we ever stop to think about how many people in this world lack the luxury of access to clean water. We don't think twice when we turn on our faucets—we know there is going to be fresh, clean water flowing. The statistics, however, are surprising. About 1.1 billion people lack access to clean water worldwide according to a United Nations Environment Programs study (Dams, 2007).

It makes sense that people have chosen to live near water. Lakes, rivers, streams, and ponds all provide us with a resource that is not only used for nourishment, but for a myriad of other uses as well. In today's world, water is a necessity in order to clean, drink, nourish, wash, irrigate, navigate, and even provide electricity.

My intention, therefore, is to consider how humans and water coexist, how each affects the other and how they can mutually sustain and maintain.

II. THE UNFORTUNATE REALITY

Water is life; we can talk endlessly about the value of water in our everyday lives, but the unfortunate truth is that its supplies are limited. Here at Penn State, water conservation is constantly preached; there are stickers, posters, and initiatives to "turn the faucet off" or "don't leave the water running while brushing." Americans are being preached about water scarcity, something they cannot foresee as truly being a reality. Americans seem unable or unwilling to empathize with those who have suffered water-shortages, draught, or famine.

The fact of the matter is that humans need freshwater to survive. What is often misunderstood is that this type of water makes up a very small portion of the whole. Perhaps the best way to paint the simple picture of just how little of the world's water is fresh and drinkable for human consumption and use is to read a paragraph from a young students' atlas (DK, 1998):

> Over 97% of the Earth's water is salt water. The total amount of salt in the world's oceans and seas would cover all of Europe to a depth of three miles. Less than 3% of the Earth's water is fresh. Of this, 2.24% is frozen in ice sheets and about .6% is stored underground as groundwater. The remainder is in lakes and rivers

If one does the math, he soon discovers that of all the fresh (non-salt) water in the world, humans only have access to 0.16% of it. On top of that, this harsh statistic still counts the water that may be contaminated. That information is grim for sure and almost unbelievable at first glance.

To further compound the problem, our Earth's climate is changing, slowly warming. Perhaps it is just another warming trend in the long climate story, but changes in climate are still affecting our ecosystems. Warming in global climate now accounts for the shrinking in the polar ice caps (a large percentage of the world's freshwater) and has caused huge blocks of freshwater ice in the world's polar regions to fall into the ocean and be assimilated with the rest of the salt water—to be "fresh" again only with rain, but never in such vast amounts.

Since the world does have a finite supply of freshwater and in varying locales, efforts must be made to harness water's benefits in more careful ways. History has showed that while human ingenuity has prevailed in providing water, it has not always been practiced mindfully.

III. HUMAN MANAGEMENT OF WATER RESOURCES

Since the beginning of time, humans relied on Mother Earth for survival. Throughout many millennia, humans became adept at surviving on the land and obtaining life's necessities—water, food, shelter. From the river valleys of the Fertile Crescent, people ventured outward, settling on all corners of the globe, living farther away from the most endowed lands. The Earth offers few locations that have a bountiful excess of fertile soils for food growth and abundant availability of fresh water. This is where human ingenuity was introduced. Horticulture, agriculture, herding, and hunting and gathering are all practices utilized by humans to obtain food and calories for nourishment, and are all practices that need water.

Water, one of life's necessities, is in scarce supply in many regions. How have societies and civilizations kept a relatively steady supply of water during times of little rain? How have farmers watered their crops when their fields are miles away from the source? The answer: they dam, divert, and irrigate.

In the West, simple water raising tools were used 2000 years ago during the Roman Empire to carry water to heights where it could then be allowed to flow downward by gravity into channels and into fields for irrigation. At other times, Romans quenched their thirst for water by simple landscaping that diverted rivers and streams, but even more drastic actions to obtain water were utilized prior to Roman Civilization.

Dam remnants and ruins have been found dating back to the ancient civilizations of the Middle East in current day Yemen, Turkey, Egypt, and Jordan—with the latter having the site of what is arguably the first man-made dam in the world: the Jawa Dam

(Hillel, 1991). It is fitting that the oldest dams would be found in some of the Earth's most arid landscapes where the need to utilize what little rainfall and water there was available is a dire necessity. Dams allowed a river source to be blocked, allowing the area behind the dam to fill up, thus becoming a reservoir. This water can then be diverted to different areas in need and can be regulated using spillways and gates to control water level.

There has also been a history of other forms of smaller dams being developed and built around the world within the past 50 years. Seasonal and inflatable tube dams have been used to catch or divert water in smaller, less drastic ways during times of little rainfall and river flow to help supplement and stabilize the water supply. These dams are opened/closed, inflated/deflated when necessary (Beyond Dams, 2009). They have also been vital to those communities which utilize fishing as a primary element of their diets.

Fast forward to today, dams have become useful for far much more than just water or fisheries. There are approximately 45,000 dams with a height of fifty feet or more in the world. They are responsible for providing 40% of the water for irrigated lands and provide half the electricity for over sixty nations (Nersesian, 2007). Hydropower, power that is derived from the flowing force of water, has emerged as a major replenishable source of energy over the years and has been projected to replace much of the energy previously supplied by coal.

What makes hydropower attractive is the fact it is pollution-free and includes little cost after the initial construction that involves preparing the site, construction of the dam and the laying of electricity transmission lines from the conjoined power plant. No fuel is needed to drive the dam or its turbines. The movement of the water does all of the work to turn turbines that generate electricity.

