CENTRO DE INCIDENCIA AMBIENTAL

# The Ecological and Social Impacts of Hydroelectric Dams on the Rio Chico and Chiriquí Viejo Watersheds

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Prepared for McGill University, Centro de Incidencia Ambiental (CIAM), The Smithsonian Institute, and the populace of the Rio Chico and Chiriquí Viejo Watersheds

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# 1. **Executive Summary**

## *1.1 English Version*

Over the past decade, the production of hydroelectric energy in Panama has increased drastically in response to rapid economic development. A large majority of Panama's hydroelectric energy is produced in the provinces of Chiriquí and Bocas del Toro, typically taking the form of small (less than 80 mW) run-of-the-river dams that are often on the same river. The local population has criticized the dams for their ecological and social impacts, but little concrete information is available. The absence of studies assessing the cumulative social and ecological impacts of multiple small hydroelectric developments in Chiriquí, and on river systems globally, forms the justification for our study.

The study assesses two watersheds at different stages of the hydroelectric development process: the Rio Chico watershed, with the greatest number of hydroelectric projects already constructed, and the Rio Chiriquí Viejo watershed, with 14 new concessions. The objectives of this research project are to form a baseline understanding of the ecological and social impacts of multiple small hydroelectric projects on neotropical river systems. The report includes an ecological study, social diagnostic, and evaluation of Environmental Impact Assessments.

Over the course of this four month research project, we carried out fieldwork in Chiriquí for 13 days and research in Panama City for 21 days. We conducted a literature review on the ecological and social impacts of small hydroelectric projects. Our ecological study included four study sites at the hydroelectric projects of Paso Ancho, Macano, Pedregalito, and Bajo Frio. We tested various water quality parameters as well as discharge.  Our social diagnostic included six study sites, the communities of Victoria, Pedregalito, San Andres, Paraiso, Paso Ancho, and

Altos de Chiriquí. The methodology consisted of random interviews that lasted an average of 20 minutes. We interviewed a total of 110 individuals and followed the McGill Code of Ethics.

From our ecological literature review we determined that major ecological impacts of small hydroelectric projects include river fragmentation and dewatering. Our ecological study identified the parameters of temperature, conductivity, and ecological flow as points of interest and potential future focus. The ecological flow of Paso Ancho was notably below the legal limit.

The results of our social literature review discuss the major positive and negative social impacts of hydroelectric development. Social benefits are primarily economic growth and improved flood control, while negative social impacts are displacement, adverse effects to human health, and livelihood changes. Our social diagnostic found interesting results regarding uses of the river, public knowledge and participation, impacts of the dams, and general community support. Important findings were that communities are variably impacted by the dams, and that the main impacts were employment, water shortages, and limited use of the rivers. All interviewed communities expressed a lack of representation in the public participation process.

The final section deals with a review of the Environmental Impact Assessments for Paso Ancho, Macano, Pedregalito, and Bajo Frio. A critique is presented regarding the content, clarity, and methods of the EIAs, followed by a comparison of EIA data with our own social diagnostic. The main findings were disparities surrounding employment and community support for the projects, as well as disparity in representation in the public participation process. The public participation process is then discussed, with recommendations for improvement in the future.

The overall results of our study show that small hydroelectric projects may have extensive ecological and social impacts, yet there is a large gap in the literature regarding this subject in the neotropics. Directions to pursue in an ecological study include extensive sampling of parameters that are impacted by fragmentation, including temperature, conductivity and suspended sediment; as well as extensive assessment of discharge before the dams and in the dewatered reach below the dams. Ecological flow requirements should be reassessed and more frequent monitoring should be in place to ensure compliance with these requirements. Directions to pursue in the human sense are assessing the consequences of changes to livelihood, particularly subsistence; as well as participation in hydroelectric planning. More legal emphasis on the public participation process is recommended. We hope that this study will help to orient CIAM towards appropriate and effective legal action in Chiriquí, and that it will prove useful to our partner organizations in Chiriquí as well as Chiriquí's impacted communities.

### *1.2 Versión Español*

Durante la última década, la producción de energía hidroeléctrica en Panamá ha incrementado drásticamente causado por un rápido desarrollo económico. La gran mayoría de la energía hidroeléctrica en Panamá se produce en las provincias de Chiriquí y Bocas del Toro. Generalmente, estos proyectos son pequeños (menos de 80 mW) con el diseño de "run-of-the-river" y muchas veces son construidos en el mismo río. La población local ha denunciado impactos ecológicos y sociales por las hidroeléctricas, pero hay poca información concreta para negar o confirmar estas afirmaciones. Nuestro estudio está justificado por la ausencia de estudios sobre los impactos acumulativos de varios pequeños hidroeléctricos en Chiriquí y a nivel mundial.

El estudio evalúa dos cuencas hidrográficas en las diferentes etapas del proceso de desarrollo hidroeléctrico: la cuenca del Río Chico, con el mayor número de proyectos hidroeléctricos ya construidos o en diseño final, y la cuenca del Río Chiriquí Viejo, con 14 nuevas concesiones. El objetivo de nuestra investigación es fortalecer conocimiento sobre los impactos ecológicos y sociales de los múltiples pequeños hidroeléctricas en ríos neotropicales. El informe incluye un estudio ecológico, investigación social, y evaluación de los Estudios de Impacto Ambiental relevantes.

Durante nuestro investigación de cuatro meses, se llevó a cabo trabajo de campo en Chiriquí durante 13 días y investigación en la ciudad de Panamá durante 21 días. Realizamos una revisión de la literatura sobre los impactos ecológicos y sociales de pequeños proyectos hidroeléctricos. Nuestro estudio ecológico incluye cuatro sitios: los proyectos hidroeléctricos de Paso Ancho, Macano, Pedregalito y Frío Bajo. Probamos diferentes parámetros de calidad del agua y descarga. Nuestro diagnóstico social incluye seis sitios de estudio: las comunidades de Victoria, Pedregalito, San Andrés, Paraíso, Paso Ancho, y Altos de Chiriquí. La metodología consistió en entrevistas al azar que duraron un promedio de 20 minutos. Entrevistamos un total de 110 individuos y seguimos el Código de Ética de McGill.

De nuestra revisión de la literatura ecológica determinamos que los principales impactos ecológicos de los pequeños proyectos hidroeléctricos son fragmentación de los ríos y la deshidratación en el caudal ecológico. Nuestro estudio ecológico identificó los parámetros de temperatura, conductividad, y el caudal ecológico como puntos de interés y focos potenciales en el futuro. El caudal ecológico de Paso Ancho fue notablemente por debajo del límite legal.

Nuestra revisión de la literatura social analizó los principales impactos sociales positivos y negativos del desarrollo hidroeléctrico. Los beneficios sociales son principalmente el crecimiento económico y control de inundaciones, mientras que los impactos sociales negativos son los efectos del desplazamiento, los efectos adversos para la salud humana, y los cambios de los medios de subsistencia. Nuestros diagnósticos sociales resultaron interesantes con respecto a los usos del río, el conocimiento y participación público, los impactos de las represas, y el apoyo de la comunidad en general. Hallazgos importantes fueron que las comunidades son variablemente afectadas por las represas, y que los principales impactos son el empleo, la escasez de agua, y el uso limitado de los ríos. Todas las comunidades entrevistadas expresaron la falta de representación en el proceso de participación pública.

La última sección es una revisión de los Estudios de Impacto Ambiental para Paso Ancho, Macano, Pedregalito y Frío Bajo. Presentamos una crítica del contenido, la claridad, y los métodos del EIA, seguido por una comparación de los datos de los EIAs con nuestro propio diagnóstico social. Había disparidades entre los datos de los EIAs y los nuestros sobre empleo y opinión comunitaria de los proyectos. También había una disparidad entre los datos con respeto a la representación comunitaria en el proceso de participación pública. Concluimos con una discusión del proceso de participación pública, con recomendaciones para mejorarlo en el futuro.

Los resultados de nuestro estudio muestran que los pequeños proyectos hidroeléctricos pueden tener amplios impactos ecológicos y sociales, sin embargo, hay una gran brecha en la literatura sobre este tema en el neotrópico. Estudios ecológicos en el futuro deben incluir un amplio muestreo de los parámetros que se ven afectadas por la fragmentación, incluyendo la temperatura, conductividad y sólidos suspendidos. También deben tener una evaluación amplia de la descarga antes de las represas y en el caudal ecológico. Requisitos para el caudal ecológico deben ser reevaluados y debe impulsar un monitoreo más frecuente para asegurar el cumplimiento de estos requisitos. Direcciones para seguir en el sentido humano son las consecuencias de los cambios en los medios de subsistencia y la participación en la planificación hidráulica. Más énfasis legal en el proceso de participación pública es recomendable. Esperamos que este estudio ayudará CIAM a orientarse hacia la acción jurídica adecuada y eficaz en Chiriquí, y que sea de utilidad para nuestras organizaciones asociadas y las comunidades afectadas de Chiriquí.

### *1.3 Project Hours*

Full Days for Travel to Chiriqui: 8

Full Work Days in Chiriqui: 13

Full Work Days in Panama City: 21

## *2.* Introduction

### *2.1 Host Institution*

CIAM, el Centro de Incidencia Ambiental, is a non-governmental, not-for-profit organization headquartered in Panama City. The organization is dedicated to defending Panama's natural resources, with a mission of promoting environmental protection and increasing public participation in decision-making (CIAM, 2011). CIAM consists of a team of lawyers and an environmental engineer, and is the only NGO currently involved in environmental litigation in Panama. They are working on a full spectrum of issues facing Panama's ecosystems, including marine and coastal protection, forestconservation, green urban planning, hydroelectric projects and monitoring mining concessions.

CIAM recently began work on hydroelectric projects in Panama headed by lic. Joana Abrego and lic. Washington Lum. To date their campaign has focused primarily on hydroelectric concessions in the Comarca Ngöbe-Buglé, but looks to extend its reach to the province of Chiriquí which has the highest number of new hydroelectric projects in Panama.

*2.2 Background Information*

Hydropower is by no means a new phenomenon; the first hydroelectric facility came online in 1882 when energy demand driven by the industrial revolution required a broadening of energy sources. As energy demand has continued to rise into the present day, hydropower dams are being built with increasing frequency on tropical rivers worldwide (Anderson et al. 2006). Panama is no exception. The longitudinal orientation of mountain chains along the Central American isthmus, together with high levels of precipitation, produces highly favourable conditions for hydroelectricity generation. The foundations for economic feasibility of hydroelectric development in Panama were laid in the 1990s when legislation was passed to shift ownership of power generating facilities from government to private institutions (ECLAC, 1996). Panama's Law 16 of July 14th 1992 created the Coordinating Unity for the Privatization Process to facilitate privatization and oversee sales of state assets. Following this, Law 6 of February 1995 permits private companies to generate electricity for self consumption or sale and encourages the use of renewable resources, specifically hydropower (Anderson Olivas, 2004 ).

Panama's westernmost province, Chiriquí, currently has the greatest number of proposed projects: there are 31 anticipated projects, which when completed will generate an additional 1,047 MW of electricity. Fifteen of these projects are currently in construction, and the remaining 16 are in the final stages of the design process (PennWell, 2009). The worldwide acceleration of hydropower development is explained as a response to increasing demands and rising expectations: the developing world is experiencing rising demand for the high-energy commodities that are characteristic of industrialized nations (Rogers, 1991). In Panama the current installed capacity of hydroelectric facilities is 1,663 MW and the Authoridad Nacional de los Servicios Publicos (ASEP) has predicted that by 2013 peak electricity demand will have reached only 1,373 MW (PennWell, 2009). Consequently, the continued development of Panama's hydropower potential is being carried out with the intention of exporting a significant quantity of excess power (PennWell, 2009).

Hydropower is hailed as a reliable source of domestically produced energy, and is often supported by claims that it is less environmentally damaging than alternative forms of energy. It is considered superior to other "environmentally friendly" alternatives such as solar or wind energy because it contains water storage capacity, therefore it is able to store potential energy in order to generate electricity when it is most needed (Anderson et al. 2006). Furthermore, it provides a large-scale alternative to dependence on fossil fuel based energy sources, therefore reducing emissions of harmful gasses and particulates (Anderson et al. 2006; Klimpt et al. 2002). For example, hydropower production in Costa Rica in 2004 reduced oil imports by 5 million barrels and avoided emission of 6.4 billion tons of CO2 equivalent (CEPAL, 2005). Obviously hydroelectricity is highly dependent on water, but most thermal forms of electricity generation also use massive quantities of water for steam power and cooling of the generation system. In most cases the majority of water used by thermal power plants is transformed into steam and is not reusable on site or returned to its source (Sternberg, 2008). Further support for the environmental soundness of hydroelectricity in Panama comes from the fact that the vast majority of hydroelectric dams being built in Panama are classified as small dams, meaning that they are less than 15m high and have a reservoir capacity of less than 3x103 m3 (ICOLD, 1998; WCD, 2000). Generally, small dams are expected to have less environmental and social impacts than large dams.

