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A- Project proposal

Guanacaste is the Northwest province of Costa Rica, and it is known for the high prevalence of tropical dry forests as well as for its high meat and milk production from cattle ranching (Voice, 2018). As the climate is changing, this region is experiencing a decline in water availability, which is affecting over 20,000 livestock producers who work in this region (Organization, 2019). My project has two key elements; I am interested in finding a way to increase access to water for livestock producers in Guanacaste as the water availability declines, and I would be interested in funding a PhD program with a focus on the conservation and biodiversity of the tropical dry forests in Santa Rosa.

In order to accomplish this goal, I propose funding an expansion of the Southern Crop Irrigation Canal in order to increase livestock farmers' access to a reliable water source in the dry season. Currently, the Southern Crop Irrigation Canal is 42 kilometers long and provides water to farms in the Cañas canton (Lopez, 2014). The expansion of the canal would include both more channels being constructed and more water being diverted into these channels from Lake Arenal, which would lead to increased socioeconomic development for farmers and other stakeholders in this region (Costa Rica, 2012). Additionally, I will fund a research program with a focus on documenting species abundance and diversity in the tropical dry forests in this region. These forests have been greatly reduced in size because a high proportion of the land in this region is used for agriculture, which has caused the species in remaining forests to be highly susceptible to population decline due to habitat fragmentation. Documenting species abundance and diversity of tropical dry forest life would be valuable because species who are experiencing significant declines could be more heavily protected. Also, it is crucial to document species diversity for future generations as many species are on the brink of extinction due to climate change.

B- Stakeholders and their interests

The primary group of stakeholders who would be affected by the implementation of my project are the cattle ranchers in the Guanacaste province. The agricultural industry is responsible for the majority of the water use in this region, and would therefore gain the most benefits from the expansion of the Southern Crop Irrigation Canal (Wikipedia, 2019). Rice and sugarcane farmers would also likely have higher crop yields following the expansion of this canal. Additionally, other residents of the province of Guanacaste who rely on this water for domestic and industrial use would benefit from the expansion of the canal during the dry season (Wikipedia, 2019). Other than agriculture, tourism is a crucial industry in this province, and both tourists and the tourism industry would benefit from having a reliable water supply all year. A downside of this project is that land will need to be flooded in order to extend the canal.

The expansion of the Southern Crop Irrigation Canal would not only benefit the people who live in Guanacaste, but also the health of the wildlife and tropical dry forest ecosystem. The additional water could be used to create pastures that are less nutrient depleted through the cultivation of farmland with more native tree species incorporated into them. Some of the water could be diverted towards Santa Rosa National Park in order to ensure that this pristine ecosystem remains healthy as the climate becomes hotter and drier in the upcoming years.

The national parks system would also benefit from the creation of the new PhD program at the Palo Verde Research Station, which will have a focus on biodiversity and the conservation of the tropical dry forests. PhD students in this program could work with ranchers in order to help them develop more sustainable farming methods so that this land can healthily support the amount of ranching that takes place in this region as it is impacted by the changing climate. This program would be beneficial for graduate students because it would provide opportunities and funding for research projects and experience in the field.

Additionally, the water that is being channeled into this region through the expansion of the canal could be used to generate hydroelectric power due to the amount of altitude changes in this region, which are favorable for hydroelectric power generation. As the water is moving from regions of high to low altitude, it can be passed through turbines to generate power.

Lastly, the indigenous communities in this region could benefit from the irrigation and new PhD program in the region. The additional water can ensure that it is possible for tribes to continue to farm their ancestral land as the climate becomes drier and less able to support farming at its current scale. The PhD program would be a crucial step in preventing the extinction of many native species that may have cultural value for the native people or may be harvested. Also, the PhD students can engineer ways to help the land remain productive as the climate changes, and the students could work with the indigenous communities so that their land remains as productive as possible for their lifestyle.

C- How the region will likely change in the future & consequences for stakeholders

This project is critical in order for ranching and farming to continue at its current scale in this region (Voice, 2018). As Guanacaste warms, it is also becoming increasingly dry, and droughts are becoming more common (Voice, 2018). In the mid 1990s, Guanacaste experienced a drought for three years, and another drought struck this region again in 2013-2015 (Voice, 2018). This recent drought caused a state of emergency for ranchers, and in 2015 farmers required thousands of dollars in aid because of the poor farming conditions (Voice, 2018). Without access to water, it will be impossible for farming to continue at its current scale in Guanacaste (Crespo, 2018). Additionally, the lack of water during a drought would negatively affect families and businesses in the region that are not involved in the agricultural industry. This project would require land to be purchased in order to be flooded so that the canal can be extended, and it may divide the land on some ranches and make farming more difficult (Crespo, 2018).

