Implications for hydropower development in Costa Rica: A spatial visualization and analysis of the implications for hydroelectric dams in the Chirripo Valley

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ENVS 4520 (J. Podur)

April 10th, 2014

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Background

The hydro electrification of Costa Rica both has a positive and negative theme for the province. At one point the use and shift towards hydroelectricity and 'clean energy' is seen as beneficial since they are moving away from traditional 'dirty' energy. Moreover, the country is known for its commitment towards renewable energy (United National Industrial Development Organization, 2014, p.). On the other side, hydroelectricity is costly both towards the actual construction of it and the cost it has to the environment and the people living in the proposed areas.

Literature Review

Costa Rica is a country located in Central America. The country is between Nicaragua to the North and Panama to the South, With the North Pacific Ocean on the West coast and the Caribbean Sea on the East Coast. Since Costa Rica is located in Central America it has a sub tropic to tropic climate. With weather and temperate being different in the mountainous areas than to what is experience on the coast (CIA World Factbook, 2014).

Understanding the issue of energy exploration in Costa Rica has striking similarities to energy exploration and extraction in Canada. Whereas, there is a marginalized group where the extraction and or exploration process is taking place and there voice is silenced. In Canada, there has been mistreatment of aboriginals over issues of energy exploration. In Costa Rica, there is a similar story. The Teribe people are a community of indigenous peoples living near the largest dam under construction in Central America, the El Diqius (Human Rights Clinic, 2010, p. 15). A report examining the participation of the indigenous and local people in consultation in the planning process noted that they were not involved at any stage:

> …ICE and other state actors have failed to provide this information, and no mechanism has been in place for the indigenous peoples to exercise their right to consultation. In addition to contributing to a violation of the Teribe peoples' right to effective participation, this lack of information violates the Teribe peoples' right to information, recognized under international and domestic law
> (Human Rights Clinic, 2010, p. 3.)

When the dam is constructed, it will result in massive flooding of the land where most of the Teribe people reside. Ownership in this region has also dramatically shifted to the point where 90% of the lands are owned by non-indigenous people (Human Rights Clinic, 2010, p. 16). The Teribe people live off the land and if they were forced to move or have a large percentage of their land loss due to flooding, they would lose their livelihood; as the report states, "it could also have a devastating cultural impact given the vital relationship between indigenous peoples and their land" (Human Rights Clinic, 2010, p. 18).

Overall, any type of development that does not include the voice of the community that will be affected has some serious issues. In the report on the adverse effects on the Teribe people due to hydroelectricity, there is a powerful quote that summarized what is taking place. It states:

> The proposal for El Diquís is the most recent threat to indigenous landholdings as it would both flood indigenous lands and bring more outsiders to the indigenous territories of southern Costa Rica. This project is just the most recent example of projects proposed in the interest of national development, but with particularized negative externalities felt by indigenous communities
> (Human Rights Clinic, 2010, p. 17)

Site Description

We will be exploring the proposal of hydroelectric dams in Costa Rica and their negative effects on the environment and the local community. We will explore the area of the Chirripo Valley. We will be looking at a number of proposed dams in the area and how they could potentially impact the environment, cultural, and the communities.

Hydropower development: brief history and proposed developments

Costa Rica is a country that is heavily expanding its energy sector, which is being achieved through massive investments in hydroelectric projects. Presently, Costa Rica has the majority of its energy production, about 93%, coming from renewable sources, of which about 82% comes strictly from hydroelectric production (Zuñiga, 2014). By further expanding the amount of hydroelectric projects in the country, Costa Rica could look to diversify its economy by exporting energy as well (Liberia, 2009). As the country is located

in a strategic location, it could look to sell energy both to South and North American countries, which is a process that the government is heavily considering in order to raise the standard of living and generate profit to reduce a large national deficit (Liberia, 2009).

International organizations are also very supportive of expanding hydroelectric capabilities. The Institute of Electricity in Costa Rica (ICE) is a state-owned company charged with the task of providing power to the residents of the country, and ICE has received notable contributions from the World Bank and IMF in order to further develop its energy network (Chavez, 2013). For instance, ICE received up to $1.4 billion from international investors for the construction of the Reventazon Hydroelectric Project (in the Limon province) (Costa Rican Times, 2014). This type of attention and prioritization of the energy network has encouraged the Costa Rican government to look for other areas to develop hydroelectric projects as well.