Despite the various advantages of hydropower development in Panama, however, it is essential to recognise that there are also numerous negative consequences to be addressed. The rivers in Chiriquí are becoming highly fragmented by a multitude of dams, and the collective impact of multiple small dams may be greater than the impact of one large dam (Anderson et al. 2006). The sheer number of dams is problematic, but their design serves to compound the problem. The majority of small dams being built in Chiriquí are diversion dams, they contain the following primary structures: a water diversion circuit (containing a headrace channel, which is simply an open channel or tunnel, a forebay, and a penstock), a powerhouse (containing turbines and generators), and a tailrace channel, which returns the diverted water back to the main river channel (Pinho et al. 2007). Simply put, the water is diverted from the main river at the dam site; it is transported by an artificial channel, and often stored in an off-river reservoir, and sent through the powerhouse before being discharged back into the river some distance below the dam (Anderson et al., 2006). The river section between the dam and the end of the tailrace channel is commonly referred to as the diversion section or dewatered section and it is often the most severely affected; however, the sections above the dam and below the tailrace channel also undergo changes (Pinho et al., 2007).

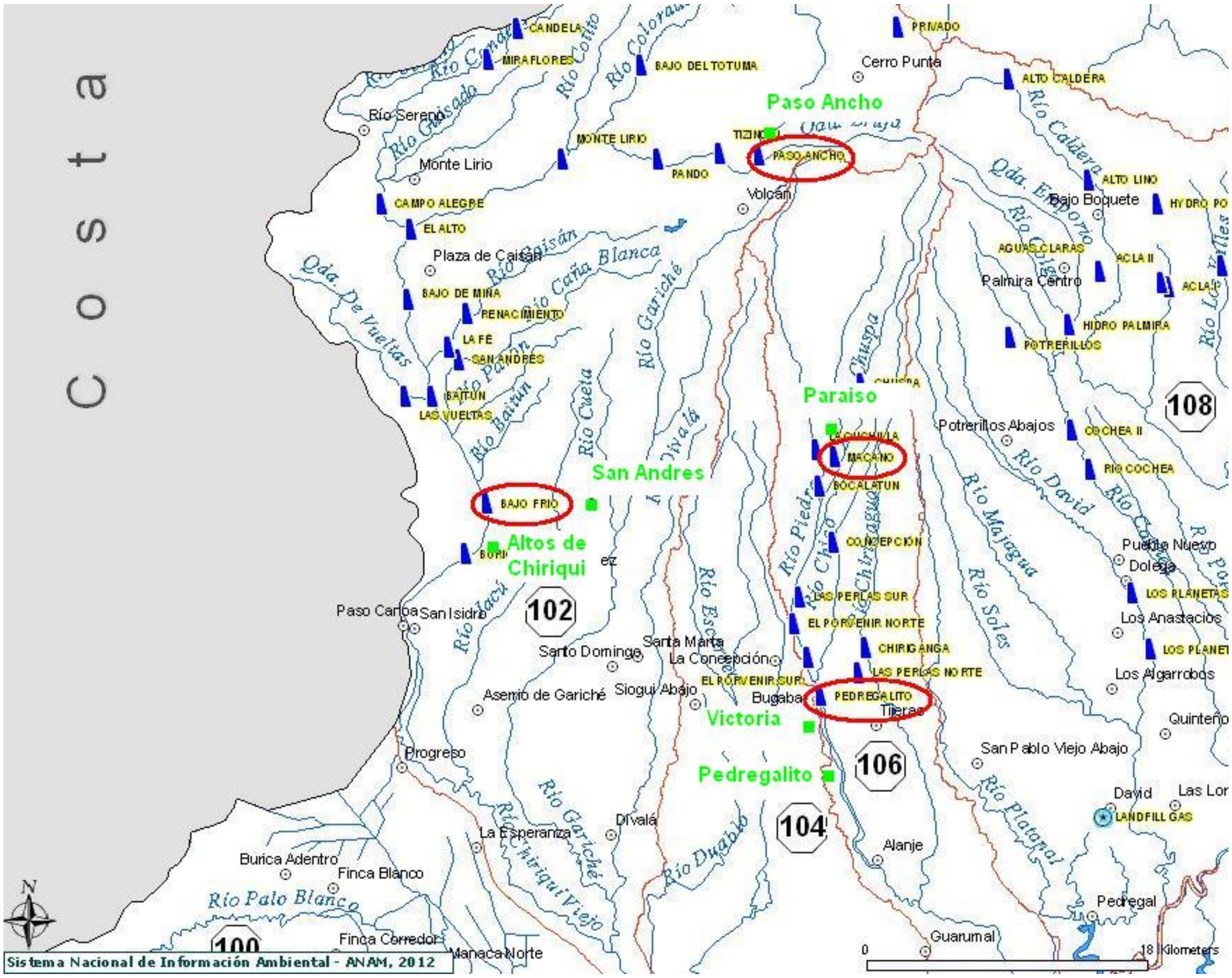
### *2.3 Objectives*

The primary objective of our study was to provide information that CIAM will be able to use in order to determine their focus with regard to hydroelectric projects in Chiriquí. To this end, we set out to conduct a basic pilot study of the ecological impacts of the Paso Ancho, Macano, Bajo Frio and Pedregalito hydroelectric projects in Chiriquí. Furthermore, our desire to investigate the social impacts of these projects led us to conduct interviews in various impacted communities. Our final objective was to do an assessment and evaluation of the Environmental Impact Assessment (EIA) for each of the four projects.

*2.4 Study Area*

We chose to study the Chico (106) and Chiriquí Viejo (102) watersheds in the province of Chiriquí in Panama because the Rio Chico watershed has the most dams currently in operation and the Rio Chiriqui Viejo watershed has the most concessions. In order to illustrate impacts throughout the watersheds, we elected to focus on four projects, one at the top of each watershed (Paso Ancho and Macano) and one at the bottom of each watershed (Bajo Frio and Pedregalito).

Additionally we interviewed in six different communities, Paso Ancho, San Andres and Altos de Chiriqui, in the Chiriqui Viejo watershed, and Paraiso, Victoria and Pedregalito in the Chico watershed. We chose these towns for their proximity to the dams that we focused our ecological sampling on. The towns of Paso Ancho and Paraiso were chosen for their location above the highest dam constructed on each river. Victoria, Pedregalito and Altos de Chiriqui were chosen for being located below the lowest dam in construction or in operation on each river. San Andres was chosen for its location further from the river but within reasonable distance from several dams in the construction phase.




(mapserver.anam.gob.pa/website/mdl/viewer.htm)

## 3. Ecological Study

### *3.1 Literature Review: Ecological Impacts of Small Dams*

Compared with temperate rivers, little research has been done on the ecological impacts of dams on tropical rivers (WCD, 2000; Greathouse et al., 2006). Furthermore, the majority of research that has been done on tropical systems has focused on large dams, and the environmental impacts of small diversion dams are not well known (Anderson et al. 2006). Even less is known about the *cumulative* effects of multiple small dams – in both tropical and temperate systems little research has been done to examine the local or regional impacts of multiple dams on one river system (Rosenberg et al., 2000). Having said this, valuable information can be found in the few studies that have been done, and two attempts have been made to provide models for understanding cumulative impacts of dams; these are the Serial Discontinuity Concept and the Fragmentation Index (Ward and Standord, 1983; Dynesius and Nilsson, 1994). Although no studies have addressed cumulative impacts of multiple dams in Chiriquí specifically, some general conclusions or expectations can be drawn from the existing literature. Figure 22 in the Appendix maps out some of the main environmental impacts associated with dams on headwater and low-order rivers.

*Impacts of Fragmentation:*

Central American rivers are relatively short, and both the Río Chico and Río Chiriquí Viejo are less than 100 km long; as a result, they may be more susceptible to extensive fragmentation by dams and consequent reduction of hydrologic connectivity (Anderson et al., 2006). Hydrologic connectivity maintains the ecological integrity of a watershed and can be defined as the flow of energy, matter and organisms along spatial and temporal pathways within a watershed (Ward and Stanford, 1989; Pringle, 2003). Constructing multiple dams on a river creates isolated stream reaches that are disconnected from the remainder of the watershed. As a result of this disconnectedness, nutrient cycling, and downstream transport of sediment, organic matter, plants, and animals can be disrupted (Ward and Stanford, 1983; Peterson et al. 2001). For example, a study on various dams in the Caribbean showed that even small dams can cause significant mortality in shrimp populations migrating downstream (Benstead et al., 1999). In rivers that carry large loads of suspended sediment the construction of a dam is likely to increase upstream sedimentation (particularly in the reservoir where water speed slows significantly) and increase the amount of bedrock exposed immediately downstream of the dam (Ward & Stanford, 1979; Anderson et al., 2006). There are many variables involved, and when considering the many potential impacts of dams it is important to understand that the magnitude and type of impacts is site specific and should be considered carefully for each dam and river system (Velinsky et al., 2006).

In addition to disruption of downstream movement, migratory biota are prevented from travelling upstream beyond dams (this has been confirmed for small dams (Anderson Olivas, 2004). Diadromic fish, which require the ability to migrate between fresh and salt water in order to complete their life-cycles, have already been almost entirely blocked from accessing rivers on the Pacific slope of Panama because of the extensive damming (McLarney et al. 2010). A single dam alone provides a substantial barrier to migratory fish, but multiple dams significantly decreases their survivorship, as was shown in a study on the Columbia-Snake River in the United States. The study showed that the mortality of salmon smolts increased with the number of dams that the smolts had to pass through (Williams et al., 2001).

*Impacts of dewatering:*

For diversion dams, it has been considered environmentally responsible to construct a system where the gross static height, which is the difference in elevation between the dam site and the turbines, is much greater than the dam height. This is thought to be advantageous because it reduces evaporation and sedimentation behind the dam by creating a smaller reservoir (Anderson Olivas, 2004). These benefits might be outweighed, however, by the harm that is done when large river sections are dewatered. The quantity and quality of riverine habitat can be significantly reduced in the dewatered sections of diversion dams. This can result in biodiversity loss and/or establishment of invasive species (Gleick, 1992; Marchetti & Moyle, 2001). Research has demonstrated that prolonged periods of low-flow significantly alter aquatic communities by forcing crowding of biota, which can lead to increased competition, decreased reproduction and increased predation pressure (Coviche et al., 2003). Results from a study on the Puerto Viejo River in Costa Rica indicate that dewatering most severely affects a subset of fish species that have more complex reproductive requirements, and provides competitive advantage to opportunistic-type, colonising species (Anderson et al., 2006 B)

Dewatering has impacts beyond the scope of the river itself: the subterranean flow is also affected and groundwater recharge rates will be reduced – this has the potential to reduce the availability of water in nearby wells (Pringle & Triska, 2000). In Costa Rica municipal water users have expressed concern that the loss of groundwater recharge due to diversion by hydroelectric projects will significantly reduce potable water supply (Pringle & Triska, 2000).

*Impacts on temperature:*

There are multiple stages in diversion dam systems that could potentially induce temperature changes in the river. The best known mechanism by which dams alter river temperature is by release of cold hypolimnetic water, but this mechanism applies only to large reservoirs that experience stratification (Lessard &Hayes, 2003). What is less well known, and more applicable to small dams, is the effect of releasing warm, surface waters. In their 2003 study, Lessard and Hayes showed that release of warmed reservoir surface water causes shifts in the macroinvertebrate community in a cold-water stream. This information may be applicable to the dams constructed on the headwaters of rivers in Chiriquí where the river water temperature is relatively low. Macroinvertebrates are very important trophic web components – being a food source, a source of predation, and a link between the terrestrial and aquatic ecosystems (Lessard & Hayes, 2003). In addition to temperature effects of the reservoir, decreasing flow in large sections of the river, as is done by diversion, can also impact the temperature regime of the river, which in turn will impact the biotic community (Anderson Olivas, 2004). Temperature may be altered again after the tailrace channel returns water to the river. Hydroelectric facilities commonly operate in conjunction with power demand regimes; as a result, electricity is generated at full capacity during hours of peak energy demand (commonly between 10:00 – 12:30 and 17:30 – 20:00 on weekdays) and large amounts of flow are returned to the river at this time (Anderson et al. 2006). During the time of peak energy generation the level of water in the river below the tailrace channel rises significantly and this has been shown to result in temperature decreasing by 3 – 4 degrees Celsius (Anderson et al., 2006). In addition to changing temperature regimes, water release that is coordinated with power demand results in unnatural fluctuations of flow, which further favours opportunistic species that are better evolved to dynamic environments (Anderson Olivas, 2004).