Also, climate change and human disturbance has already caused many species to decline in Santa Rosa and the surrounding tropical dry forests when pastures were created. It is crucial to conduct as much

research as possible before the conditions become worse and species are lost because of climate change and habitat disturbance. This region is a popular destination for tourists because of all of the native species that can be seen in Santa Rosa National Park, and if these species are lost the demand for tourism in this region will likely decline. This will lead to less money being brought into the region and a lower quality of life for citizens. Lastly, if the canal is not extended, the indigenous people may find it difficult to remain on ancestral land because there is not enough water to grow food and raise livestock.

D- Needs proposal will address

There are currently around 20,000 livestock producers in the area surrounding Santa Rosa, and the meat industry experienced significant growth in this region between 1950 to 1980 (Voice, 2018). This period of growth in livestock production and agricultural land use is what contributed to such an extreme decline in the amount of forests in the area surrounding Santa Rosa National Park (Voice, 2018). Currently in Guanacaste, 60% of the land has been converted to grasslands to use as pastures for livestock (Voice, 2018). The increase in cattle abundance has led to a decline in the amount of forests, protected zones, and trees (Voice, 2018). It is crucial for the agricultural industry to have reliable access to water throughout the year; the agricultural industry uses 53% of the water supply in Guanacaste, while domestic use requires 29% of the water supply and the remaining 18% is required for industrial use (Wikipedia, 2019).

Additionally, the increased grazing of cattle in pastures has depleted much of the land of nutrients and has led to increased erosion (Voice, 2018). Along with cattle, the farming of rice and sugarcane, which are shade intolerant plants, have contributed to the deforestation and increased need for irrigation in Guanacaste (Voice, 2018). Increased irrigation will allow for land that has already been cleared for farming to remain usable so that additional deforestation is not necessary. Having more water can lead to socioeconomic benefits by increasing yields for farmers growing crops or raising livestock.

In the 1970s, the tropical dry forests reached a point where they had experienced the most significant declines in area (Voice, 2018). The PhD program that I am proposing could study the species diversity of the old-growth tropical dry forests that avoided deforestation in the 1970s (Voice, 2018). It would be interesting to fill the current gaps in knowledge about species that are most abundant in tropical dry forests in regions that were previously deforested compared to forests with minimal disturbance. Additionally, it is currently unknown how many species in the Costa Rican tropical dry forest will respond to increased drought and temperature, so this new PhD program would provide the opportunity for more researchers to investigate species diversity and conduct experiments as Santa Rosa undergoes significant changes.

After researching higher education if Guanacaste, I was not able to find any PhD programs with a focus on biology offered at universities in the region, which reveals that there is likely a lack of expertise on the tropical dry forest ecosystems here. I did not find the lack of a biology PhD program in Guanacaste surprising because the emphasis on agriculture in this region leads many to work on farms rather than pursue graduate degrees. In a time when the lifestyles of many thousand farmers in this region is at stake, it is crucial to be investigating this ecosystem in order to save jobs and understand the full extent of climate change on the abundance of species in Guanacaste.

E- Description of project

For the first part of my plan, I would like to use part of my budget to fund the expansion of an irrigation canal system in Santa Rosa and the surrounding farmland. The region is becoming dryer because the annual rainfall is declining and is causing water shortages for local farmers and others who live in the region (Lopez, 2014). Less water leads to higher unemployment for agricultural workers and causes a lower quality of life (Lopez, 2014). Therefore, I believe that the best use of the majority of the $10,000,000 would be to use it for the expansion of the Southern Crop Irrigation Canal. I propose that the

canal should be extended 17 kilometers by flooding more land, which could provide the water to irrigate 17,800 hectares of farmland based on the calculations by The Costa Rican Star (Lopez, 2014).

This water would not only be crucial for making it possible for the region to continue to sustain its current levels of agriculture, but this canal could also provide drinking water to tourists and those who live in the region and are not farmers (Lopez, 2014). Guanacaste currently relies on irrigation from the Arenal reservoir, but as the region becomes dryer each year, more land will require irrigation from this water source (Evans, 2014). As this water is moved from Arenal to Guanacaste, it passes through turbines and is used as a source of hydroelectric energy (Evans, 2014). This region is the driest part of the country, but it is responsible for 50% of the national meat and milk production annually (Evans, 2014;Voice, 2018).