A major project that will have huge social, economic, and environmental impacts is the El Diquis hydroelectric project. Located in the Southern portion of the country, the El Diquis is a megaproject that will be the culmination of many smaller local dam projects that flow into the Rio General River (Casallas, 2012; Vaughn, 2010). The massive structure will see a 173 metre high 600 metre long wall, and will flood over 6 million acres of land while simultaneously producing about 630 megawatts of power, all for the cost of approximately US $2 billion (Casallas, 2012; Vaughn, 2010). It is clear to see that the government is putting much effort and resources in developing its hydroelectric system, though under the pressure of national and international investment, there are many social and environmental consequences that have been overlooked.

Implications of hydropower development: impacts to local ecology and communities

Ecology

Long term, large scale impoundment developments are relatively new to tropical regions like Costa Rica. As such, there are few examples of this type of development and a lack of data on their impacts specific to tropical regions (Anderson et al., 2006). The research that has been done, however, is cause enough for concern, with regard to potential ecological impacts. At the local scale (i.e. with respect to individual dam projects), impacts include loss of wildlife habitat, decreases to downstream fish production, and

sediment build up in reservoirs (Vaux and Goldman, 1990).

There are over 1000 catalogued species of Atlantic and Pacific fish, the majority of which occur on the Pacific coast of Costa Rica (Bussing and López, 2009). 135 species of fish are known to inhabit within the region of Costa Rica where the proposed dams are situated (Anderson et al., 2006). The fish are of particular concern, as they are integral to the local economy, thus making the fish of both ecological, as well as socio-economic concern.

The style of dams for this region are diversion-type dams, whereby the water is diverted via artificial canals, tunnels, or pipelines to powerhouses, where electricity is generated, and the water is discharged into the river downstream (Anderson et al., 2006).

Diversion has major ecological implications for many reasons that are addressed by our research. The dewatering of the river, as well as impoundment of sediment has the potential to restructure the ecosystem downstream of the dams (Dynesius and Nilsson, 1994; Anderson et al., 2006). Sediment flowing downstream is impeded by the dams, building up in the reservoirs, and leaving the bedrock bare downstream. The long term effects of ecosystem restructuring results in the fragmentation of marine ecosystems. The nature of the dams impedes movement along the river, and since dams are planned for the entire river network, they will act as a barrier to wildlife.

Our research will focus on showing the impacts of the network of dams currently being proposed. Our research will create ecological context for hydropower development and show the barrier effect that these developments can have on wildlife.

Socio-economic

One of the biggest fears the Teribe community are facing is the possible threat of "cultural extinction" through development. This fear is possible if the construction of the dams take place. One of the initiatives the hydroelectric company wants to do is bring in educational centres and the internet. As the report states:

> The penetration by outsiders of indigenous territories led to the loss of indigenous territories to non-indigenous and made indigenous peoples a minority in their own territories. Dispossession of their lands impoverished the Teribe both economically and spiritually (Human Rights Clinic, 2010, p. 17)

Methodology

The data used for this project were acquired by multiple sources. Some layers were provided by Dr. Justin Podur and by Dr. Phillip Montoya. Further information was taken off of the Las Nubes website (individual items are referenced in the maps accordingly). The base maps were obtained with the Open Layers plugin in QGIS, with 1984 Pseudo Mercator as the projection.

The first step was properly georeferencing the maps obtained from the Las Nubes site and from Dr. Montoya. These maps were critical to the project as they showed areas of interest such as the locations of the proposed hydroelectric dams, the locations of nearby villages that would potentially be affected, and the proximity to conservation areas with national and international significance. All georeferencing was done with QGIS, with multiple ground control points being used to ensure accuracy with the image and the Google base layer. Using a Helmert transformation with nearest neighbour resampling, a final residual value under 1.0 was obtained for all GCPs of the images.

The next step is was to digitize features, using the georeferenced maps as locators for the important features. Both point and line digitizing for vector data was used, and multiple features were digitized, including: the location of the villages, the location of the dams, the local rivers, protected natural areas, and other areas of interest. Digitizing these features helped show the impact that the dams would have on their immediate surroundings.

Once the images were properly georeferenced and digitized, buffers were applied to certain features to show potential impact. Buffers of 5km were applied to the local dams (and 10km to the El Diquis mega dam) to show areas which are most likely to be affected by the coming projects. Buffers were also applied to many of the rivers to show both make them more noticeable and to show the downstream effects (i.e. less flow downstream of a major dam).