### *3.2 Methodology*

We conducted our ecological survey during two trips: the first on the 24th and 25th of February, and the second on April 18th and 19th. We were unable to conduct more extensive sampling because of time, equipment and accessibility constraints.The first trip took place during the middle of the dry season, while the second took place at the beginning of the wet season.

During the first trip, we measured pH, temperature, conductivity, color and turbidity above (in the river before the reservoir) and below (in the "ecological flow" between where the water is removed by the dam to go to through the turbines and where it is returned to the river) the highest and lowest dams on the Chico and Chiriqui Viejo rivers. The river directly above Bajo Frio was not sampled due to limited access, instead we sampled further up on the river between the dams of El Alto and Bajo de Mina. In addition, we sampled the Pedregalito I artificial channel and the well for the town of Victoria.

During the second trip, we measured pH, temperature, conductivity, and discharge above (in the river before the reservoir) and below (in the “ecological flow”) these same dams (Paso Ancho, Bajo Frio, Macano and Pedregalito I). In addition, at Pedregalito, we measured discharge after the point where the water that went through the turbines is returned to the river. We did this in order to get an idea of water loss due toevaporation, since we had access to the river section and the climate in this area is hotter and drier than it is for the other dams.

PH, temperature and conductivity were measured by placing the themometer, pH or conductivity probe directly into the river at least 5 meters from the edge of the river and upstream of the person handling the equipment until the probe/thermometer reached a constant number. We used a portable laboratory for these measurements.For the color and turbidity measurements, we took water samples in sterile plastic jars at our measurement sites and kept them under cold (either in an iced cooler or in a fridge) and dark conditions for up to 48 hours. We used a portable spectrometer to measure color and turbidity.

To measure the river discharge, we chose a location in the river which we could wade into, swim through, or access above from a bridge. Furthermore, we selected a location where the width and flow was relatively constant over roughly 5 meters. We measured the width of the river and the depth at regular intervals. In order to save time, we changed the distance between the intervals according to the width of the river and variability in depth of the river bed. We measured the surface velocity of the river using the “float method” (Gierke, 2002). At the center of the river we measured out a 5 meter transect parallel to the direction of flow and recorded the amount of time that it took for a quarter of a paper plate to float the 5 meter distance. We calculated the average velocity of the section by multiplying the observed surface velocity by 0.85, which is the accepted adjustment value (Dingman, 2002). We calculated the cross-sectional area for the river and multiplied it by the average velocity to determine the discharge (Gierke, 2002).

*3.3 Results and Discussion*

Due to our very small sample size, we did not generate statistically significant results for our measurements of temperature, pH, conductivity, turbidity or colour. In order to have the potential of discovering significant trends, one would need to conduct a study over a longer time period and sampling would need to be carried out on a more frequent basis. Nevertheless, there are some interesting points that can be drawn from our results, which are summarized in Table 1.

When looking at the results for Bajo Frio, notice that the conductivity measurement changes from 444.0 μS to 152 μS. These samples were taken at the same site with the same equipment. Their high variability exemplifies the dynamic nature of the river and emphasises the importance of having many samples from different times of day and season. Multiple other sample sets show noticeable changes in conductivity. Conductivity is a measurement of the concentration of dissolved inorganic solids such as chloride, nitrate, sulphate and phosphate anions, which carry a negative charge, and sodium, magnesium, calcium, iron, and aluminum cations, which carry a positive charge. Conductivity is a coarse and highly variable measurement and it is indicative of various things including the geology of the river's bedrock and/or pollution from sewage or agricultural run-off. If a dam is affecting the nutrient cycles within a river system, this change may be indicated by changes in conductivity; however, conductivity measurements alone will be insufficient to determine what mechanism is operating. Future studies should undergo a more rigorous assessment of conductivity, and if statistically significant changes are discovered it would be worthwhile to pursue other, more specific, methods of determining the water chemistry.

Another change that is worth noting is the difference in temperature of +1.1°C in the second sample set for Paso Ancho, +1.4°C in the first and second sample set for Macano – Chuspa, and the first sample set for Pedregalito. For each set the samples were taken within a short time of one another and the distance between them is unlikely to explain the change in temperature. This result suggests that the surface water warming in the small reservoir behind each of the dams is sufficient to alter the temperature of each river. Such changes, if prolonged or intensified, can have impacts on the ecology of the river. Future sampling efforts should consider this and undergo a more rigorous assessment of temperature.

| | | 24/02/2012 | | 18/04/2012 | |
|---|---|---|---|---|---|
| | | **Before Dam** | **After Dam** | **Before Dam** | **After Dam** |
| **Paso Ancho** | Temperature (°C) | 14.8 | 15.0 | 18.4 | 19.5 |
| | pH | 6.36 | 6.38 | 6.88 | 6.99 |
| | Conductivity (µS) | 134.7 | 133.3 | 123.4 | 128.4 |
| | Turbidity (FTU) | 2 | 0 | NA | NA |
| **Macano: Chuspa** | Temperature (°C) | 21.1 | 22.5 | 20.1 | 21.5 |
| | pH | 6.94 | 6.90 | 6.75 | 6.96 |
| | Conductivity (µS) | 115.9 | 107.4 | 77.9 | 80.2 |
| | Turbidity (FTU) | 3 | 1 | NA | NA |
| **Macano: Piedra** | Temperature (°C) | NA | NA | 21.1 | 21.3 |
| | pH | NA | NA | 6.90 | 7.01 |
| | Conductivity (µS) | NA | NA | 52.1 | 71.3 |
| **Bajo Frio*** | Temperature (°C) | 23.9 | | NA | |
| | pH | 6.51 | | 6.70 | |
| | Conductivity (µS) | 444.0 | | 152.0 | |
| | Turbidity (FTU) | 15 | | NA | |
| **Pedregalito** | Temperature (°C) | 24.7 | 26.1 | 26.0 | NA |
| | pH | 7.04 | 6.61 | 6.27 | 7.60 |
| | Conductivity (µS) | 149.2 | 173.7 | 107.2 | 105.4 |
| | Turbidity (FTU) | 0 | 0 | NA | NA |
| *There is no dam yet, so we did not conduct before/after samples | | | | | |

Table 1: Results of Ecological Sampling

In addition to conductivity and temperature, we generated some interesting results for ecological flow. Figure 1 displays the ecological flow for Macano, Pedregalito and Paso Ancho. There is no data for Bajo Frio because the dam is not constructed yet. For Macano, there are two columns because we measured the discharge in the Chuspa and Piedra rivers separately, the powerhouse for the Macano project is fueled by water that is brought in canals from three different rivers, Chuspa, Piedra and Bonilla (which we did not have access to).

For Pedregalito and both rivers of Macano, the ecological flow at the time of our sampling was more than half of the flow directly before the dam; however, the ecological flow for Paso Ancho was only 3% of the natural flow at the time. According to the law stated in the Environmental Impact Assessments (EIAs) for each dam, the ecological flow must always be at least ten percent of the average annual flow. For Paso Ancho, this value was calculated in the EIA as 0.6 m3/s. Given this value, the ecological flow at the time of our sampling, 0.37 m3/s, was below the legal limit.

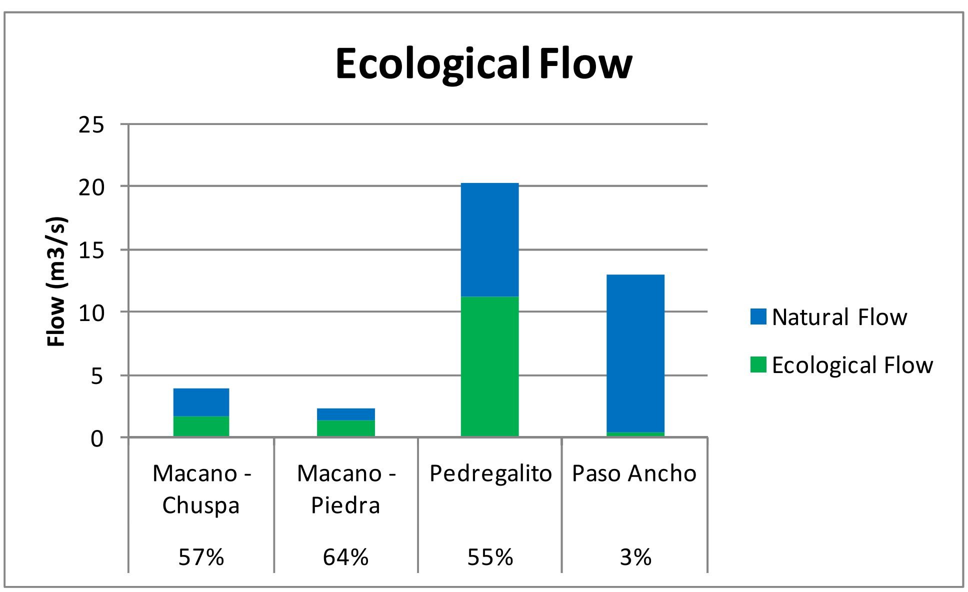



Figure 1: Ecological flow for Macano, Pedregalito and Paso Ancho

Furthermore, the requirement of 10% of the average annual flow is too lenient. This requirement is based on the requirements in France. While it may work for France, it is important to consider that France has a temperate climate and very different river ecology. In Panama the difference in river discharge between the dry season and wet season is enormous. Even within one day the discharge can be highly variable. Furthermore, it is not just the minimum flow in the river that is ecologically important: the natural variability of the flow is also very important. As a result, it would be more appropriate if the ecological flow requirement was calculated as a percentage of the natural flow at any given moment.

One final note of interest relates to the limitation of our discharge calculation methodology. It is very difficult to measure discharge in these rivers without specialised and expensive equipment because the rivers are large and very forceful. We did the best that we could with the equipment that was available to us, but our methodology was not highly precise and this should be taken into account when considering our discharge calculations. Since our methodology was consistent between our above dam and below dam measurements, we believe that the comparison between the natural and ecological flow is still very relevant. Our attempt to measure discharge below the powerhouse for Pedregalito was not successful because the flow patterns in the river segment that we were able to access are highly complex. Our methodology was not precise enough to accurately capture that complexity; therefore, we are unable to make a conclusion about the loss of water to evaporation in this system.

## 4. **Social Diagnostic**

### *4.1 Literature Review: Social Impacts of Small Dams*

Human uses of rivers can include transportation, tourism, fishing, potable water, bathing irrigation, recreation, water for animals, and wastewater drainage among others (WCD, 2000).

Hydroelectric development may affect these activities to varying degrees, and social impacts of small hydroelectric dams are myriad.

However, the literature regarding direct social impacts of small hydroelectric dams is sparse, with the majority of studies focused on the social and environmental effects of large dams (Goldsmith and Hildyard 1984; McCully 1996; Rosenberg et al. 1997; Horning 1999; WCD 2000). Even in the case of large dams the literature regarding social impacts is unrepresentative. While there are over 45,000 large dams worldwide, the literature focuses on those with particularly controversial or interesting problems. As Frans (2002) states, “The literature dealing with problem dams is highly repetitive, the same cases are cited over and over again.” Therefore, the literature on large dams is skewed towards an unrepresentative sample of problematic dams, so it is difficult to make generalizations about the community impacts of hydroelectric projects. This is particularly true of small dams, which are an increasingly pervasive feature of hydroelectric development and cause of conflict, yet lack emphasis in the literature due to perceived lesser impacts (Benstead et al. 1999; Graf 1999). This gap in the literature calls for more research specific to small hydroelectric projects, in particular research directed towards the cumulative effects of multiple projects.

Nevertheless, the literature mentions a number of social impacts resulting from hydroelectric development. This review of the literature will first identify changes perceived as positive, namely economic development and opportunity, revenue generation, and flood control. Subsequently, the review will address changes perceived as negative. Such changes include resettlement, detrimental effects to human health, changes to the natural resource base and local livelihoods, and social changes due to temporary economic booms.

