“Life Cycle Assessment in Cusco and Machu Picchu”

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Goal and scope definition

Goal of Study

The goal of this study is to prove that Inca structures (product A) are in fact an eco-friendly structures that satisfies the need without affecting its environment and the overall environment impact. By this, they will implement the idea of molding according to Mother Nature instead of destruction, and alteration of the natural areas. Moreover, the principles of sustainable engineering will be applied in their constructions. This analysis will be done from the cradle to gate process-based method.

Scope

Because the construction will be held on top of the Machu Picchu Mountains, there will be a lot of limitations and we may need to add other methods to obtain vital resources. Some of the limitations we may have are that the acquirement of the materials would be harmful for the rivers (there will be a certain quantity of mercury freed in the rivers), the transportation of the materials used (using people, animas and other resources as transportation), the strength of the materials in the climates they are in (if their life span is greater to have a greater endurance to the climates). Now when the construction is done, because it’s up high in a mountain, there got to be the need to use more resources to obtain other vital resources like water (hydraulics), food (land for farming would cause erosion), and transportation (trails in and out of the city which would use men to build it and stones to make the trail).

Building Lifespan

The life span of these structures is estimated to be about 100 year + buildings based on the materials used and the climate they are in. (it’s been approximately 100 year since these buildings have been made).
Tools Used

The tools we used were the MS-Excel for the graphing and EduPack for the material calculations.

Inventory Analysis

As we have reviewed, the most important legacy the Incas left behind is the engineering behind their construction. Unfortunately, they did not leave behind any clue that will lead us to the complete understanding of the process for their construction. But throughout this review we will try to come up with their process and materials used in their process. Based on this an inventory analysis will be done in order to illustrate the sustainability of the Inca’s construction. First of all, the process could be divided in these activities, the first one extraction of the raw material, transportation of the raw material to the area of construction, the phase of construction which includes material production, manufacture of finished product, and finally the lifetime operation and disposal.
Extraction of Raw Material

Inside the activity of extraction, we have to be able to recognize the raw material used in their construction, which is essentially rocks. Geologists define rock as a naturally occurring solid aggregate of one or more minerals or mineraloids. According to that definition rocks could be found anywhere in nature. This means the Incas did not use a lot of energy in the extraction of the material because rocks are given in nature. According to CES EduPack 2012 a stone has an embodied energy of 0.4 to 0.6 MJ/kg, and a CO2 footprint of 0.0269 to 0.0297 kg/kg.

Transportation

After analyzing the extraction of raw material, we need to take a gaze into the second phase of the process which is the transportation of the material. This is where the analysis of their construction becomes interesting, because until now it becomes a mystery how the Incas transported a rock of that size in order to construct their buildings. By the time of the Incas the iron was not used, and wheels where not even invented. This means no transportation vehicles were yet invented, but since they have much nature that surrounded them, a lot of natural resources available to use for transportation. The Incas were a very intelligent culture, and they could have use a tree trunk as a rolling device to help them transport the big rocks. Assuming the Incas used the tree trunk for transportation we could use wood and analyze the amount of CO2 and energy used by using the tree trunk in transportation. Through the program CES EduPack 2012, I was able to obtain information about the hardwood: oak, across grain which is the one that probably they could have use for their transportation, the embodied energy for that material is 9.82 to 10.9 MJ/kg and the CO2 footprint is 0.841 to 0.93 kg/kg. To make the transportation possible, another fact is the quantity and the energy used by the Incas in order to move the rocks. Until today the number of men needed to transport the rocks is still unknown, but according to
the weight of the rocks and using the RWL formula, which is the recommended weight limit we
should be able to estimate approximately how many men were needed for the transportation.