Results

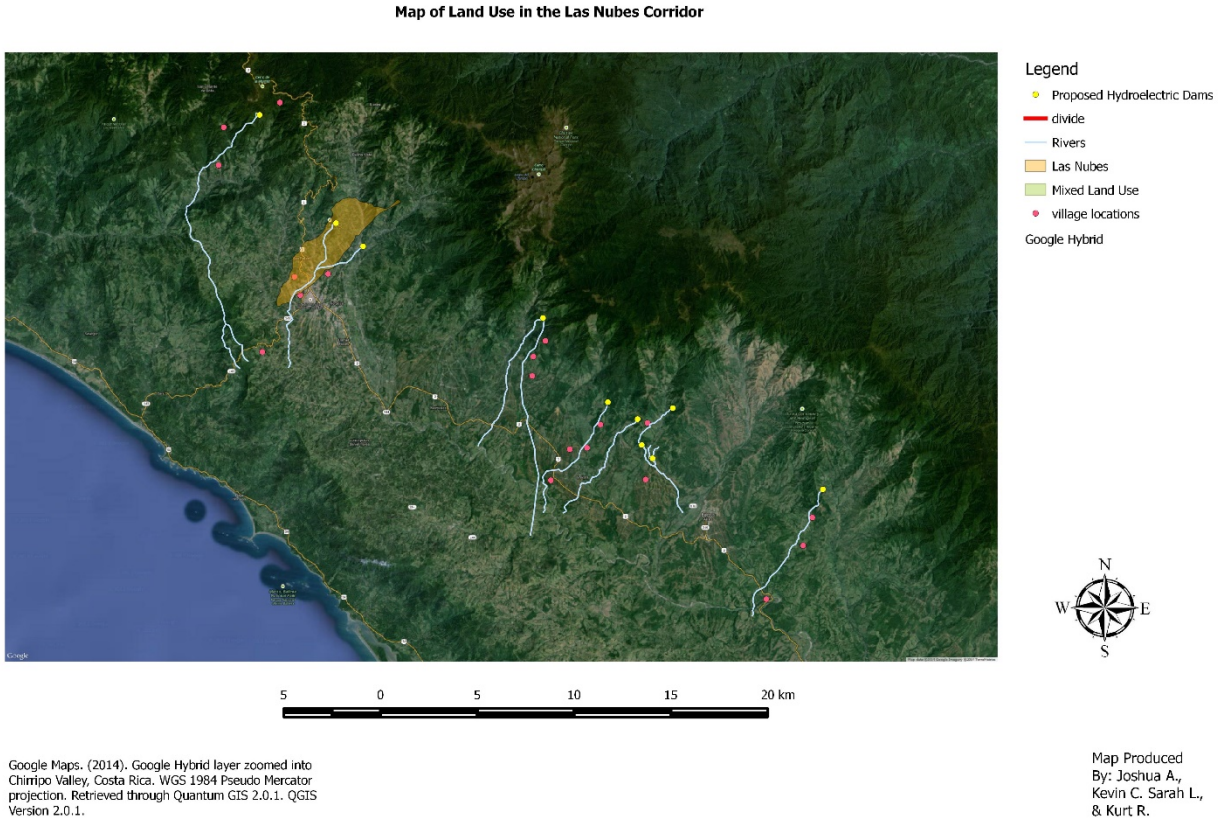

Figure 1. This is a map of providing a detailed look of the area of interest. It highlights the rivers, villages, the proposed hydroelectric dams, and the Las Nubes Biological Corridor.