A broad spectrum of literature addresses the economic benefits of hydroelectric projects (Castelan, 2002). On a macro level, large scale hydroelectric projects have also been shown to contribute to poverty reduction and have significant positive economic impacts. Economic growth occurs as a result of these projects due to increased productivity, employment generation, transportation, and energy availability. As more dams and related infrastructure are built, increased foreign investment is attracted to a country (Brown, 2010). Developing countries have therefore increasingly pursued large scale dam projects, with at least 45,000 large dams constructed by 2000 for the purpose of water development or energy (WCD, 2000). In such projects, employment is generated for skilled and unskilled laborers due to construction related activities, creating a positive feedback loop where demand increases thus creating more employment. In terms of transportation, dam projects generally occur in upper catchment areas which often suffer from a lack of adequate infrastructure and have a relatively worse standard of living than in lower catchment areas; roads linking highlands to lowlands for dam construction provide links for trade and commerce.

Dams used for hydroelectric power increase opportunities for commercial and industrial development (Biswas, 2004); however, another body of studies shows that improving the performance of existing infrastructure is a significantly more efficient way to increase economic growth than building new hydropower plants (Zwarts, 2006). This is largely due to river diversion and ecological change which negatively impact agriculturally-based livelihoods (fisheries, livestock, and biodiversity) and transfer benefits from one region to another. Barham et al. find that hydropower in Brazil raised the value of housing stock, increased employment, raised average income, and reduced the poverty head count ratio (Barham, Lipscomb, & Mobarak, 2011). However, the question of who receives improved access from these dam projects remains pertinent, and it is not likely that economic benefits will be evenly distributed. Indeed, the World Commission on Dams (2000) states that poor vulnerable groups are likely to bear a disproportionate share of the social and environmental costs without commensurate economic benefits.

A case study of the construction of the Bhakra Multipurpose Dam System in Northern India highlights the macroeconomic benefits of dams. Construction for the Bhakra Dam, which was intended to increase water supply for drinking, irrigation, and energy, began in 1948 and was completed in 1963. By 1999, aggregate gross output in the region was 30-34% larger than it would have been without the project and aggregate regional value added was estimated to have grown by 30%. The agricultural output growth due to the project was high (46-66% higher than the "without" case) and the direct agriculture and electricity value added was 54%. In the project area (i.e. Punjab) this meant a multiplier of as much as 1.9 reflecting inter-industry linkages as well as consumption-induced effects. It was found that the income level of agricultural labor households was 65% higher with the dam than without it (Biswas et al., 2004). It is clear from this example and many others that large, effectively implemented hydrologic infrastructure projects may contribute to economic growth and poverty reduction in the surrounding area (Biswas et al, 2004).

However, on a more local level such benefits may be less common. When the revenue from a hydroelectric project is shared in a way that is beneficial to the community, benefits may include job creation, road and infrastructure improvement, recreational facilities and other community projects, and greater local government income generated by taxes (Frans, 2002). In his study of small hydroelectric projects in rural India, Sinclair (2003) found that positive impacts of the projects included tourism potential and new job opportunities. Indeed, job generation is one of the strongest impetuses for local people to agree to develop hydroelectric energy. Another local benefit from hydropower development can be improved flood control (Trussart et al., 2002). However, stipulations for flood control must be written into the initial dam design; for instance, the design of a recent hydroelectric facility on the Toulnustouc River in Quebec was optimized to increase the reservoir volume specifically for cases of flooding (Gaudette & Bulota, 2003). As demonstrated by the aforementioned studies, dams can have a positive impact on macroeconomic activity as well as create jobs at a local level and potentially control floods.

On the other hand, the literature cites a number of negative social impacts resulting from hydroelectric development, particularly displacement and expropriation, increases to water-borne illness, changes to local livelihoods and the natural resource base, and social changes due to the economic boom. The first of these changes, displacement, has been a major focus in the literature regarding large hydro projects (Manatunge 2009; Fujikura et al, 2009; Pankhurst 2009; Degeores 2006; Dwivedi 2002; WCD 2000; Charnley 1997). The World Commission on Dams, for instance, gives a review of the failures of resettlement processes over the past 50 years while more recent literature such as that by Manatunge discusses two current cases of resettlement in Southeast Asia and proffers strategies for livelihood rebuilding. A more thorough review of the resettlement literature is beyond the scope of this study, as none of the dams on the Rivers Chiriqui Viejo or Chico require the forced displacement of citizens. However, it is notable that the World Commission on Dams (2000) defines displacement as both physical and livelihood displacement, as communities may lose access to agricultural services, fishing, and the collection of forest products, a point which will be elaborated upon in further discussion of livelihood changes.

Negative impacts to human health may result from hydroelectric projects. Such negative health impacts may arise from dams that increase the amount of stagnant water, thus increasing the prevalence of vector borne disease. While most cases documenting dams and the spread of disease consider large dams, the slow-moving river pools of smaller dams are also a possible breeding site for disease vectors (Jobin 1999; Anderson Olivas 2004). However, as malaria and dengue are not of particular concern in the Río Chiriqui Viejo and Chico watersheds, a significant increase of vector-borne illness from stagnant water is unlikely. Other potential human health effects include toxic cyanobacteria blooms from eutrophication (WCD 2000) and build up of mercury in reservoir fish (Horning 1999; Rosenberg 1997). However, these impacts are also much more likely to occur for large dams with large reservoirs.

Changes to downstream livelihoods – namely groundwater depletion, fishery production, loss of access to forest products and water, and lost economic opportunities – are some of the most relevant negative impacts of hydroelectric projects on the Ríos Chico and Chiriqui Viejo. Changes to the river's flow may result in changes to potable water supplies, as water may be diverted from areas of groundwater recharge (Pringle and Triska, 2000). Depletion of groundwater may also result in negative impacts to agriculture, which relies on this water for irrigation and soil moisture (WCD, 2000). Fishery production is also a major livelihood concern. Physical barriers imposed by dams have the potential to create a barrier for migratory fish species, and reduced flow may destroy specific niches. In her study of small dams in Costa Rica, Anderson Olivas (2004) mentions local concern over the migratory *Joturus pichardi* which is important for recreational and subsistence fishing. Loss of access to forest resources is also of concern to local livelihoods. In his study of rural India, Sinclair (2003) found that a major complaint of villagers regarding small hydroelectric projects was lack of access to land that they had previously used to collect forest products, as well as deforestation by the company. Limited access applies not only to forest products but to the river water itself, which may no longer be available for herd animals to drink.

Rurther livelihood shifts that may occur due to dams can take the form of lost economic opportunities. An example of such is white-water rafting, which is an increasingly important tourism activity in Central America. Unnatural flow fluctuations and decreased flow may make rafting unsafe or impossible downstream of dams (Anderson Olivas, 2004). Problematically, downstream communities are often left out of project impacts and are thus not considered for mitigation measures (Castelan, 2002). As the livelihoods of downstream communities may be affected by dams, it is important to expand the view of the range of dam impacts and include these communities in the planning process.

Along with impacts to downstream livelihoods, the boom phase of construction can create a number of social changes that are felt at the local level. To begin with, many dams are planned years before the construction phase begins, which may lead to stress for those whose land may be flooded or are uncertain as to when construction could begin (WCD 2000). The construction phase demands a large amount of unskilled labor and a small amount of skilled labor. Such labor floods the community and may generate negative consequences. As the World Commission on Dams states, "existing settlements at construction sites have found themselves subject to increased health problems (including malaria, STIs, and HIV/AIDS) and a loss of social cohesion with the large influx of outsiders" (2000). While positive benefits may also be generated, such as demand for services, booms tend to be short-lived and may be socially disruptive (Goldsmith &Hildyard, 1984). Local people may also feel resentful of outside hired labor, as they are the ones suffering the ecological consequences so others can benefit (Sinclair, 2003).

Furthermore, pre-existing gender imbalances may be exacerbated by the construction boom, as companies will often hire exclusively male labor for the construction phase, thus exacerbating gender imbalances. In an extreme case, the Grand Coulee project in the United States hired only men for the early construction phase and hired women afterwards for clerical positions. This puts a disproportionate share of social costs on women. In Argentina, for instance, McCully notes that “cultural resource management activities related to large dams were either poorly done or not done at all” (1996).

Finally, scenic beauty is another unquantifiable loss, highlighted in Anderson Olivas’s study of the Sarapiqui River in Costa Rica, where locals complained that wonderful canyons and waterfalls were replaced by concrete impoundments and pipelines (2004). However, it is important to note that scenic changes and other social impacts discussed here are not ubiquitously perceived as negative; for example, many people perceive in-migration and economic changes as benefits.

To conclude, the literature emphasizes the positive economic impacts of hydroelectric dams and their potential for flood control as main social benefits from such projects. Principal disadvantages are displacement, adverse effects to human health, livelihood changes, and social changes due to the construction boom. An interesting note is that hydroelectric development can lead to consequent increases in anthropogenic disturbance within a watershed.. That is, as infrastructure and economic development in the area increases due to hydropower, more population and development pressure transforms more land for human uses such as agriculture (Anderson Olivas, 2004). These land use changes have the potential to exacerbate ecological changes in the river. For instance agricultural conversion increases soil erosion and the presence of agrochemicals in runoff, which exacerbates ecological disturbance in rivers. As demonstrated by this example, it is impossible to think of the social impacts of hydropower in a vacuum. The social and ecological impacts of hydropower are closely linked.

### *4.2 Methodology*

#### *Community Interviews*

We used structured interviews in each town to assess the knowledge and opinions of people in affected communities along with the perceived impacts of hydroelectric projects. Our method varied slightly according to the particularities of each community, however, our general approach was to knock on a certain percentage (determined by a rough estimate of the town's population) of the doors in the towns beginning at the center of the town and working outwards in two separate groups. Before separating into two groups we conducted some interviews all together in order to standardize the process. The following table gives a more precise description of our methodology by town:

Table 1: Interview method by town

| **Town** | **Population Interviewed** | **Start Point** | **Methodology** |
|---|---|---|---|
| **Paso Ancho** | 20 | Bus stop | Every third house |
| **San Andres** | 22 | House of Javier Gravales | Every third house |
| **Altos de Chiriqui** | 15 | Primary School | Every house |
| **Paraiso** | 21 | Refresqueria | Every house |
| **Victoria** | 22 | Super de Lubelia | Every fifth house |
| **Pedregalito** | 10 | Bus stop | Every house |
| **Total** | 110 | ------------------- | ----------------------- |

Our interviews had between and 27 and 33 questions, depending on responses and generally lasted between 10 and 30 minutes. For the complete list of interview questions, see the Appendix.

One problem with our method is that because we were limited by time and the distance that we could walk on foot, it was necessary to limit our interviewing to people who lived within the central cluster of the town. Therefore, those who live on the outskirts of the towns that we visited were not well represented. Because these towns are themselves very small and quite rural this might not significantly affect our results, but it must still be considered.

During our interviews we followed McGill's code of ethics for research with human subjects. In addition to showing basic respect for our interviewees throughout the interview, at the beginning of each interview we informed people that their participation in our study was anonymous, that we are doing our research with the support of CIAM and that the results of our study will be available to CIAM, publicly on the internet and to the community themselves. We have produced a brief summary of our report in Spanish and will deliver to a local business or school in each community.

Although we made it clear that surveys were anonymous and names would only be used for data organization purposes, some interviewees did not want to disclose their name but still accepted to be interviewed. Also, if people were unclear about the purpose of our study or the identity of our associations, we made sure to explain it. There was only one person who refused to be interviewed. We also made sure that all of our interviewees were 18 years of age or older.

During our interviews we did not ask whether our interviewees identified as Ngöbe or any other ethnicity. We are including comments from two interviews with persons who clearly identified as Ngöbe, but these comments are to be read cautiously due to our extremely small sample size and should not be taken as representative of the Ngöbe demographic.

### 4.3 Results and Discussion

#### Demographic information

We included demographic information (e.g. gender, age, occupation, education…) in our interviews (see Appendix) in order to control for any biases that our sampling method may have created.

Assuming that the towns have a fairly balanced ratio of men to women, we interviewed more women than men in all towns except Paraiso (see figure 17 in the Appendix). This is most likely because the men of the houses were at work during the day when, due to logistical constraints, we conducted our interviews. This may have skewed our results considering that there might be a difference of knowledge and opinion between men and women in the community.

In addition, education levels in some towns, especially Paso Ancho, Altos de Chiriqui and La Victoria, are quite low (see figure 21 in the Appendix. One woman in Altos de Chiriqui reported that she could not read or write and that there were others adults in the community who could not either. This is important because it reduces these individuals ability to inform themselves about the dams which affect them. Furthermore, the lack of schooling may also impede their understanding of some of the concepts that are involved in hydroelectric dams and their impacts.

#### Uses of the river

Our interviewees generally reported higher previous uses of the river. Use for subsistence included fishing, use for agriculture, drinking, and washing. Use for recreation included swimming, tourism and other recreation such as church retreats. We deleted interviews for which the person did not answer both the question for previous use of the river and current use of the river in order to keep a constant sample size for both.