While there are many types of dams in use today, coming in many different sizes and made of many different types of materials, they all have basically the same purpose: to provide food, water, and electricity. The focus of my research includes only large dams, much different from the smaller seasonal dams which impede water for only part of the year, allowing sediment, fish and water to pass for the rest. In contrast, large dams are massive projects spanning years to construct, involving thousands of workers, and requiring millions of dollars of investment capital to help the "development" project become complete.

Unfortunately, this form of development can impact environments and ecosystems forever. As will be discussed later, dams are not as friendly toward their environment as they can be to the people who benefit from the water, fish, or electricity provided, that is if the focus is limited to those living upstream.

IV. CURRENT TRENDS IN WATER MANAGEMENT LARGE DAMS: A NECESSARY EVIL?

When talking of development, several aspects come to mind; modernization, westernization, and industrialization. Countries are looking to find ways in which they develop, grow, and modernize their economies. The aim is for countries to increase their gross domestic product (GDP), which is a measure of a country's entire output of goods and services for a year. Development by attempting to increase GDP can come in many forms; countries may choose to invest in its populace, utilize its natural resources, or move to an industry-based economy. There is no single best method for development, it varies by country; however, there is a right mindset that a country's decision-makers must have in order for development initiatives to have long-term success.

Today, when government leaders and economists debate about how they can manipulate and extract necessities from the Earth in a mindful, responsible manner, the term utilized is "sustainable development." This term is fuzzy at best; it is like attempting to define what "going green" means. However, for our purposes, when talking about water and sustainable development, a simple definition will suffice. "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their needs" (Rees, 1995).

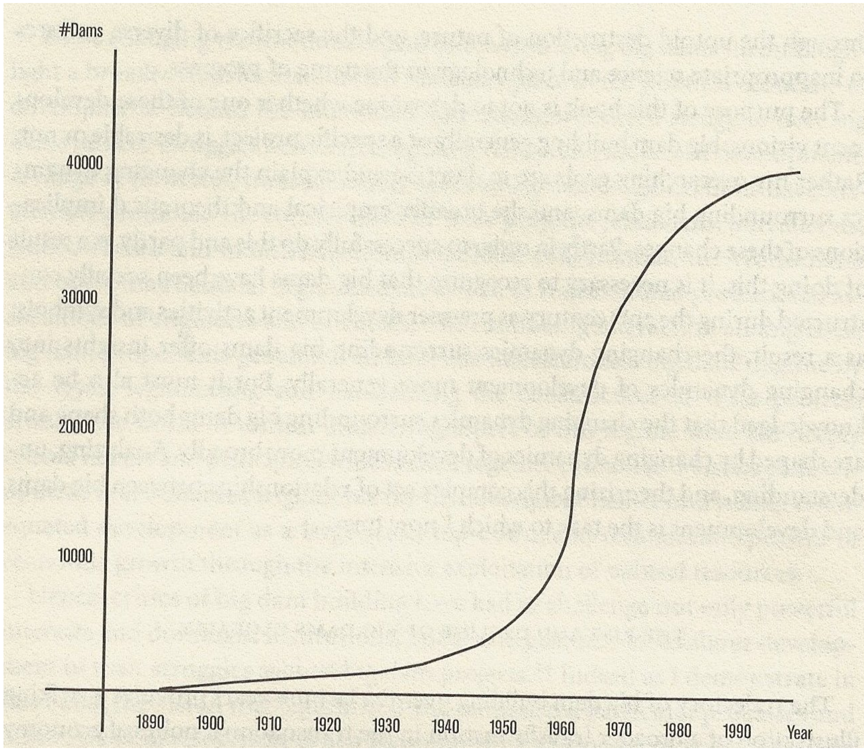
Sustainable development sounds great in theory, but have humans lived by that guideline? They most certainly have not—poor planning, as well as inaccurate perceptions on development strategies, have led to a variety of externalities that have made recent attempts at sustainable development unachievable.

Construction of large hydropower dams are one such sustainable development strategy that have been both inadequately planned out and inaccurately perceived. The reason stems from an ideal of a replenishable/clean energy and water source and investors who fund the construction of these dams without sustainability in mind. Instead, large dams are built with results and money in mind, with little or no regard for what is necessary to obtain them. But large dam construction particularly introduces a dilemma that needs consideration: how can one argue against a dam that provides water to a developing nation? Two billion of the world's ever-growing population is without stable electricity and access to a steady supply of water—two problems that may be alleviated in the short term by a large dam with the possibilities of long-term deleterious effects. What is to be done (Goldsmith, 1986)?

The 20th century has seen a dramatic increase in the number of large dams, as Figure 1 below illustrates. More dams are being built because they allow for greater land intensification, thus feeding more people. However, as we will see, this does not come without a cost to the people and environments; the consensus among river ecologists that "dams are the single greatest cause of the decline of river ecosystems" (Beyond Dams, 2009).

Figure 1: 20th Century Cumulative Number of Big Dams Constructed Worldwide

Adapted from Khagram (2004)



Perhaps this sentiment is why more recent years have seen declines in the number of large dams being built. Environmentalists and organized groups have fought long and hard in recent years to limit the building of dams. They point to land degradation, disease epidemics, population displacement, and disturbed habitats as reasons to prevent these large projects. Table 1 below illustrates the rise in organizations whose goal is to stop the construction of these dams and if we then refer back to Figure 1, some may say that the logarithmic growth in dams ceases and begins leveling off around the year 1980, corresponding to the time period that exhibited a near doubling in quantity of Non Governmental Organizations who were opposed to these dams.