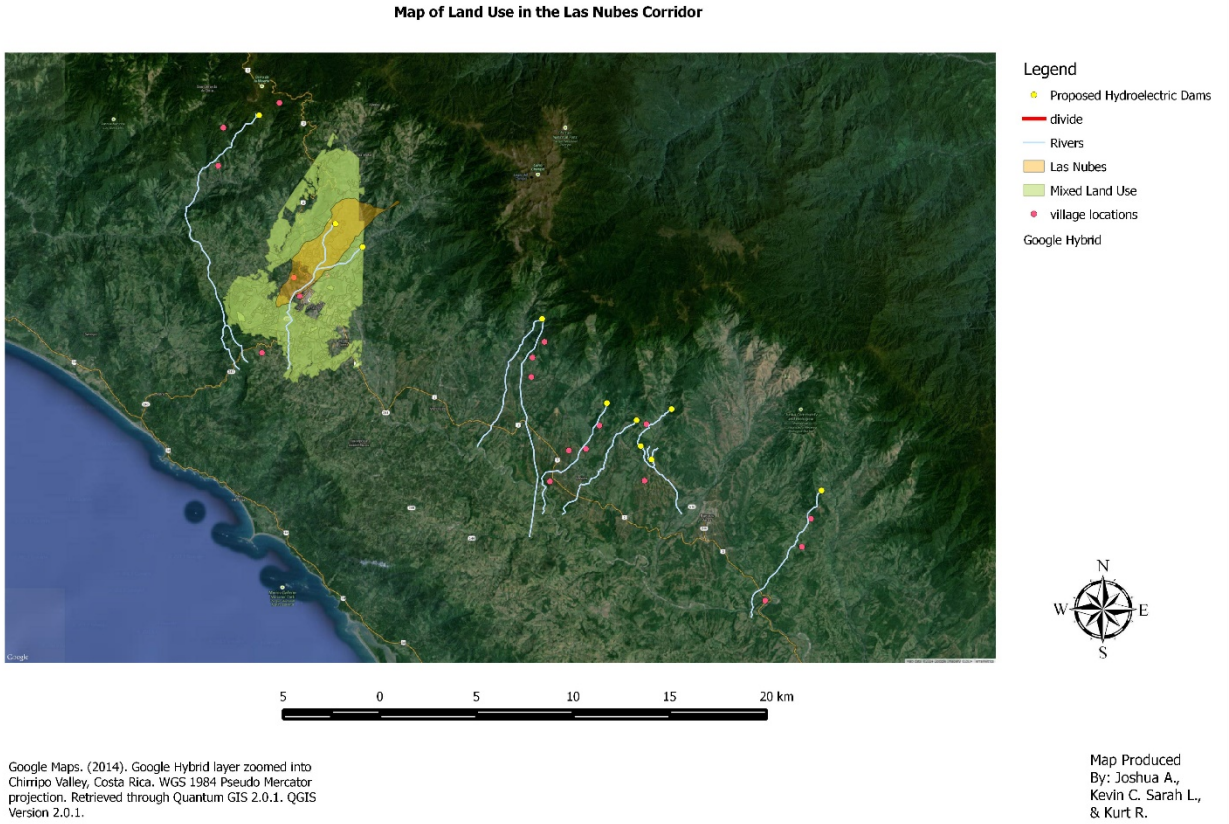

Figure 2. Similar to the previous map, this map shows the mixed land use area surrounding the Las Nubes Biological Corridor. Within this polygon there are various activities taking place, i.e. restoration projects and coffee bean harvesting.