Construction

After transportation, the construction phase is next, what material and how much energy
is produced. Incas construction is characterized for their especial way to ensemble the rocks.
The way they ensemble the rocks is by shaping them and forming a kind of puzzle where one
rocks fit into other rock. In one rock they make a hole, while in the other they leave a piece that
fits into the hole of the other rock that way both rocks keep together. The Incas did not use any
mixture between their rocks in order to keep them together. As all about the Incas, the material
used for their construction is also unknown; the only material known is a stone with metal which
was used to shape the rocks. But the interesting thing is how they cut the rocks to give them the
perfect shape of a puzzle, that is something unknown but for sure whatever they have used was
not a high technology artifact, was something already obtained in nature as the rock with metal
they used. As in the other phases, it seems as the Incas used their own strength and teamwork
and found a way to facilitate their work, but their technology is still unknown, that’s what makes
Cusco and Machu Picchu interesting. Another important thing to highlight about their
construction is that they constructed on top of the bigger rocks instead of making their own space
for construction. That is one of the facts that make their engineering sustainable. The embodied
energy and the footprint CO2 for this phase will be the same as mentioned before for the rock.
For the rock with metal the energy and CO2 could be a little higher but since they are still in
their own nature there is no energy used for the production of that item, because it is given in
nature.
**Lifetime and Disposal**

And for the lifetime and disposal the buildings are still there, which means they were able to survive a lot of years, this only says that the Incas constructed thinking in the future. And these buildings could be in better conditions if they had taken care since the extinction of the Incas. Most of the damage made in this construction was due to the Spanish people who conquer them.

![Impact Assessment](image)

**Impact Assessment**

The Incas were a civilization that cleverly utilized the natural resources. The structures the Inca Empire built are durable structures because they worked in cooperation with nature.
Inca engineers applied the principle of sustainability on their designs; they ensured that their projects were economically viable, socially equitable, and environmentally sustainable. It is imperative to mention that all human designs somehow will impact the environment. Therefore, the Incas designed projects that were friendly with the environment and caused the less amount of damage to nature.

**Environmental Impacts**

An environmental impact is the effect produced by human activity on the environment. Environmental impact could be positive (afforestation) or negative, it depends if such activity helps or harm the environment. Environmental impacts are separated into several impact categories. All human activity affects the environment, the impact categories that the Incas’ activities affected were: depletion of abiotic resources, global warming, and Eco toxicity.

**Depletion of abiotic resources:** Like most civilizations in history, the Inca Empire relied on firewood. Firewood demand triggers the felling of trees. According to the article, *Causes and consequences of deforestation in Ecuador* the expansion of the Inca Empire caused deforestation. Consequently, Population growth always requires more natural resources and it is unavoidable to affect the environment.
Global Warming: A minor but important component that causes global warming is the increase of atmospheric Carbon Dioxide. The Incas caused an increase in Carbon Dioxide by deforestation and burning wood. Even though the CO2 produced by the Incas is minimum it is important to mention the impact to the environment. Usually, we consider global warming as something negative but the article *Climate change helped the Incas build civilization* mentions that the rise in atmospheric temperature helped the Incas to expand their empire.

Eco toxicity: Eco toxicity is the effect of chemicals on the environment. The Peruvian Incas used mercury in gold mines to extract gold. The article *Mercury traces exposes Inca mining boom* states “Evidence of massive mining of mercury ores in South America by the Spanish, Incas and others before them has been extracted from the bottom of Peruvian lakes”. It means that the Mercury utilized by the Incas to extract gold impacted negatively lakes.
Interpretation

**Positive Impact:** The environmental impact not necessarily needs to be negative; it could be a positive impact. Again, the simplest example would be afforestation. The Incas had a special concern for finding ways to improve soil conditions for agriculture. They used terraces to obtain useful land for agriculture. In addition, the terraced fields built by the Incas positively impacted the environment because it helped to decrease erosion and surface runoff. According to some scholars, global warming also helped the Inca Empire to expand its territory.
**Negative Impact:** Usually, Human activities are responsible for negatively impact the environment. Incas’ impact on the environment was minimum. However, they did impact the environment negatively. The Inca civilization caused deforestation, lake pollution, and also an increment on the atmospheric carbon dioxide. It is important to mention that the Incas respected nature and tried to build in collaboration with the environment. According to the article, *Steps to Sustainability- Part 4 of a Series: Unique Empires* mentions that the Incas even had hunting regulations. In essence, the Incas were friendly to nature and were pioneers of sustainability.

![CO2 Footprint](image)

**Conclusion**

In conclusion, all human activity will somehow affect the environment in a positive or negative way. Because the Inca civilization recognized and respected the importance of Pachamama, our Mother Nature, the Incas built eco-friendly structures to lessen their impact on the environment. Sustainability is the balance of society, economy, and environment for current and future health. Therefore, sustainable projects lead to better constructions that help our environment. It is important to design following the 12 principles of green engineering to maintain balance between society, economy, and environment.
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