In certain towns such as Pedregalito and Victoria, use for recreation has decreased a lot more substantially than use for subsistence. In others such as Altos de Chiriquí and Paraiso, both have decreased. However, neither use has changed much over time in either San Andrés or Paso Ancho (See figures 1 and 2).

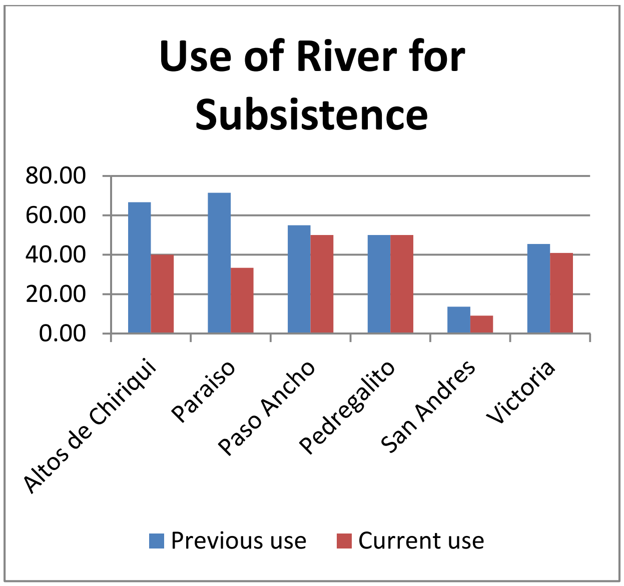



**Figure 1**

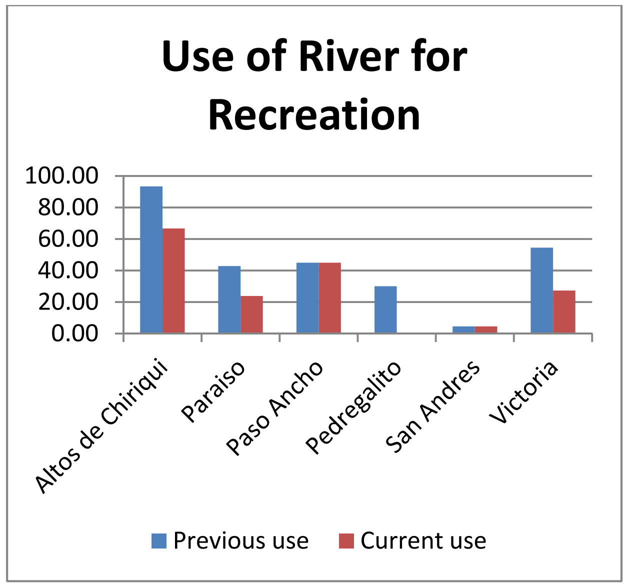



**Figure 2**

We also categorized people's responses into more specific uses for subsistence: for agriculture, drinking and fishing. While the use for agriculture has not seemed to decrease much (see figure 3), the mention of the use of the river for drinking water in Pedregalito has decreased from 40% of people reporting previous use of the river for drinking water to zero people reporting current use for drinking (see figure 4). Generally, the drinking water is not taken directly from the river, but by way of the municipal well and an aqueduct. Many people in Pedregalito and La Victoria also mentioned that their running water only lasted a few hours a day and when the water loss lasted longer, they either went to get water at the tap in front of the

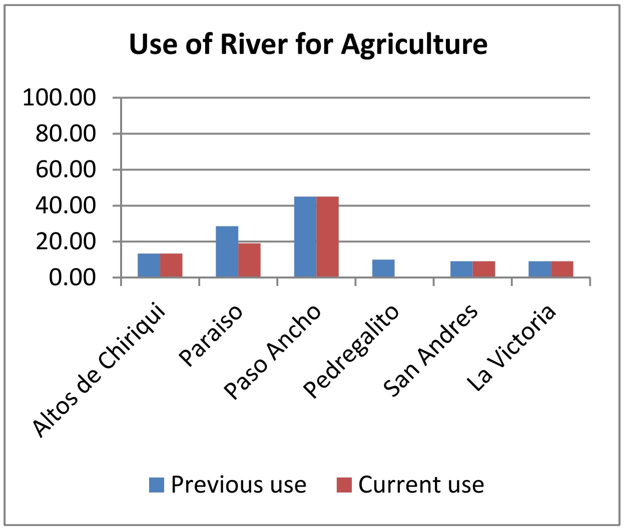
CooLeche milk processing plant or purchase it. The change in use for fishing has perhaps been the largest change, mostly in Altos de Chiriquí, Paraiso and La Victoria (see figure 5). Other uses that were not major enough to be focused on here include washing and swimming.

One thing to note about the drying up of wells in Pedregalito and La Victoria is that this problem seems to be mostly limited to the dry season. Furthermore, the lack of water in the aqueduct might be due fully or partly to an infrastructure problem. More in depth investigation would need to be done on this to pin down exactly what the extent of the impact of the dam is.

In addition, the changes reported by our interviewees only account for a complete halt of use of the resource and not any in between impediments to use, for instance, use can be reduced, but not completely destroyed and this does not show up on this graph. Some of these in between impacts are listed in the community impacts section of this document.

The reported changes in the uses of the river, from before to after the construction of each town's respective nearby hydroelectric dam, highlight that the dams are negatively impacting the local's ability to use the river and are forcing them to search elsewhere for alternatives.

Finally, while this data is limited in its potential for extrapolation to other communities because of the great variability between communities, it is useful to see which communities use the river for what purposes. This type of information might be used by CIAM, by the hydroelectric companies or by ANAM to help mitigate these problems.



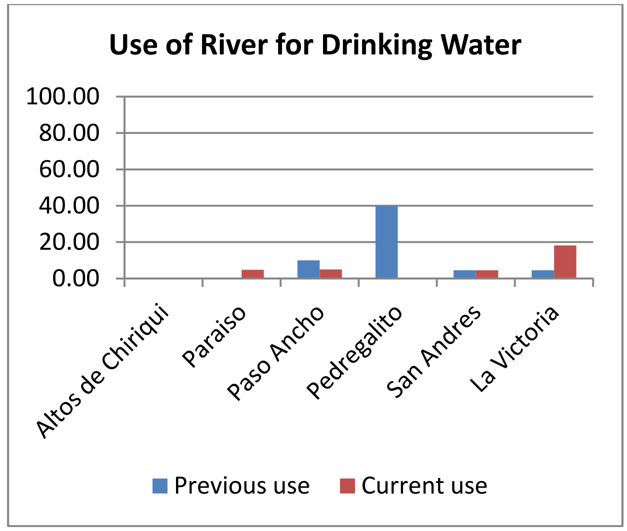




**Figure 3**

**Figure 4**

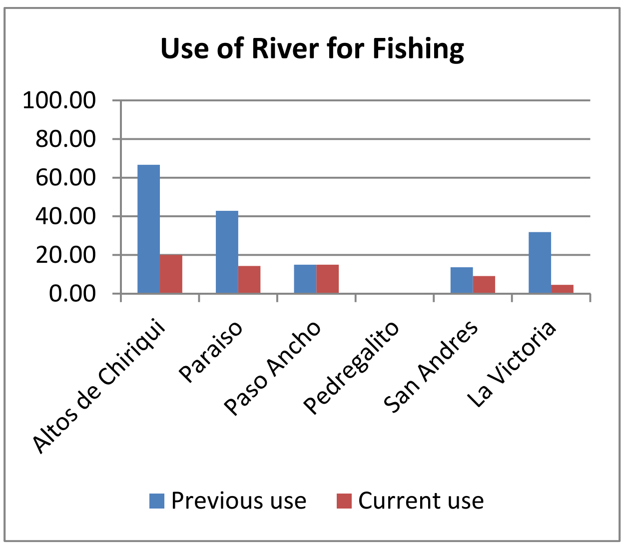



**Figure 5**

*Knowledge*

Knowledge of the dam varied between interviewees, and between certain towns (see figure 6). However, generally people were very poorly informed about the dam and its ecological and social impacts; having said this, people were often more informed about how it affected their community than how it affected the environment when these two concerns did not overlap.

Limitations to measuring knowledge include the following. Our categories for knowledge about the dam were based on the information that the person shared during the interviews and by comparing interviewees to one another. Our scale for rating knowledge was determined after all the interviews were completed. While evaluating knowledge of the dam is useful to get a better picture of the community's understanding of the situation, it would require a more precise methodology that would objectively rate interviewees' knowledge in order to say anything conclusive about the information that the community has.

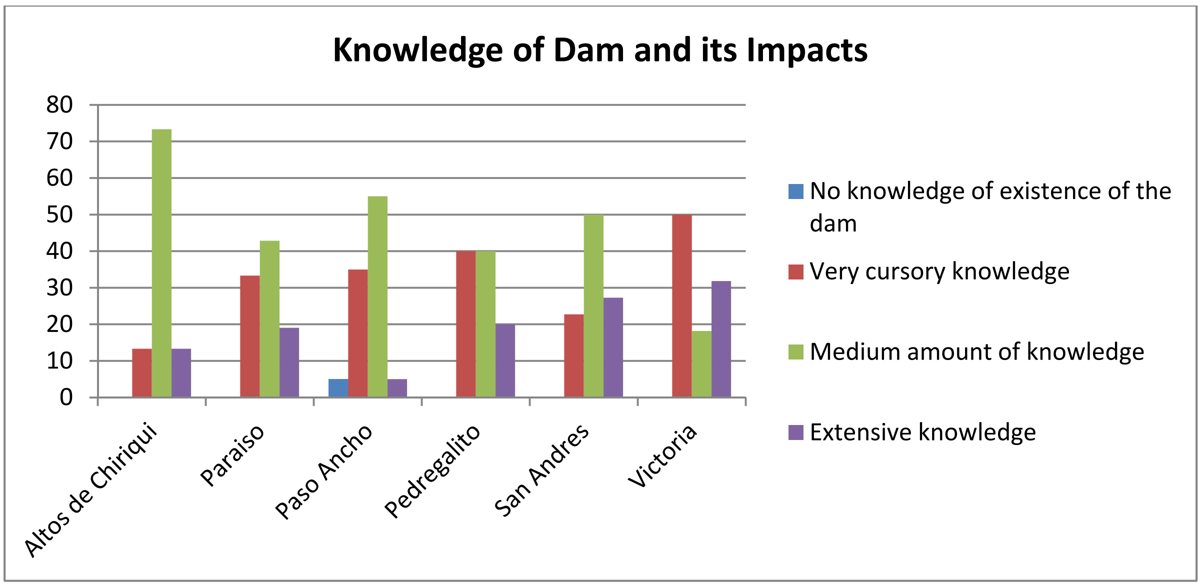



**Figure 6**

*Source of Information*

Interviewees reported various sources of information (see figure 7). The most common sources of information are the community-dam meetings in communities which had a meeting and neighbors or friends. In San Andrés there is a particularly high number of people informed by environmental, anti-dam activists.

The source of information may have an impact on the type of information that people receive and the value judgments that they make about the dam, however, no significant relationship between the two was found here. For instance, many individuals in different towns had a negative opinion of the dam, but could not explain why. They may have heard other's negative opinions and taken it on as their own without fully understanding why.