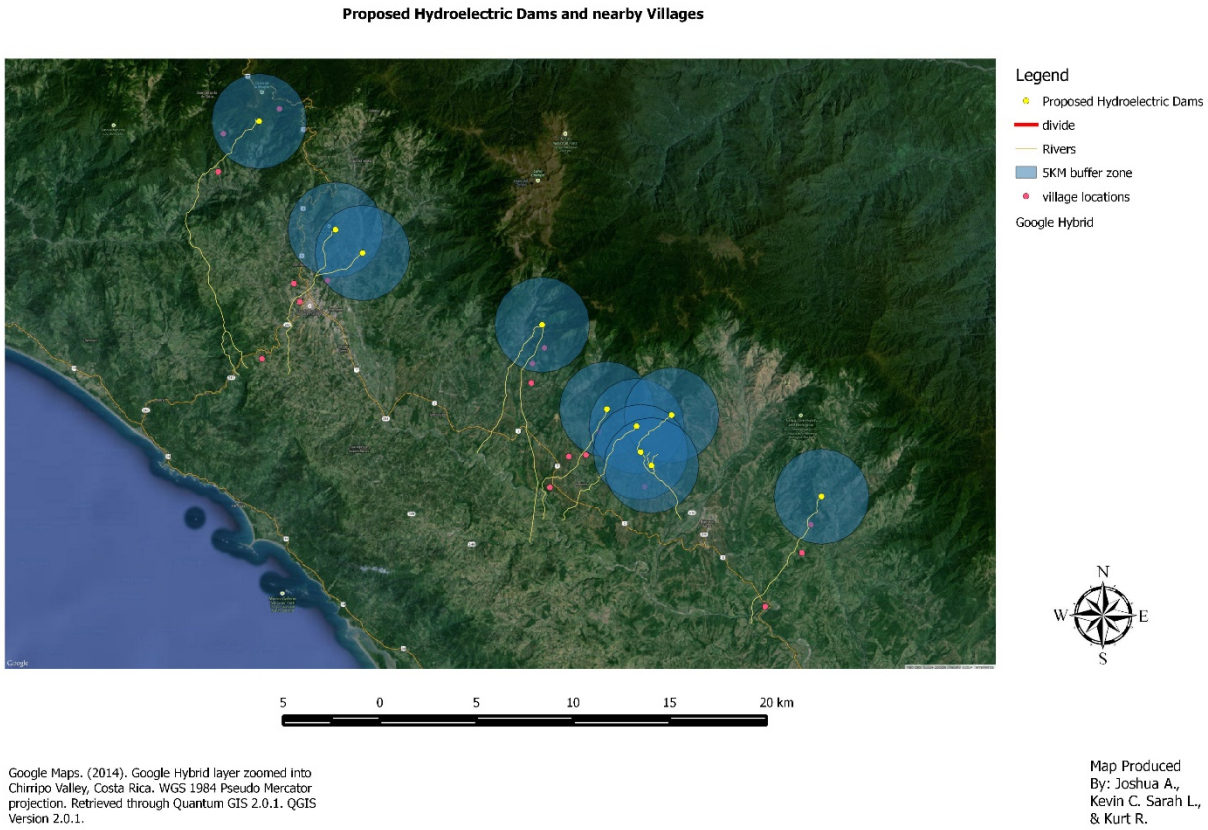

Figure 3. This is a map providing information on the proposed hydroelectric dams in the area and their location to the local villages. We created a 5km buffer zone around the dams as an estimation of area these dams may impact.

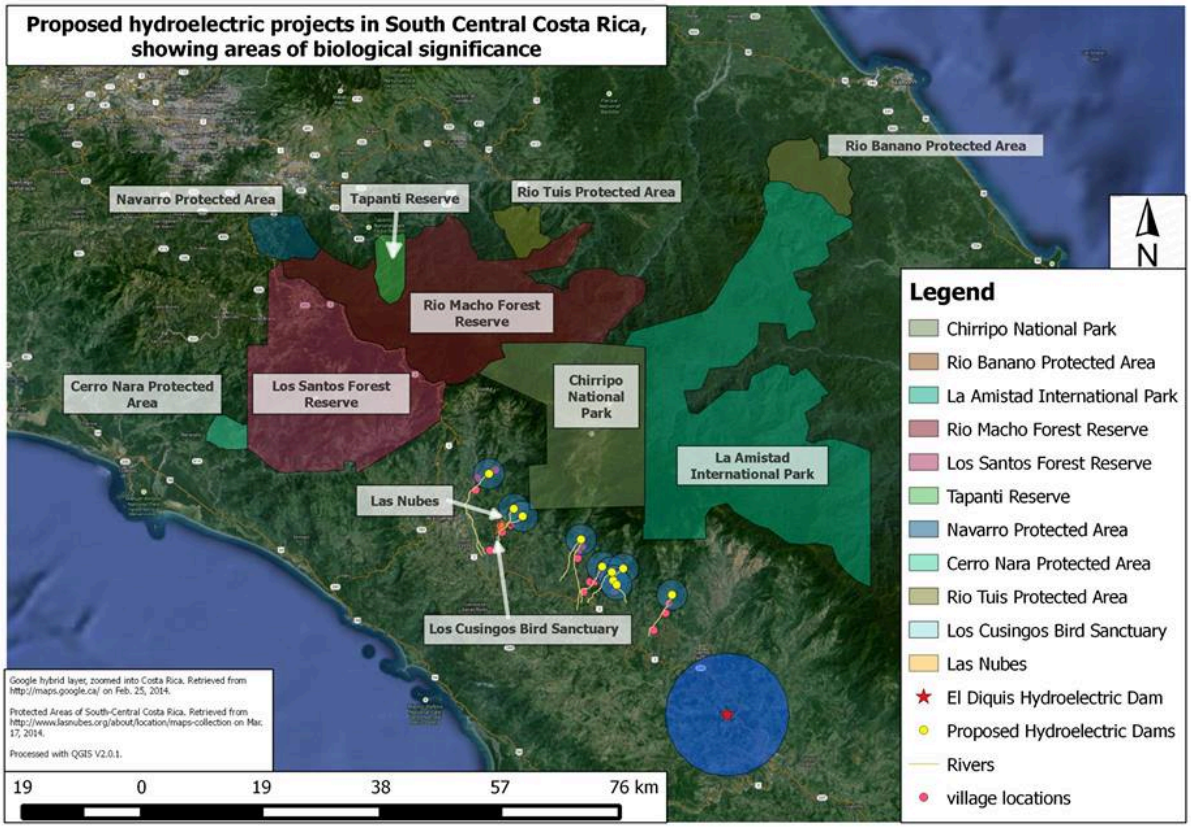

Figure 4. This map provides information on the proposed hydroelectric projects in South Central Costa Rica and the areas of biological significance. It is very noticeable that these dams are conveniently located at the edges of protected areas.