Table 1: The Growth of Transnational Nongovernmental Advocacy Organizations

Adapted from Khagram (2004)

Issue Area	**1953**	**1963**	**1973**	**1983**	**1993**
Human Rights	33	38	41	79	190
Environment	2	5	10	26	123
Development	3	3	7	13	47

However, other groups may contribute the decline in large dam projects simply to the dwindling in the number of ideal sites that make building dams worthwhile. If the current trend in development remains while neglecting to invest in more sustainable practices, there will be fewer and fewer practical locations for building dams. Nevertheless, how is the world's growing population going to have water safe for drinking and suitable for irrigation, or how are developing nations going to get electricity, which in turn can help bring industry and modernization? Such issues become the rationale behind large dams of late.

Whether large dams are beneficial or not is still a debatable question; perhaps they are beneficial for short term business and industry, and deleterious for the environment and long-term sustainability of water, health, and electricity. Irrigation from dams does bring life to areas of little rainfall, but at what cost and for how long? Who are the stakeholders? What determines a dam's efficacy and whether it is sustainable? These questions will need to be addressed as more dams are built.

One country where these questions are emerging is Peru. There a project is underway to build yet another large dam. By examining Peru's environment and context, as well as the history of large dams, I aim to provide a solid projection about where this developing country is headed and whether or not this endeavor is as sustainable as it is advertised.

V. OUR CASE STUDY – PERU

In no country does the topic of proper water management fit better with current events than in the South American country of Peru. This country of approximately 30 million will be the focus of this thesis. It is here that an ambitious irrigation project is currently underway, a project that aims to bring "life" to the country's people.

Peru is located on the north-western edge of South America. With an area slightly smaller than Alaska, America's largest state, it is home to plenty of diverse landscapes and biomes. On the surface, Peru is segregated into three bioregions: the costa (coast), sierra (Andes Mountains), and selva (rainforest), respectively (Masterson, 2009). It is only when we understand the geography and demographics of Peru can we begin to understand the necessity of proper water management in a real context. The maps in Figures 2 and 3 below will help illustrate the relationship between the land and people.

Figure 2: Peru's Costa, Sierra, and Selva

Adapted from Peru (2010)

Figure 3: Peru's Population Density

Adapted from La Selva (2009)

The first and most populated area of Peru is called the “costa;” the arid western ridge and coast of Peru. According to the *APEC Energy Overview (2008)*, 54.6% of Peru’s population lives along this thin strip of land which includes the capital city of Lima. Couple that with the fact that this plot of land accounts for only 11.74% of the country’s total, and it becomes clear that this region, the densest in Peru, requires vast resources to sustain it.

The second most populated region in Peru is the sierra. This includes the Andes Mountains with their high peaks and low valleys, as well as the source for much of the Amazon River—the largest and most expansive river basin in the world. Thirty-two percent of Peru’s population can be found in this region that accounts for 28% of the country’s land area.

The third and final area is the selva, the Eastern rainforests of the Amazon. This region makes up 60% of all of Peru and contains 90% of the country’s fresh water. Yet the rainforests contain less than ten percent of the nation’s population. How interesting that 300 years after the Spaniards viewed this area as the key to the region’s prosperity it would be viewed in a similar manner today. However, today the value comes from its water supply and not its rubber, timber, oil, or fruit (Masterson, 2009)!

VI. THE LOS OLMOS PROJECT

After looking closely at the characteristics of Peru, a dilemma reveals itself. How can a country with 85% of the people living within or on one side of the impregnable Andes Mountains gain access to the 90% of the country's fresh water on the other side? That has been the age-old struggle in Peru, as illustrated by the discoveries of elaborate irrigation systems dating back to the Incan Empire at Cuzco (Circa 1400) and small scale coastal irrigation dating back to 1800BC (Masterson, 2009). Today, with recent ambitious planning and funding, steps are being made to bridge, or should I say "tunnel" this gap.

Figure 4 depicts the location (via the red circle) of the Los Olmos Project, a dam and trans-Andean irrigation system, which is located on the border of the Cajamarca Province and the western edge of the Andes Mountains. It is here that efforts are being made to tunnel through the rugged mountains of the South American Continental Divide, taking water from the Rio Huancabamba (a major tributary of the Amazon) to the Pacific side of the Andes and into the arid Costa where it may be used for consumption, irrigation, or industry (Schexnayder, 2008).