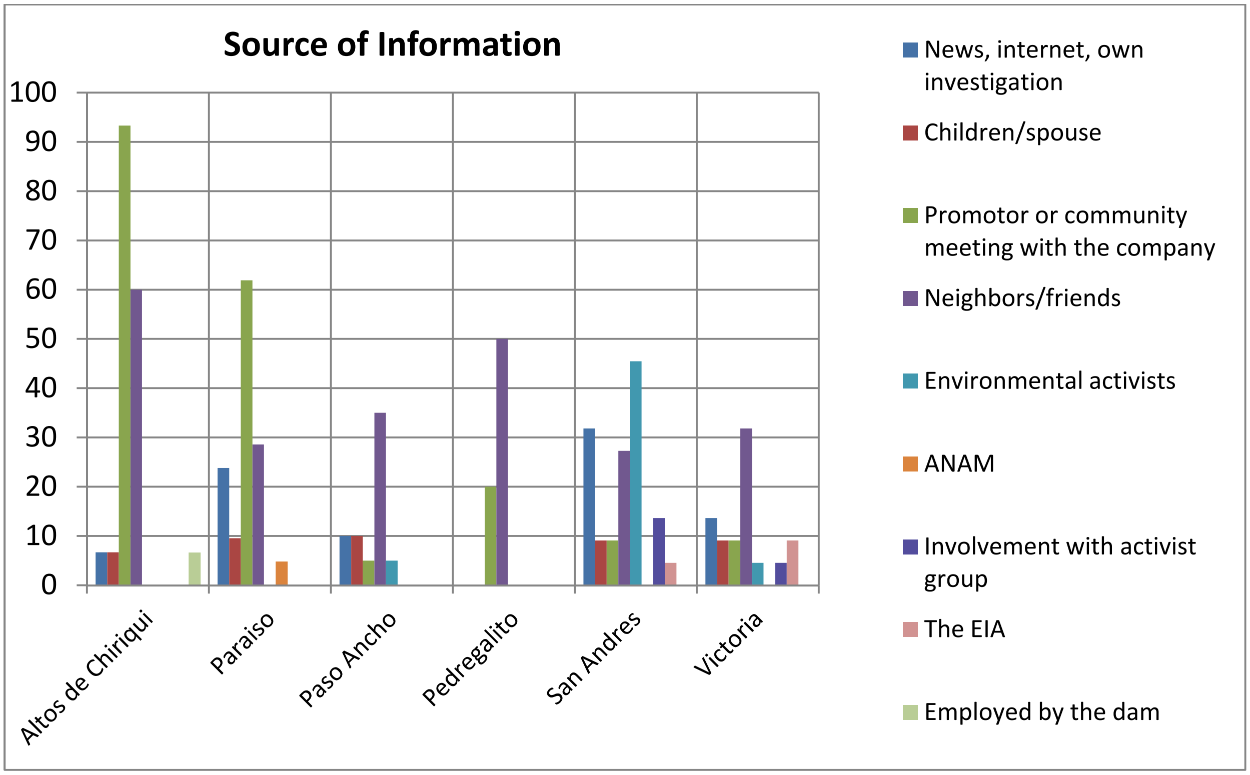



**Figure 7**

*Community meeting*

We sought to determine what number of people knew about the community meeting with the hydroelectric company, how many attended, and what proportion of the community members who attended the meeting supported the dam project at the meeting.

Community meetings with the hydroelectric companies took place in Altos de Chiriquí, Paraiso and Pedregalito (see figure 8). In addition, a few people in La Victoria and in San Andrés knew about meetings that took place in nearby towns.

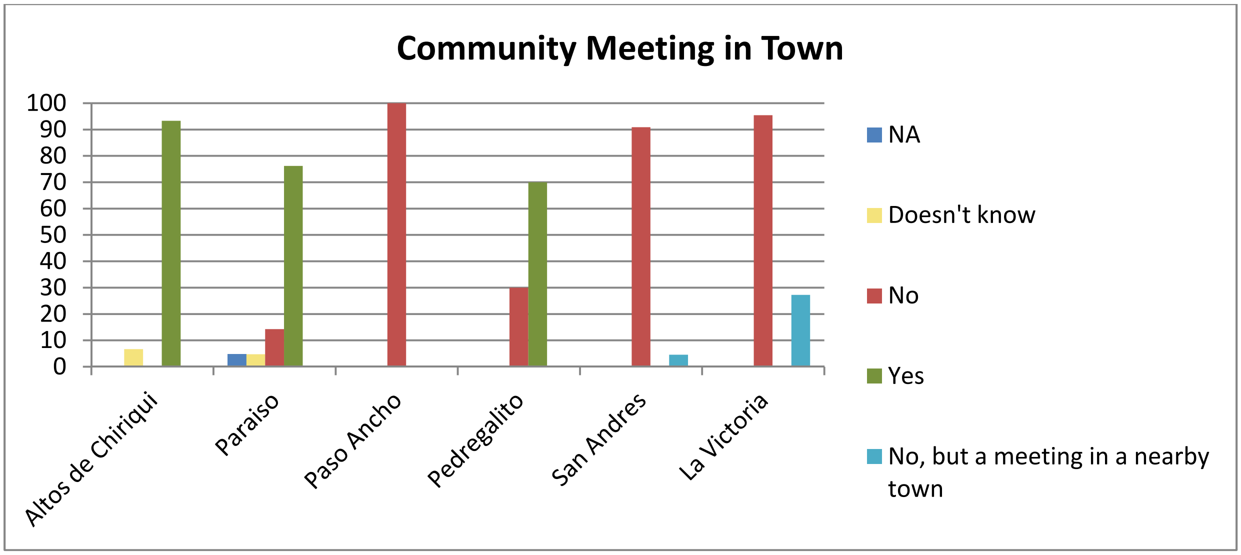



**Figure 8**

For the towns in which meetings occurred—Altos de Chiriquí, Paraiso and Pedregalito—80, 40 and 20 percent of interviewees, respectively, attended at least one of the meetings (see figure 9). In addition, in La Victoria and San Andrés, 23% and 5% of interviewees, respectively, reported attending at least one meeting in another town.

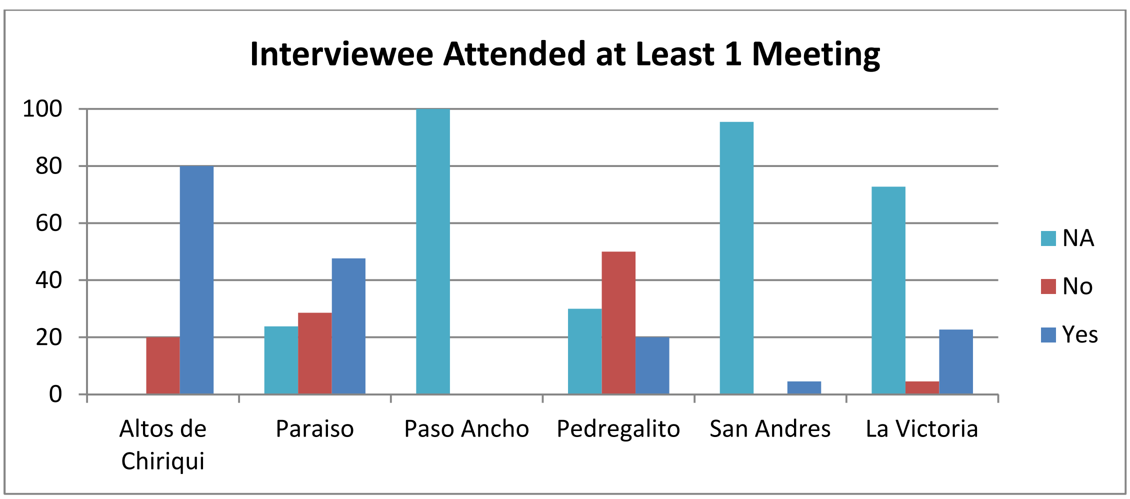



**Figure 9**

In La Victoria, every interviewee who attended a meeting in another town reported a majority of the community members at that meeting to be in favor of the project (see figure 10).

In Altos de Chiriquí and Pedregalito, most people said that only a minority were in favor of the dam. In Paraiso, people reported different proportions, but mostly thought that a majority of the community was in favor of the dam.

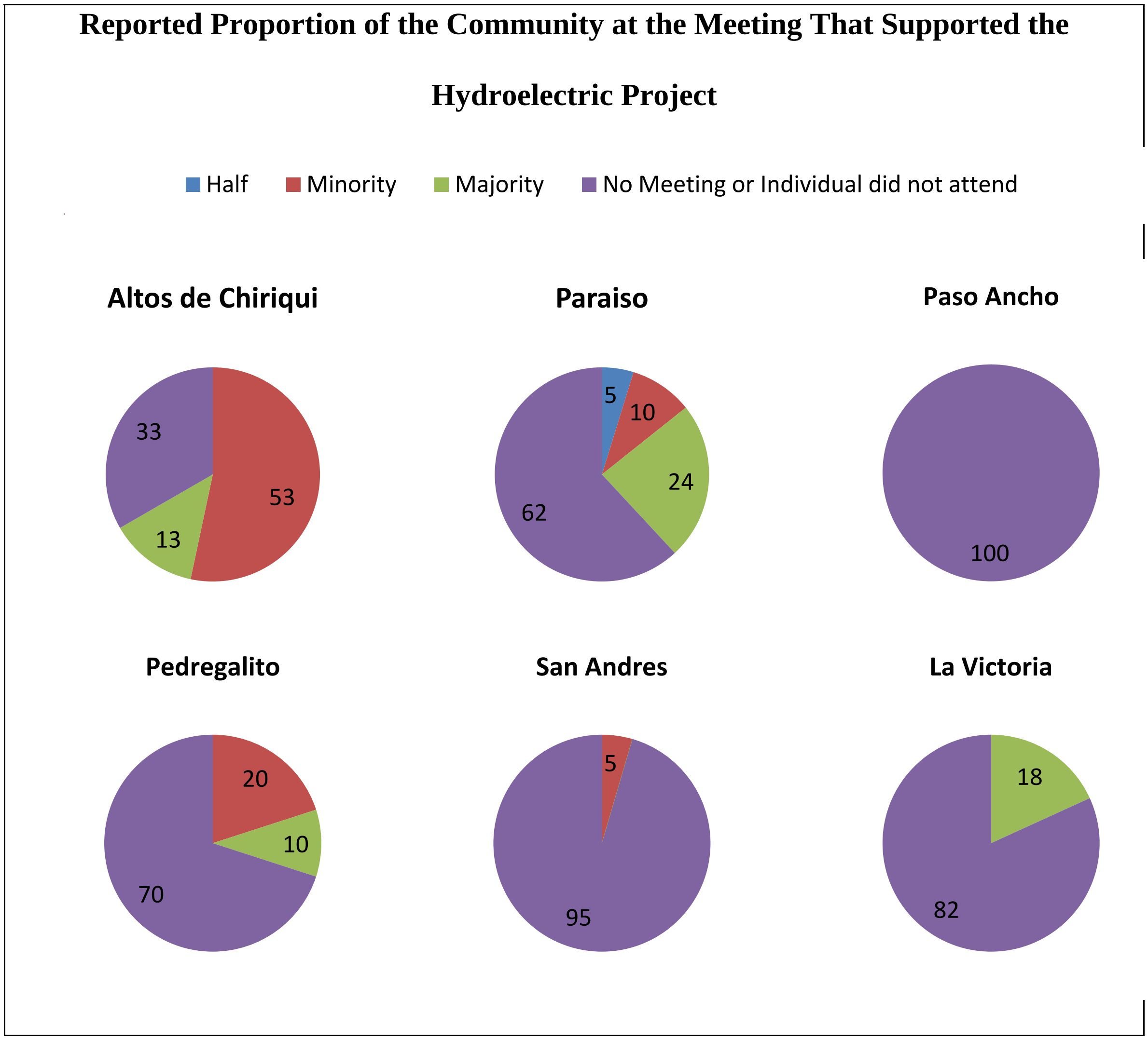



**Figure 10**

For the most part, between 0% and 10% of interviewees said that they felt that their opinion was represented in the public participation process of the dam, except for in Altos de Chiriquí in which only about half of respondents said that they felt represented (see figure 15).