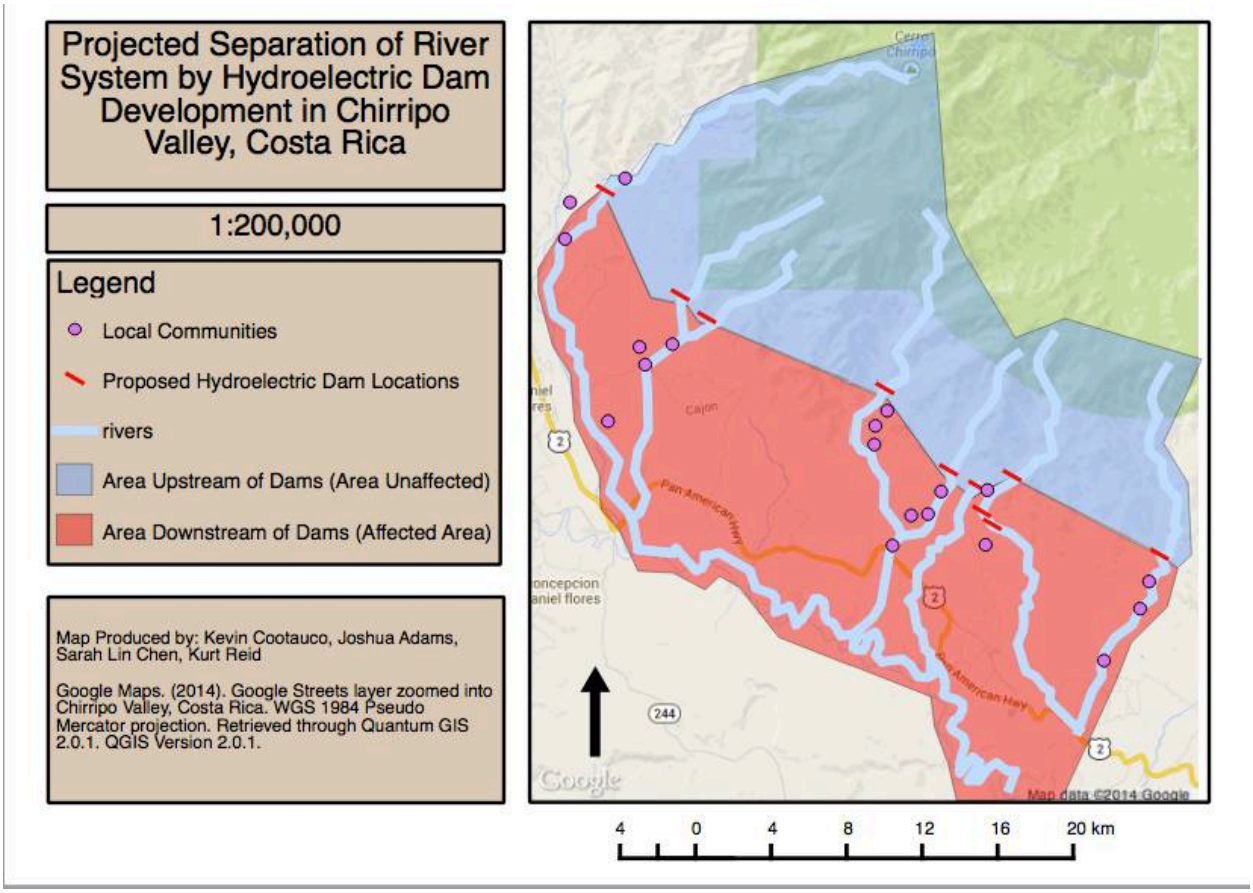

Figure 5. This map provides information on the local communities and both areas up and down stream that are likely to be affected by the proposed hydroelectric dams.