Figure 4: The Los Olmos Project Location

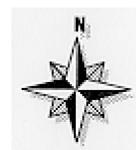


Fig. 4: Odebrecht, Peru Map Map. Image. 2008. Web. 7 March. 2010.

http://enr.construction.com/features/transportation/archives/080528-1.asp

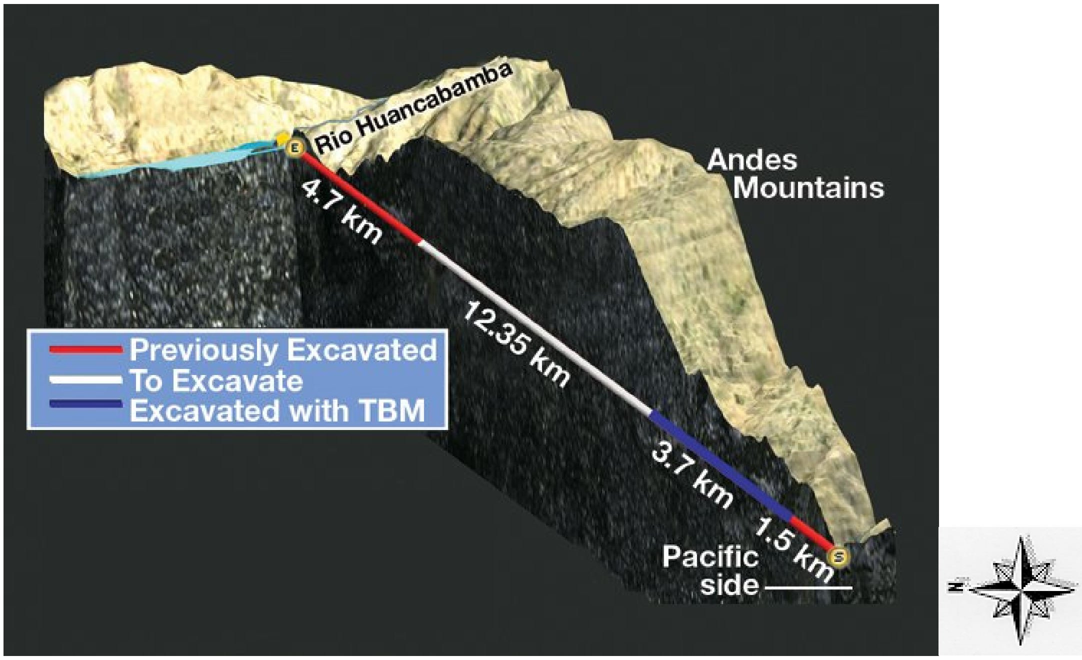
The tool necessary for such task, which is the second deepest tunneling job on record at a depth of 6,890 feet, is a Robbins Tunnel Boring Machine (TBM). This 14 million dollar machine, funded by construction giant Odebrecht, has succeeded in such projects as the Chunnel (Tunnel connecting France and Great Britain) and the Gotthard Base Tunnel in Switzerland, the deepest tunnel on Earth (Willis, 2007). Drilling at 22 meters a day, the Los Olmos Project tunnel should be completed in the spring of 2010, at which time the TBM will be retracted and the tunnel lined with concrete for stability—an important aspect for a tunnel traversing two major fault lines, each measuring 50 meters.

Upon completion of the tunnel, the project will finish the Limón Dam on the Rio Huancabamba in the Cajamarca region. Also included will be a 275 hectare reservoir that will be diverted through the 12.5 mile long tunnel, to be completed later in Spring/Summer of 2010. This tunnel and dam will help bridge the gap between the water-rich Cajamarca Mountains (location of the dam) to the neighboring Lambayeque region in the costa. Figure 5 below illustrates a cross-sectional diagram of just what the Los Olmos Project tunneling effort is attempting to do, as well as its prior progress.

Upon completion of this 190 million dollar investment (of which 77 million is funded by the government), the Huancabamba River will irrigate 57,000 hectares of land in the project's first phase and increase to over 150,000 hectares a year.. Each hectare is equal to 10,000 square meters, about two and a half acres. So in other words approximately 400,000 acres will benefit from the water of this project—that’s 360,000 football fields or over half the size of Rhode Island! This will help with food crops and with agricultural exports such as cotton. The arid land of the west will now have access to more water and the people of northern Peru will be supplied with over 2,000 million cubic meters of water per year (Peru, 2009).

Figure 5: Cross Section of the Los Olmos Tunnel

Adapted from Schexnayder (2009)



These are just some projected statistics of the Los Olmos Project, but what does it really mean for the country of Peru? At first glance, it looks great—there will be a renewable source of water and energy to an area containing little. What negatives could there be? Is this too good to be true? We shall see that the history of dams primarily follows the same course of short term benefits and long term costs. Peru's newest dam and irrigation system may well succumb to this trend. By examining the history of large dams as well as Peru's scenario, we will soon be able to weigh the pros and cons of this endeavor.

VII. SHORT TERM BENEFITS

Historically, large dam projects have been shown to provide numerous short term benefits for the home country and its people. What I mean by short term benefits are those that diminish in returns over time. Upon completion of the project, Peruvians will nearly immediately benefit from the availability of new construction jobs, electricity, water, and improved agriculture. However, in a relatively short period of time, these benefits will diminish. What follows is a careful consideration of each of the short term benefits.

The construction of any large project requires manpower. Many local Peruvians will be offered construction jobs. These workers will help with site preparation and the physical construction of the dam. Over 10,000 direct and indirect short-term jobs will be created (Peru, 2009). Unfortunately, once the dam and tunnel are complete, the workers will need to find other work. It is hoped that this project will also bring in new industry and jobs due to the new supply of electricity. Only then, perhaps, could this benefit become more long-term. Electricity is vital to emerging economies and developing peoples. Hydroelectricity is often vital to countries rich in natural resources, yet devoid of fossil fuels.