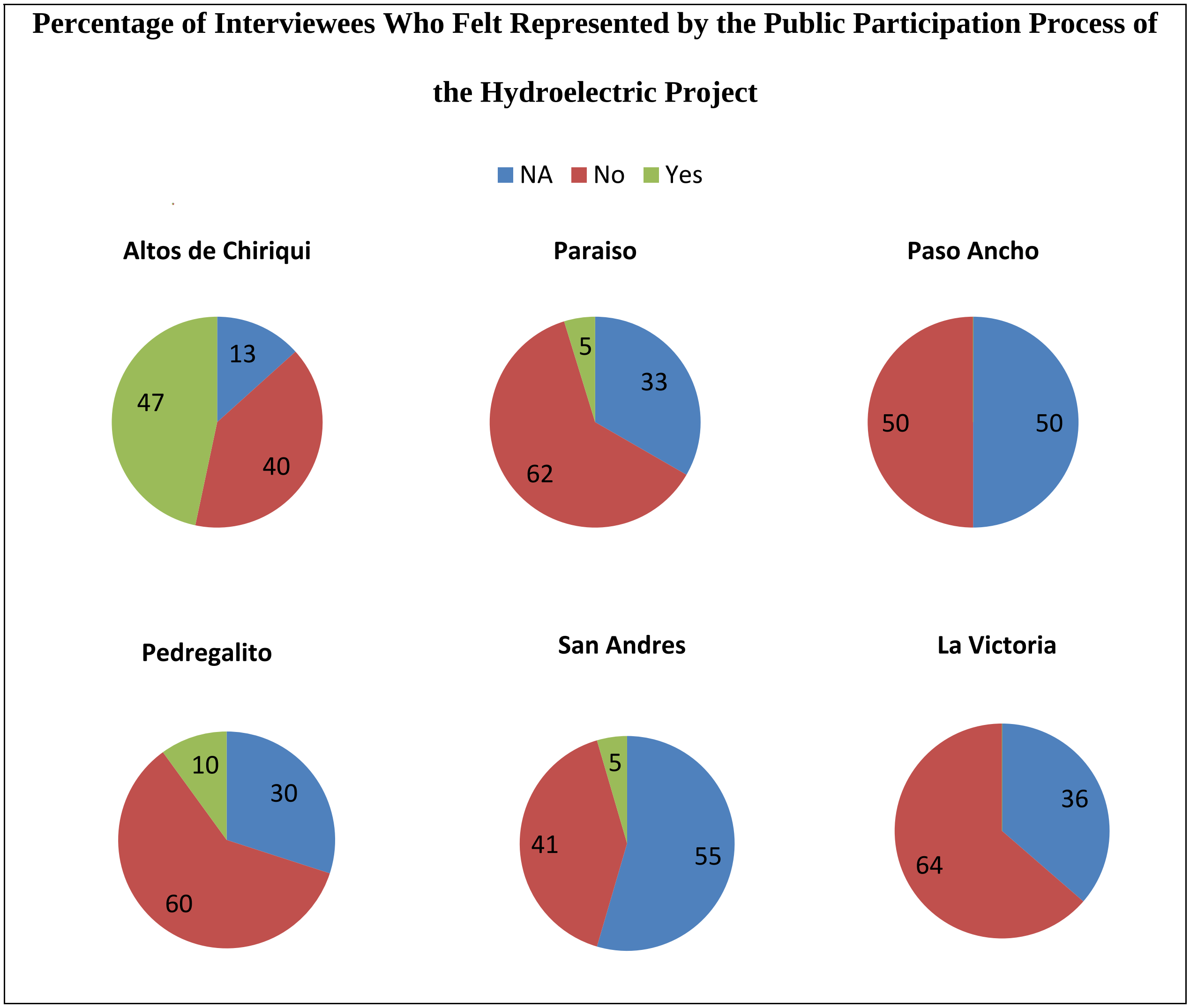



**Figure 11**

*Community Impacts*

Employment creation was the biggest impact of the dams in Altos de Chiriquí and San Andrés (see table 1). However, in San Andrés, several interviewees reported important health risks associated with working in the dam construction including respiratory problems and risk of death by electrocution and by being crushed by machinery or a collapsing tunnel, all four of which have reportedly occurred in the last three years of the construction of Bajo de Mina. Lack of water in the river was by far the most frequently mentioned impact in Pedregalito and Victoria and was also quite common in Paraiso. A substantial 40% of interviewees in Paso Ancho did not report any impacts.

The reported lack of water in Pedregalito and La Victoria are somewhat supported by our ecological survey as the flow is reduced for a large section of the river near these communities. However, it is interesting that the lack of drinking water is so substantial despite the ecological flow being well over the minimum legally required limit. The lack of water in Paraiso, however, is less clearly attributable to the dam since Paraiso is upstream of the dam. One possible explanation is that people were referring to individuals whose farms extend to below the dam but who still include themselves in the community of Paraiso and to people who fish (or used to fish) further downstream where it is easier to access the river.

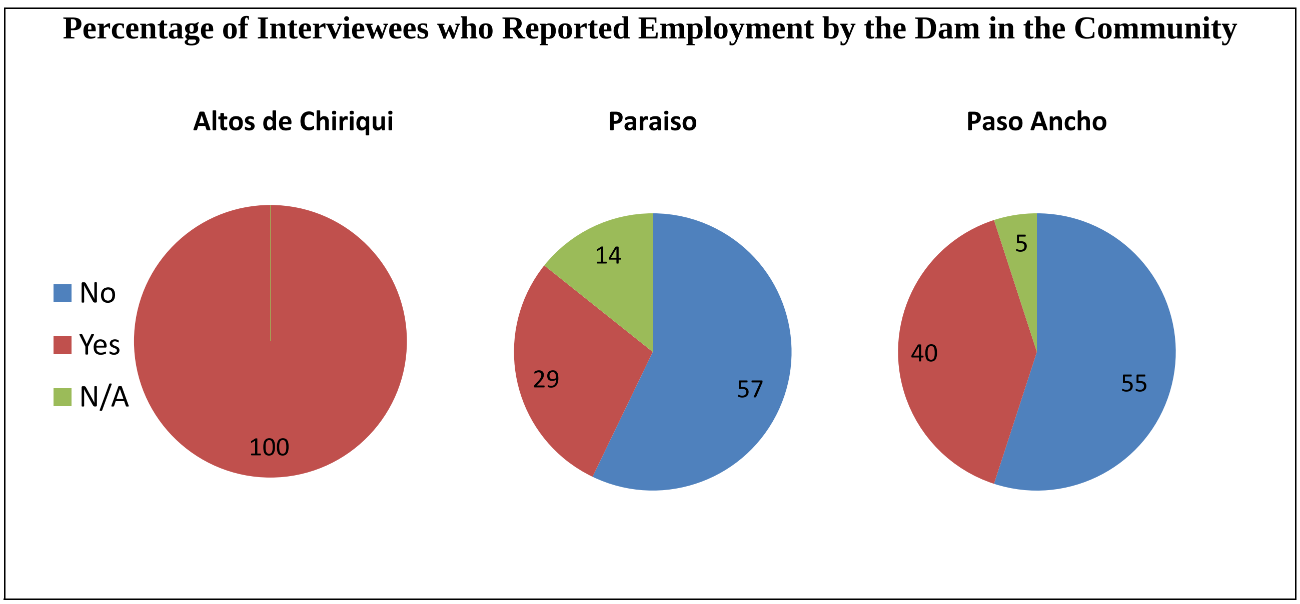
On the other hand, the lack of reported impacts in Paso Ancho might be due to the fact that the community is indeed upstream of the dam on the river. However, another potential explanation is the lack of knowledge about the dam and the lack of a community meeting with the hydroelectric company about the dam.

**Table 1: Percentage of people who reported each impact**

| Community Impacts | Altos de Chiriquí | Paraiso | Paso Ancho | Pedregalito | San Andrés | Victoria | Total (%) |
|---|---|---|---|---|---|---|---|
| **Employment creation** | 53 | 0 | 5 | 0 | 50 | 14 | 25 |
| **Loss of Fish** | 13 | 29 | 10 | 20 | 5 | 0 | 14 |
| **Lack of water, low flow** | 7 | 38 | 10 | 90 | 5 | 73 | 41 |
| **Environmental Damage** | 13 | 0 | 15 | 0 | 5 | 0 | 7 |
| **Loss of Recreation** | 13 | 33 | 0 | 20 | 0 | 23 | 18 |
| **Health Risks** | 0 | 0 | 0 | 0 | 14 | 0 | 3 |
| **Loss of Access** | 0 | 10 | 10 | 0 | 9 | 5 | 8 |
| **Agricultural Difficulties** | 0 | 19 | 0 | 0 | 5 | 18 | 10 |
| **No Impacts** | 20 | 10 | 40 | 0 | 14 | 14 | 21 |

*Employment*

The highest rate of reporting of the existence of employment opportunities was in Altos de Chiriquí and San Andrés (see figure 12). However, the highest reported numbers of jobs that are available were in San Andrés , with most people reporting around 100 jobs and one person reporting 2000 jobs (see figure 13). However, even places with high employment rates said that most jobs were temporary with only a couple to a handful of permanent positions. These permanent positions often require skills that the majority of the individuals in these towns do not have. It is interesting to note that one interviewee from Altos de Chiriquí pointed out that there are positions for women at the dam, which is not always the case.



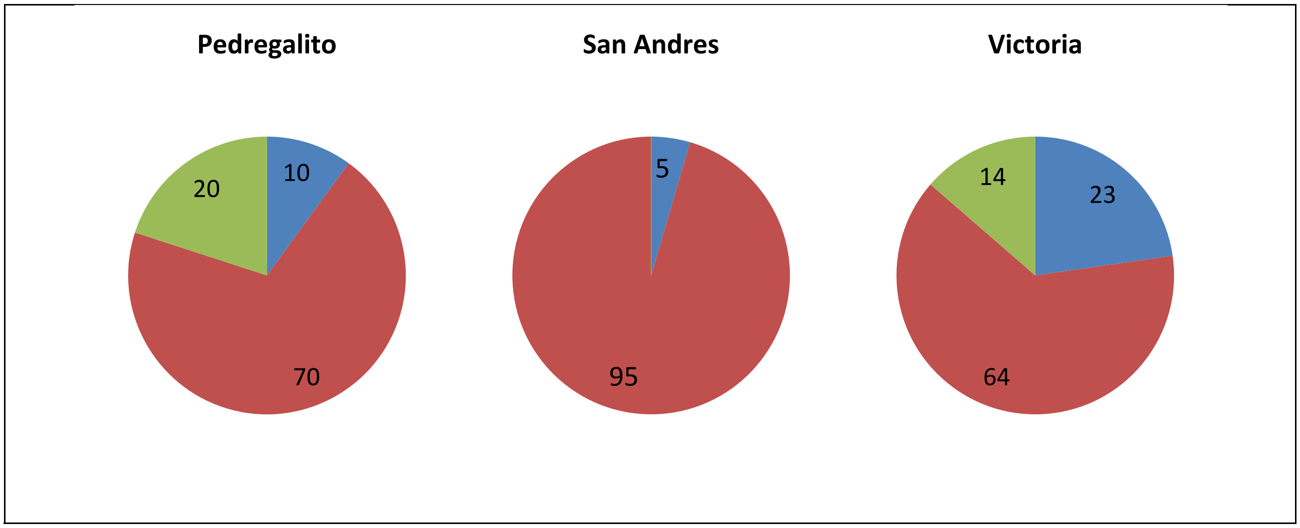



**Figure 12**

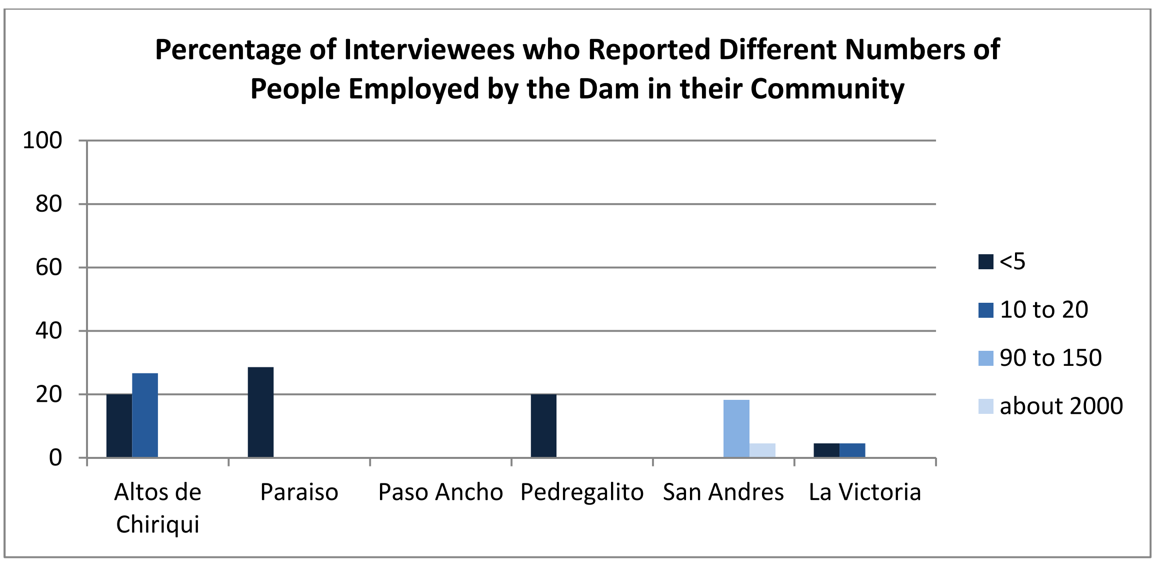



**Figure 13**

*Environmental Impacts*

Our interviewees were, in general, most concerned about reduced fish numbers and deforestation (see figure 14). Victoria and Pedregalito were especially concerned with the river drying out and a few individuals in different towns were preoccupied with the water being contaminated.

It seems to be that the most frequently reported impacts have to do with those that affect the community's use of the river (e.g. dry or contaminated river and reduced fish population) and that create obvious changes in their landscape (e.g. deforestation). However, while people knew how these impacts affected them, people were generally not very well informed about how exactly the dams cause these changes. One interviewee assured us that the deforestation along the river preventing fruit from falling into the water and therefore the fish had nothing left to eat. While this is only one person's understanding, generally, the people we interviewed had quite cursory knowledge of how the dam causes these impacts.