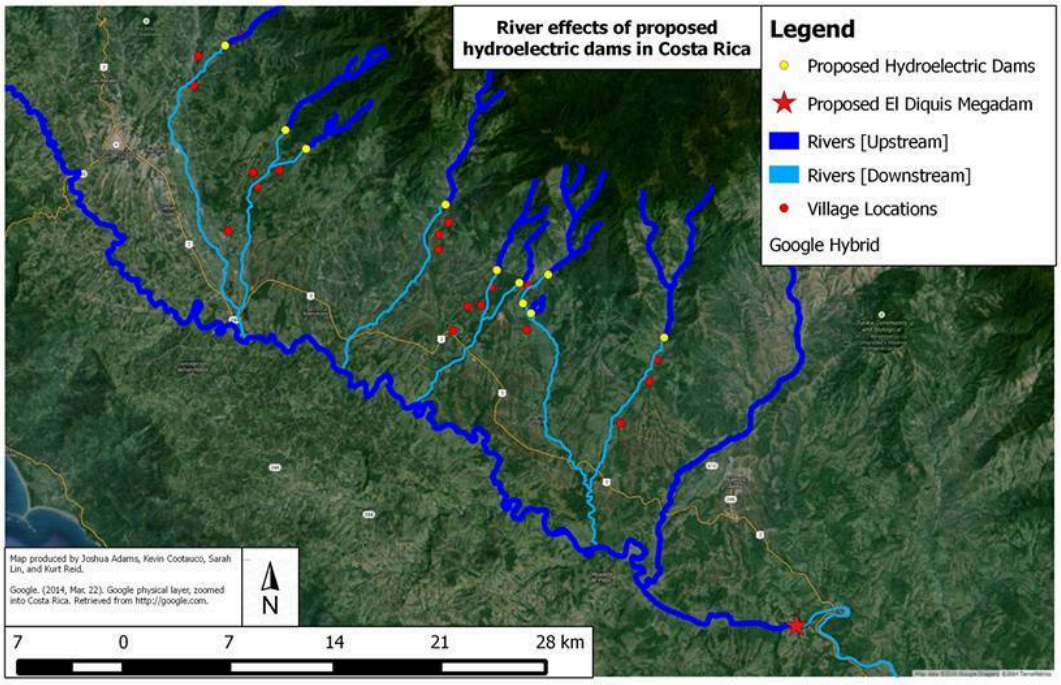

Figure 6. This map shows the current river network in the proposed areas. The river system upstream and the system leading to the biggest proposed dam site, El Diquis are highlighted.

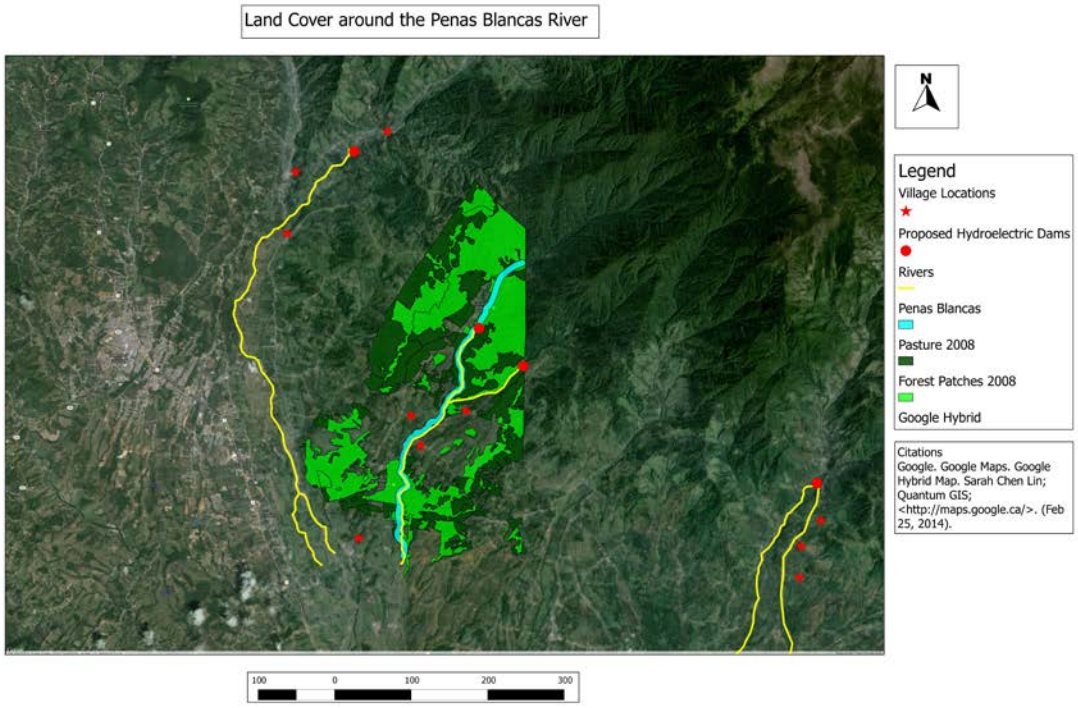

Figure 7. This map shows the pasture and forest patch cover in 2008 along with the Penas Blanca River.