Dams are a source of cheap energy, and a renewable source at that. The Amazon to the East will supplement the country's power. The Limón Dam within the Los Olmos Project is predicted to generate 600 megawatts of energy a year (Peru, 2009), or in other words, 0.6 gigawatts. To help illustrate how much energy this is, one gigawatt can serve the yearly needs of about two million people, adjusting for nations with high and low per capita consumption (Nersesian, 2009). So in the end this project will supplement the nation's energy supply and provide enough energy for over one million Peruvians or to developing industries in the country. As previously stated, developing industries means more jobs for the people of Peru.

While countries are known to export their energy to neighboring countries to build revenue, little has been released just yet on how this energy will be put to good use. Peru is currently a net importer of energy, and of that imported energy 88% is from costly petroleum. This project's energy generation will help cut some of these imports and reduce Peru's dependence on foreign energy (APEC, 2008).

Aside from electrical energy, dams in a sense provide human energy. Simply put, dams provide exactly what they hold: water. Once all stages are complete it will supply 2,050 million cubic meters of water per year to the Costa. This water will be used for drinking, washing, and for providing food via the 400,000 acres of newly irrigated fields.

This irrigation will go towards the production of animals, vegetables, grains, and cotton typically grown in the north of Peru (Peru, 2009). More water will provide higher yields which in turn will lead to higher profits and a better standard of living. The Peruvians living downstream from the new Limón Dam of the Rio Huancabamba River should also benefit from a higher standard of living, or at least a safer one.

Dikes, dams, diversions, and drains are seen as a way to harness nature's flood waters and provide security to nearby communities. This is often a promise made by the government to gain public support for such grand projects (Molle, 2009). When rain pours on the steep slopes of mountains, such as the Andes, flash floods can come rushing downstream and with these, mudslides and devastation of the landscape. Without this dam, the selva's population along the Huancabamba River could be more susceptible to these floods. Dams provide a barrier for flood control, blocking the overweening amounts of water and sediment from devastating those downstream. However, as we will see, dams that prevent mudslides and flash floods from rushing downstream endure the burden of this sediment, debris, and muddy water.

The newfound fresh water being tunneled through the Andes Mountains can be put to good use on the arid coast, especially in the fields of the Costa—providing the necessary water to grow such Peruvian staples as cotton, sugar, rice, soybeans, fruits, and tobacco. Assured irrigation will undoubtedly create higher yields in subsequent years after the dam's completion, as shown by evidence of numerous dam and irrigation projects around the world, just as long as the land is not overworked.

For example, the Bhakra-Nangal Dam in India (Table 2) was begun in 1948 and completed in 1963. In the 40 years following its completion, grain yields more than doubled—this in a mountainous, warm climate region much like Peru's. This example illustrates that not only will this dam and irrigation tunnel have the potential to improve Peru's production of food crops and cotton, but also that it can have drastic and positive impacts over the short-term. One may notice that, over time, yields increased while the amount of land used decreased, thus improved land intensification. Lands suitable for cultivation will flourish, and output will increase. Greater output for a country means greater self-reliance and perhaps, greater surplus for export, especially in terms of cotton—one of Peru's biggest and most important commercial crops.

Table 2: Growth of Area, Production and Yield in food grains

Adapted from Rangachari (2006)

Year	Area (million ha)	Production(million tones)	Yield (kg/ha)
1950-1	97.3	50.8	522
1955-6	110.6	66.8	605
1960-1	115.6	76.7	662
1965-6	115.1	72.3	629
1970-1	124.3	108.4	872
1975-6	128.2	121.0	944
1980-1	126.7	129.6	1023
1985-6	128.0	150.4	1175
1990-1	127.8	176.4	1380
1993-4	122.8	184.3	1501
1995-6	121.0	180.4	1491
1999-2000	123.1	209.8	1704

Furthermore, greater water for crops means more food for grazing animals. It should be noted that grazing animals take the parts and types of plants that humans cannot eat and turn them into meat, milk, and leather (Hillel, 1991). Improved agricultural output can provide greater amounts of higher quality food, which leads to a larger, healthier populace.

Large dam projects can also alleviate poverty for the populace of an area—which can transform and improve their lives. Plentiful electricity, water for crops, and higher yields in areas that had none of the three can bring about a ripple of economic development. Table 3 below illustrates this. Dams can help a region develop and lessen the poverty.

Table 3: Poverty Ratio in India

Adapted from Rangachari (2006)

State	**Rural**			**Urban**			**Combined**		
	1973	1993	1999	1973	1993	1999	1973	1993	1999
India	56.4	37.27	27.09	49.01	32.36	23.62	54.88	35.97	26.10
Haryana	34.2	28.02	8.27	40.18	16.38	9.99	35.36	25.05	8.74
Punjab	28.2	11.95	6.35	27.96	11.35	5.75	28.15	11.77	6.16

Having considered the benefits that the los Olmos Project will bring to regions of Peru, how could any negative outweigh these stated benefits? How can one say to Peruvians that this project will be a detriment to their children and children's children, as it provides water, electricity, increased standard of living, increased life expectancy, flood protection, and irrigation for crops? The answer emerges as the effects of dams are considered over time. Typically, dams follow the same trend, short term benefits with long term negative consequences. These long-term negative consequences are now the focus and will be discussed further within the following section.

VIII. LONG-TERM IMPACTS

In the words of Thucydides: "Knowledge of the past is an aid to interpretation of the future" (Hillel, 1991). While history does not always give humans the insight to predict the future (as is the case with large dams due to unique environments and circumstances), dams' reoccurring histories and long-term negative effects give insight that puts a damper on any hope of these large projects being safe and sustainable.