After researching biological research stations near Santa Rosa, I believe that the best possible location for starting a PhD program would be the Palo Verde research station, which is located in a 20,000 hectare national park (Organization, 2019). Palo Verde National Park is one of the most intact areas of tropical dry forests in Central America, and researchers at this station have been collecting data about the biodiversity and tropical dry forest composition in the surrounding area ever since the research station was founded in 1968 (Organization, 2019). This research institute's main goals include investigating global change, specifically how the ecosystem is responding to conditions becoming drier and hotter, agriculture, human health, protected areas, and landscape management (Organization, 2019). I believe that the goals that the research institute are investigating align well with my goals for this PhD program's research, which is why I would be interested in having Palo Verde be the home base for my program.

Currently, the Palo Verde research institute offers graduate courses for PhD students to take for a semester, but no PhD program based at the station. In order to develop my PhD program, I would be interested in working with professors from CATIE because they are familiar with they requirements that PhD students need to complete in order to earn their degrees at a research station that is somewhat similar.

Additionally, I believe that it is crucial for the new buildings to be constructed with sustainability in mind. I think that it is important to incorporate solar panels into the roofs, siding, and windows of the new structures whenever possible so that the expansion of the Palo Verde research station does not cause a negative impact on the surrounding environment. The solar energy that is generated from the new buildings could be used to power the rest of the research station. I believe that solar power would be more reliable than hydroelectric power for this station because the dry season in this region has been becoming increasingly drier as the climate changes, and it would minimize the need for water near the station (Voice, 2018).

F- Benefits, costs, possible negative side effects and how they will be mitigated

For my projects, I have planned to invest seven million dollars on the expansion of the canal, and the remaining three million dollars will be spent on founding the PhD program and building new classrooms and laboratories at the Palo Verde research station. I have determined that for seven million dollars, the Southern Crop Irrigation Canal can be extended by 17 kilometers to reach new areas, which will allow for water to be provided to approximately 17,800 hectares of farmland. This calculation included the cost of labor, materials, and the purchase of the land. I based this calculation off of the cost that the Costa Rican Star reported as the previous costs of expanding this canal previously, and the canal was extended in length by flooding farmland. This canal would provide stability to residents of Guanacaste during the dry season. In order to extend this canal, land would need to be flooded, but the land that is being flooded would be land that has been cleared for pastures and not from the tropical dry forest.

A possible negative side effect of expanding the canal is that it may have to run through farms and ranches, which would make it more challenging for farmers to work around this. However, I predict that the benefits of canal would outweigh the challenges of navigating around the canal. This canal would be providing more water to Guanacaste, but this water is coming from Lake Arenal, so it is important to ensure that the other regions that get water from this source also have enough water. Additionally, this

canal could lead to habitat fragmentation and the disturbance of biological corridors. The indigenous people may not want the canal to pass through their land because of the disturbance that it would cause. Also, this canal would make it possible to farm this region in the years to come, but it is not a permanent solution for addressing climate change in this region. Climate change will need to be addressed on a global scale in order to prevent the desertification of regions like Guanacaste and make ranching nearly impossible.

For the addition of the PhD program at the Palo Verde Research Station, I believe that there are few possible negative side effects. One possible negative impact is that the construction of additional classrooms and laboratories could disturb the nearby environment, but I believe that this construction could be completed in a sustainable manner and solar panels could provide power to the rest of the Palo Verde research station. This program would provide jobs to professors and valuable research opportunities to graduate students. Hopefully, if more students are able to earn PhDs in Costa Rica, the researchers will remain in the country after earning their doctorate in order to continue their studies of the tropical dry forests. The addition of a PhD program in Costa Rica could make it worthwhile for more researchers to continue their studies in Costa Rica now that they have access to a lab and are experts on the local ecology, which would help to increase the local expertise on tropical ecology in this region. Additionally, the PhD program would add value to the community by collaborations with local farmers and indigineous people in order to engineer ways to utilize the land as effectively as possible. The conservation research can potentially save endangered species, which will maintain the high rate of ecotourism to this region so that visitors can observe the native species. This program will inform more people about the importance of conserving tropical dry forest ecosystems, and researchers will collect evidence that reveals the importance of protecting endangered species.

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