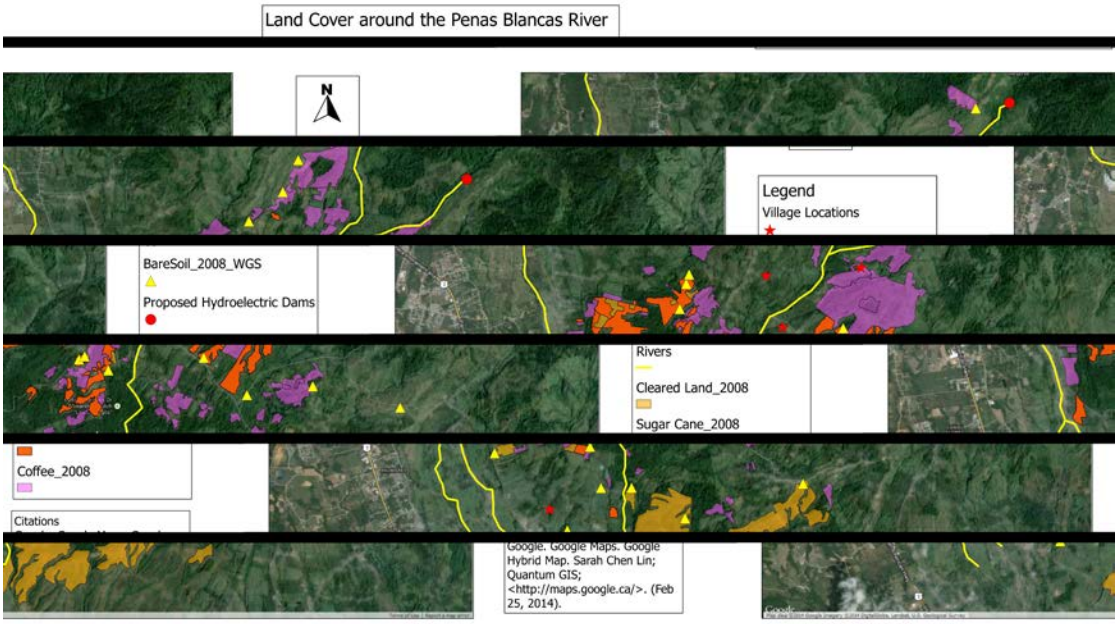

Figure 8. This map shows other types of land covers such as coffee and sugar cane coverage in 2008.

Our maps have shown the relative location of the dams and rivers with surrounding villages and national parks. Figures 1, 2, 3, and 4 show the proposed locations of the dams, and their proximity to areas that may be affected by their construction. The buffers around the proposed sites are the areas that will be most immediately affected by their construction and operation. However, many more communities may also end up being negatively affected as the dams will play a role in other communities that rely on the local rivers for agriculture and tourism. Flora and fauna will also be affected, both by the deleterious impacts of construction, and the disruption of river flows on which many species rely. Figure 5 shows some of the ecological impacts, as areas both upstream and downstream of the rivers will be affected by the river flow. Figure 6 shows how the river currents may dissipate after flowing through the dams.

Conclusions

Our team of analysts had a distinct vision in mind when approaching this project. That vision was situated on a few key tenets: clarity, accessibility, and credibility. The development on which our work is focused on is still only in preliminary stages, therefore the dams are not yet constructed, and so no real impacts from these exact dams are yet evident. Our use of open-sourced software, and data was part of a two-fold accessibility mandate. First of all, we wanted our data to be useful to researchers and to stakeholders impacted by the proposed developments. Open sourced data and software made this possible, and gave our work a certain degree of transparency that was part of the mandate. Secondly, our team made an effort to target non-expert audiences, making our work accessible in as many ways as possible. Although local communities were a primary concern of ours, we also made an effort to ensure accuracy and precision in our execution, to lend the highest degree of credibility. In a lot of ways, versatility emerged as an unintentional mandate of our vision -- our team made the utmost efforts to make our data useful to as many audiences as possible.

Prospects

As mentioned, our goal with this project was to create visual, accessible assessments of hydropower development in Costa Rica. We are confident the work that we have

produced can be used as a powerful educational medium in order to engage and involve local communities for more active and participatory management. The geospatial data that our team produced was done for the purposes of encouraging stakeholder involvement in management strategies. Being a primary stakeholder in this context, our target audience was local communities, as well as educators, and research teams involved in participatory active research.

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