The Los Olmos Project's Limón Dam will be another addition to a long list of dams that precipitate negative long-term effects. Dams have long plagued their natural environments by soil salinization, waterlogging, disease, population displacement, disrupted fisheries, sedimentation, and damaged ecosystems and habitats.

The first major concern when constructing a dam is who is going to be forced out of their homes to make way for the dam's reservoir. While this may be a short-term negative for the displaced communities, it can have long lasting effects. Families must pack up, leave their way of life, and move someplace unfamiliar, often struggling to find jobs or new support systems. Livelihoods are greatly affected by dams; both upstream and downstream. While people are usually compensated for their sacrifice, it is hardly enough to rectify the injustice. If one is lucky enough to not be displaced from his home, he will still face the world of a different landscape and a different lifestyle.

The Limón Dam within the trans-Andean Los Olmos Project will impede the water of the Rio Huancabamba from running freely downstream. By impeding the water's flow, several externalities will come for the sake of electricity and water provided to the Costa. Those externalities will be placed upon the local populations in the mountains and downstream in the rainforest.

When a dam prevents water from moving freely downstream, it also inhibits the fish from moving downstream. Fisheries, and the related livelihoods, are greatly affected by dams, and at a great cost. By placing this dam on this river, the Peruvian government is stating that electricity and water for large populations of the West are more important than the livelihoods of the rural people of the East. People are going to have their food supplies and livelihoods diminished. Will the government reimburse them for their great sacrifice to the urban centers on the coast? Developers of these dams will argue that fishing is not a central point of the rural population's livelihood by showing misrepresented populations with skewed statistics. They are clearly wrong. Fishing is vital to these rural areas of developing nations; anyone who has access to water, fishes (Molle, 2008). Is this loss of livelihood the cost that rural people living in the East must pay for flood protection? Who wins by having a dam?

Another cost for this new electricity source is paid for by the environment in its lumber and timber. Not only will the reservoirs from dams flood local villages displacing families, but it will also flood forests causing the gradual drowning of the trees and ecosystems. India, for example, has committed to developing the rivers in its northern provinces, but has lost nearly half a million hectares of forest land in the process—killing habitats for animals and further disrupting the landscape (Goldsmith, 1986). Builders see this loss only in terms of the monetary value of lumber on the newly flooded plains and disregard the air quality, loss of habitat, and impoverished soil quality. Without trees to anchor the soil it will wash downstream and against the wall of the dam. The Limón Dam in the Los Olmos Project is not exempt from this eventuality which leads to an even greater problem, sedimentation.

Simply put, sedimentation is an "unavoidable and natural process" that sets in with water storage of dams (Rangachari, 2006). If uninhibited and allowed to flow naturally downstream, sedimentation can be a blessing to the landscape. Nowhere is this better illustrated than the great Nile River and High Aswan Dam. Before the dam, the Nile was revered as a deity and a source of life in the middle of the desert. Its annual floods brought water and rich sediment that formed a fertile layer of alluvium to regenerate the slopes and fields of Egypt. This rich sediment flow allowed a vibrant civilization to prosper (Fahim, 1981). Now that same area has changed drastically—not only physically, but socially, politically, and economically.

Physically, the landscape has changed. No longer are the fields of the Lower Egypt bearing the abundance of the past. The silt and sediment that once made this area fertile is now blocked up behind the High Aswan Dam. Instead of this alluvial plain providing food for a nation of near 90 million, food must be imported. I state this to illustrate the effects of impeding rich sediment from being carried downstream. Similarly, the areas downstream of the Rio Huancabamba will be affected greatly by the lack of soil renewal that was previously provided by the river's sediment.

Obstructed sediment is a curse that will slowly kill the Limón Dam, much like it is slowly killing every dam of the world. The build-up of sediment that cannot pass downstream will start to settle at the base of the dam, slowly filling up the reservoir that is supposed to be filled with water, not debris. Egypt and India's reservoirs are suffering greatly from sedimentation, and thus are greatly losing their reservoirs' fresh water carrying capacities.

Completed in 1964, Egypt's High Aswan Dam on the Nile River has led to the accumulation of sediment—filling the reservoir at a rate of 100 metric tons per year. In the first 13 years following its completion, it is estimated that the reservoir lost 10% of its carrying capacity. Through calculations and estimations, the life expectancy of this major dam is around 300 years, but some see it close to half of that (Jobin, 1999).

Farther east in India, since the building of the Bhakra-Nangal Project on the Sutlej River, 15.02% of the reservoir's capacity has been lost in just the first 42 years of use. What is worse is that it has and will continue to increase indefinitely. Over time, the possibility of disastrous water shortages for much of India's north will become a reality and costly measures will need to be utilized to remedy this sedimentation process (Rangachari, 2006).

In the future, the Limón Dam of the Los Olmos Project will inevitably need to have large amounts of sediment and eroded topsoil removed. The steep slopes of the Andes will be unforgiving as rain and the new, high waters sweep through the landscape carrying sediment to the brink of the dam. Removal of silt can take two forms: sluicing, and removal by mechanical means.

Sluicing sediment is accomplished by having a channel at the bottom of the reservoir where the sediment can run through instead of being caught up in the dam. While it may sound like a simple solution, it is never as effective as it hoped. Sediment, rocks, and debris block this channel and nullify its effort.

Mechanical means of sediment removal require diverting the river, and then during dry times taking excavation teams to dig out and haul away the debris and earth that has accumulated. Alternatively, mechanical dredging can be performed using a clamshell or dragline, without dewatering the site, but it still requires that the excavated material be dewatered prior to truck transport to the disposal facility. To give an idea of just how costly this process is, removing one cubic yard of sediment from Stratton Dam in northeastern Illinois, cost 25 dollars in 1987. The total cost to remove 1.5 million cubic yards was around 40 million dollars (United States, 2006). This is a very costly endeavor indeed, almost as costly as the detrimental health impacts brought about by dam projects.

Water resource development has been closely tied with human health in recent years thanks to greater knowledge of the purity of water and its surrounding ecosystems. One does not have to read into the literature on dams and irrigation deeply to discover a correlation and proliferation of mosquitoes, malaria, or diseases that prevail in wet damp humid environments. The reason for this is that water changes microclimates (Goldsmith, 1986). Once a dam is introduced to an arid region, water evaporates creating moisture. In many tropical parts of the world, standing reservoir water leads to malaria. Malaria has been a plague on mankind—a deplorable externality in the quest for clean water, as insects flock to this new oasis of sorts.

It wasn't until DDT was used to fight off mosquitoes in the late 1940's that the number of malaria cases reported dropped dramatically from 75 million in 1951 to just a mere 50,000 in 1961 (Rangachari, 2006). Unfortunately, using DDT creates problems of its own, contaminating groundwater, killing wildlife, and even causing cancer (Carson, 2002).

I bring this up to illustrate that given the dam's location in a hot tropical climate, sitting water will be created, a habitat where mosquitoes and other pathogenic insects thrive. Malaria, bilharzias, fever, diarrhea, liver flukes, encephalitis, and river blindness are all diseases that will come to the sierra and selva in greater quantities (Jobin, 1999). Diseases like these have caused many communities near reservoirs in Africa and China to move away from their fishing spots and way of life due to the social and health impacts of dams. Diseases impact populations, demographics, and the entire future of regions. While the costs may seem to all fall on those losing their water, habitats, and health security, those who are receiving the water in the Costa will not be immune from negative consequences either.

The emergence of water where there once was little often provides many problems. Oftentimes, countries feel political pressure to “open the flood gates” for those who need the water for crops or a myriad of other reasons. If not properly rationed, water will saturate the soil, raise the water table and cripple entire fields through water logging. Water logging destroys the land and soil in two ways. First, the water shields the soil and cuts off the oxygen disrupting the nutrient uptake by the roots. Secondly, when water sits on top of saturated land, the salt within that water can slowly poison the soil and the crops, rendering the field beneath useless.

As waterlogging sets in, the inevitable process of salinization begins (Goldsmith, 1986). Simply put, the soil must maintain a particular water-salt balance—how ever much water is coming into the soil system must also be leached out—drained through the soil and into the ground water. If this balance is not maintained, the soil will become saturated with salt and thus, poisoned.

This process of salinization has been a reoccurring theme of the disadvantages of irrigation. Water is misused when farmers over crop and attempt to produce the greatest yield and profit with their newfound cornucopia of water. If Peruvian farmers over-irrigate the soils in the Costa's agricultural fields, crop production will eventually decline due to the excess salt in the water. The water and salt must be allowed to leach through the soil; too much water will raise the water table and flood the roots. In time, soils will be destroyed. A "good" thing (water) can create a world of "bad."

Along with too much water comes the hysteria to farm. If too much water doesn't cripple the soil from below, then human over-intensification of land use from above might. Peru is a developing economy with 45% of its people living below the poverty level. The agricultural sector comprises 9% of the country's GDP (Masterson, 2009). Inevitably, the people will attempt to help themselves through the selling of their crops and intensification of their land. When this happens, such practices as tilling and plowing occur. These processes may improve soil, but only if the lands are flat enough to not be susceptible to erosion. Peru however, especially in the Cajamarca region, farms upland crops such as wheat, barley, corn, and potatoes. These soils and their crops will be affected by this project as the slopes of the Andes are planted. Erosion will be inevitable on these large farms run by peasants. This Los Olmos irrigation project will set this region up for agricultural land intensification and subsequent land decline over time.

While the landscape of both western and eastern Peru will be greatly affected both positively and negatively, the negative externalities mentioned here, I believe, will come to the region as a whole and have the greatest long-term impact.

IX. SUGGESTIONS FOR PREVENTING A REPEAT OF HISTORY

I see myself as a sort of environmentalist, but at the same time I support development, as long as it is sapient, diplomatic, and sound. These same criteria must be taken into account with regard to the Los Olmos Project in Peru. The issue is not whether the country of Peru will invest in such a drastic endeavor that will affect the physical and social landscape; that decision has already been made. In fact, the work has proceeded so rapidly that the Los Olmos Project could be finished within the next few months.

Rather the work must be thoughtful and well carried out as dams fail everyday. For instance, despite its age, the two-year old St. Francis Dam in Santa Clarita, California failed, giving way to floods that killed almost 500 people. In 1889, the Johnstown, Pennsylvania flood was caused by the failure of a dam leading to the deaths of 2200 people (Nersesian, 2007).

Aside from structural malfunctions, a dam's location must be addressed and well-thought out, especially in the area of the tropics where warm temperatures and moisture can give rise to water-borne pathogens and disease. Precautions must be taken as to limit the possibilities of thriving ecosystems for disease carrying pathogens and political efforts must be made to accommodate and care for the people of the region taking on this challenge for the sake of the water in the West.

Beyond health precautions, those whose homes and livelihoods are affected by this project must receive fair compensation for their sacrifice. Guidelines for fair compensation practices have been established by the United Nations. The UN "Stakeholder Compensation Guidelines" include subsidization in the forms of sustainable agriculture development, property tax alleviations, and preferential electricity rates

(Dams 2007). The UN also advises community development in the form of health, transportation, education, and market resources. For this dam effort to be socially responsible there must be zero negligence of the Peruvian stakeholders.

One good example of stakeholder compensation can be found in India, where stakeholders in the region of the Bhakra-Nangal Project were consulted with prior to their resettlement. They were given options of housing, employment, and free fishing licenses on the reservoir for three years (Rangachari, 2006). The Peruvians negatively affected must be compensated in similar fashion with the completion of this dam in the Spring/Summer of 2010.

Even if the stakeholders are compensated fairly, the landscapes and habitats will still pay the price. As stated earlier, sedimentation is an undeniable externality when it comes to dams and irrigation. The key to avoiding certain downfalls is careful planning—by correctly forecasting the amount of sediment inflow and when that inflow will begin to have deleterious effects on the reservoir (Rangachari, 2006). The life for many of these dam projects around the world differs by their individual uses. It is estimated that dams used for irrigation remain productive and efficient for only 50 years, even less for hydropower (25 years). This means that on average the dam’s efficiency will remain adequate and worthwhile until that age.

Dams can remain efficient for nearly half a century, but the lands these dams serve can become degraded much quicker. For this reason, Peru, like all countries, must use its water resources mindfully—the less water that is flowing through the Andes the better. The more this windfall water is used in a frantic jubilation, the more quickly will the soils be degraded. Peruvians should take advice from their brethren in the Colca

Valley, where farmers have been using traditional, smart farming, lessening the detrimental effects of irrigation on the land. By utilizing ancient terraces, intercropping, crop rotation, land fallowing, ash and manure as fertilizer, and less frequent tilling, the Peruvians can maintain their landscape and prevent one change of their environment from snowballing into a myriad of others (Montgomery, 2007). Perhaps, Peruvians can also employ water-saving practices and devices similar to those used in Mexico City (Beyond Dams, 2009), such as harnessing the precious rain rather than allowing it to be washed away.

X. DISCUSSION AND REFLECTION

The Los Olmos Project is an extensive project that includes drilling through the Andes Mountains, an irrigation attempt to bring the water from the source of the Amazon to the dry coast of Peru. In this effort, brute strength is used to manipulate nature to peoples' advantage. While this is but one dam project, it opens the question yet again—is such effort the most sustainable course of action?

Today, two billion people in the world live without a stable electricity supply (Goldsmith, 1986). These large dams provide that and aid development of the area. Peru is no different. However, are these dams a necessary evil? What are the alternatives? One possibility, instead of funding these massive dam projects, is for Peru's government to invest in water treatment facilities or desalinization plants for Peru's Costa. After a higher initial cost, they could be more sustainable. Or, Peru could even revert back to ancient water catchment practices on the western slopes of the Andes. Would this be better? There is no single right answer. It might be difficult for one to tell the people of Peru today, that a dam will hurt their son's grandson's Peru of tomorrow, but it must be said.

The fact is that dams carry baggage and their construction should be avoided at all costs. Peru's soil will potentially be over-used and perhaps eroded or waterlogged, leading to salinization. Peruvians downstream of Limón Dam will have their fisheries and fields forever disrupted. Upstream from the dam, vibrant village communities will be abandoned. This relocation will make way for the new reservoir, which brings with it the possibility of water-borne diseases and parasites. All of this sacrifice is for the benefit of those on the opposite side of the mountains.

Time will tell how the Los Olmos Project will affect the lives of the Peruvians. I have presented this current issue and feel it follows the normal trend of benefits and drawbacks that dams have had in the past. While all stages of construction should be completed sometime this spring, the Los Olmos Project has been 100 years in the making and will have an even longer impact on the future. We can hope that it does not fall into the same lifecycle of most dams, high initial benefits, only to succumb to long-term degradation of the land, culture, and people of Peru. For if this occurs, there is no realistic remedy.

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Student Teaching (State College Area School District) — Spring & Fall 2009

- 8th grade American History
- Instilled values of teamwork, and good sportsmanship on and off the field.
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Little League International — Summer 2003- 2009
Green Acres Summer Camp (Coach, Instructor, and Camp Counselor)

- Cared for coached 14 young children (ages 9-12) for 5, week-long sessions.
- Planned and implemented units covering such topics from the time of the Constitution up to and including the American Civil War
- Created assessments and activities for 120 students

Penn State Residence Life — Spring 2007- Spring 2010
University Park, PA
Resident Assistant (in Honors College living option)

- Planned and presented programs and events for both recreational and educational purposes
- Maintained a safe and healthy environment for over 40 residents comprising both male and female

Cross Cultural Solutions International Volunteer (Ghana) May – June 2008
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- Taught 17 5th graders lessons on such subjects as French, religious studies and mathematics.
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