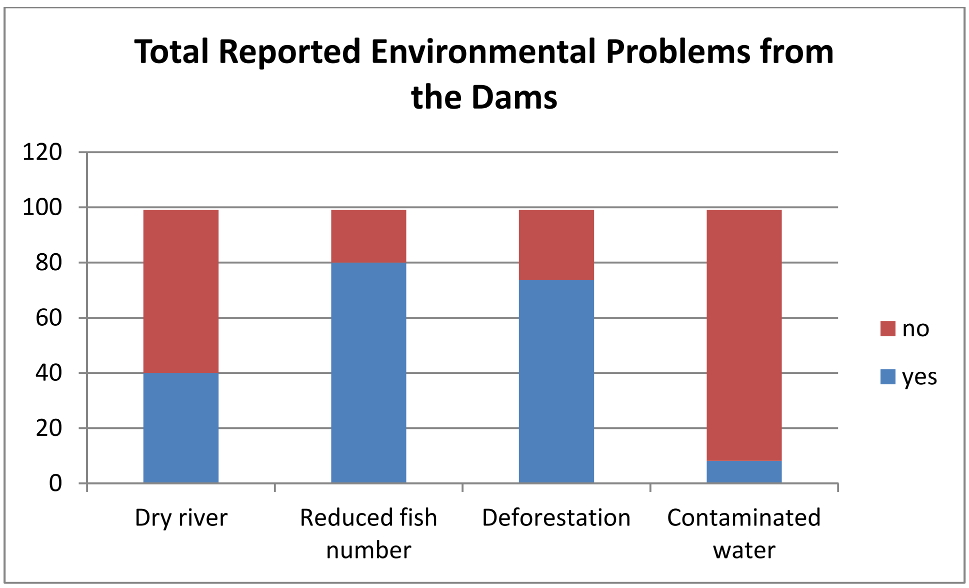



**Figure 14**

*Electricity*

While the grand majority of the individuals that we interviewed did have electricity, many of them mentioned that they thought that the price of electricity would decrease once the dam was built but that this is not currently the case (see figure 15). Of the individuals who did not have electricity in Paraiso, both of them were Ngöbe individuals working as laborers. Of the interviewees in Paso Ancho who did not have electricity one was also Ngöbe, and others may have been but did not specifically report being Ngöbe.

While most people did not know where their electricity came from, several in Paraiso thought that it came from the Macho de Monte dam. Many people in Paraiso thought that this dam was better managed and had less negative impacts on the surrounding communities than the Macano dam has. It is unclear whether this opinion is actually reflective of the Macho de Monte dam's management or whether it is a result of the source of this information and the fact that this is where individuals' electricity comes from.

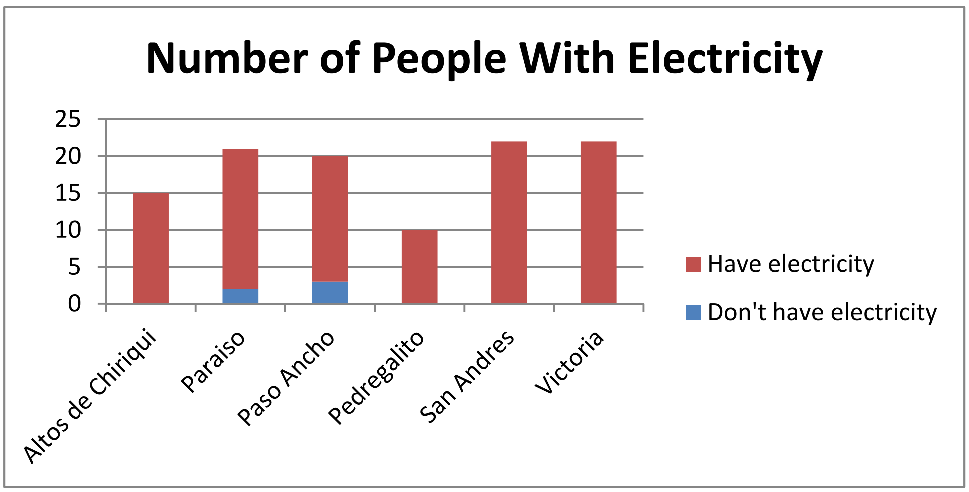



**Figure 15**

*Projects by company*

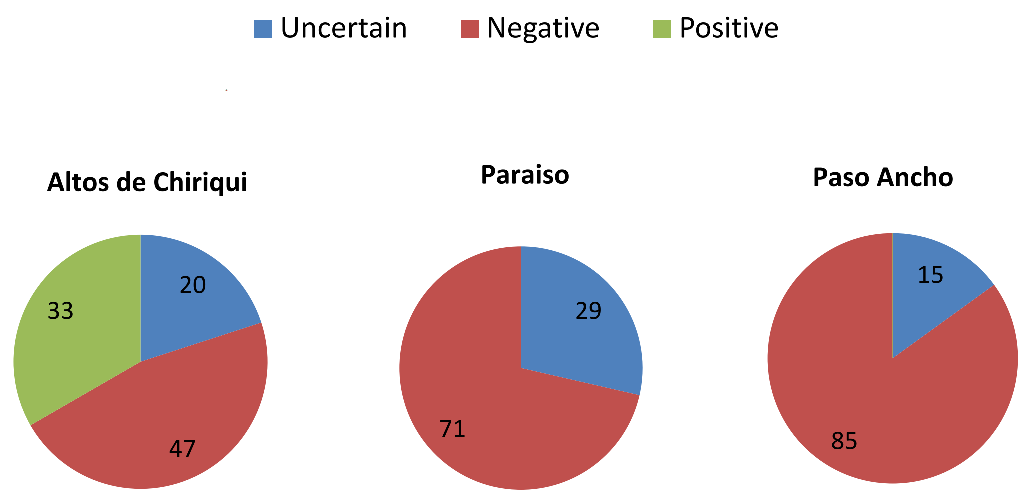
Interviews suggest that in Paraiso, the hydroelectric company gives money to the school and has funded Mother's Day and Christmas parties for the community. In Altos de Chiriquí, several people reported that the company gives school supplies to the school and has a funding program for womens' small businesses. No one in Paso Ancho reported any community projects. In Pedregalito and Victoria, many people reported that the company gives scholarships to children in the community, but very few reported their child having received one. Several interviewees in San Andrés reported improvements to the road.

As mentioned in the EIA section of this paper, the dams are not required by law to implement any of these community projects. However, many potential community projects are mentioned in the EIAs and often in the community meetings. Therefore, when answering this question, many interviewees expressed the disappointment that the hydroelectric company had not delivered what they had been promised.

*General support*

The only towns which reported any positive opinion were Altos de Chiriquí, Pedregalito and San Andrés. In all three towns only a fifth to a third of our respondents reported a positive view of the dam. It is noteworthy that San Andrés and Altos de Chiriquí are the two towns that have received the most employment opportunities from the dam and also have the highest opinion of the dam (see figure 16).

**Percentage of Interviewees Who Reported a Positive, Negative or Uncertain Opinion of the Dam**



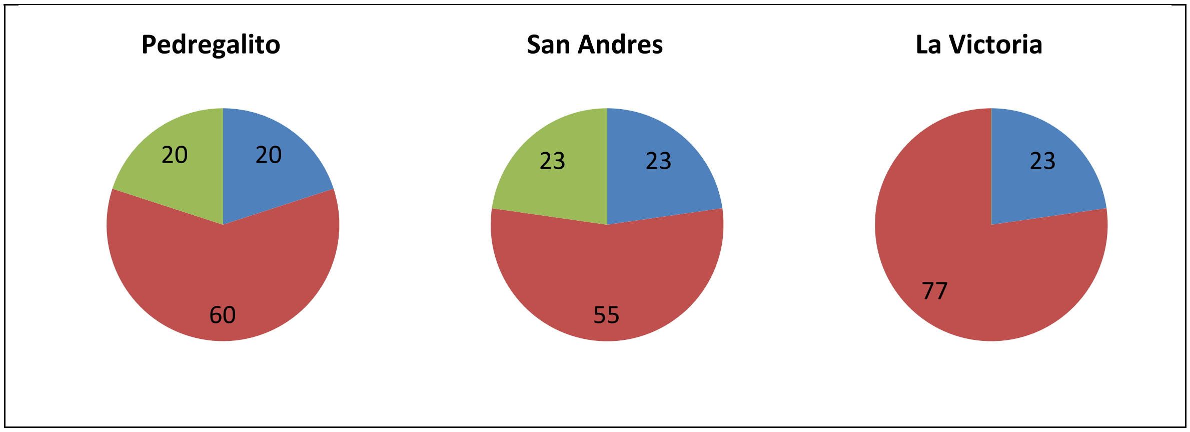



**Figure 16**

*Conclusion*

While our logistical and time limitations have kept our sample sizes relatively low, there is still a substantial amount that can be taken from these results. These results show that the hydroelectric dams in the Chiriquí Viejo and Chico watersheds have positive as well as negative impacts on the surrounding communities. Some of the towns receive more of the positive impacts and others more of the negative impacts. For instance, while the hydroelectric companies often talk-up their projects to the community, by emphasizing the jobs that it will create, not all impacted communities receive this benefit and even in those that do, most of the jobs are temporary and may pose serious health risks. Other communities at the bottom of the watershed must deal with a reoccurring lack of water. Rather than condemning hydroelectric dams as always affecting communities negatively, another approach to improve both the social impacts of these dams would be to work with the local communities and the dams to improve the benefits for both.

## 5. EIA Regulations

*5.1 Review and Critique of EIAs for Small Hydroelectric Dams in Panama*

Environmental Impact Assessments are an important part of the legal and operative framework of hydroelectric projects, and are required by Panamanian Law prior to beginning a project (General Environmental Law 41, 1998). In Panama there are three categories of EIAs, from Category I with minimal environmental impacts to Category III which have potential for significant adverse environmental impacts. All three categories require EIAs and a public participation mechanism, but those of Category III are meant to be the most detailed and complete. ANAM is the agency in charge of overseeing EIA reports (Inter American Development Bank, 2011). Each hydroelectric project we studied falls under Category III.

However, it cannot be taken for granted that approved EIAs have a consistent and satisfactory quality (Pinho, 2007). Comparative and transnational studies have been published assessing the quality and content of EIAs in the U.S., Canada, and the EU (Lee and Dancey, 1993;Wood, 1995; Sadler, 1996; EC, 1996; Tzoumis and Finegold, 2000; Wende, 2002). EIAs for smaller projects are recognized to have a lower caliber due to lesser financial incentives to do a robust study (Barker and Wood, 1999). In a review of the EIAs for Paso Ancho, Pedregalito I and II, Macano, and Bajo Frio, we identified a number of quality and content inconsistencies. Our primary critiques are that the content is not precise or robust, the studies lack clarity and accessibility, and methods and techniques are imprecise.

The content of the EIAs was not precise, demonstrated bias, and was repetitive. The Paso Ancho EIA shows a bias in the social analysis where situations are described in a certain light so as to make the construction of the dam seem like an ideal solution to many community problems. One instance of this occurs when the report describes employment, stating “estan deseosos y dispuestos a cambiar de ocupacion si se presentan nuevas oportunidades” (pg. 25, Section 10), a comment that implies the population will be much better off if new employment opportunities, such as those from a hydroelectric project, are generated. Furthermore, the impact of socio-economic changes is written off based on little evidence: “los valores de la poblacion no son tan extranos como para ser seriamente impactados por la presencia repentina de nuevas actividades socioeconomicas" (pg. 62, Section 10). There are also contradictions in the text, the social analysis of Paso Ancho states that there is very low unemployment but then emphasizes the need for job creation as many people complain about unemployment (pg. 25, Section 10). Of note, the EIA for Pedregalito II is strikingly similar to that of Pedregalito I; in fact many parts of it are exactly the same. The environmental control plans (pgs. 355-413 for Pedregalito I and pgs. 4-75 for Pedregalito II) and citizen participation sections are identical in both EIAs. Such inconsistency and biased interpretation of data is unprofessional for an EIA.

Lack of clarity and accessibility was a further problem. The EIAs have a variety of formats with no consistent template and are at times thousands of pages long, making it difficult to find necessary information, synthesize findings, and make comparisons. Maps showing topography, hydrology and population centers were also difficult to read and not clearly delineated or explained, making them difficult to interpret (Vol. 3, Paso Ancho). Furthermore, the ANAM library, located in Panama City, is inaccessible to people from Chiriqui. Travel time and the inaccessibility of abundant and repetitive information are significant barriers to access.

Methods and techniques used for the ecological study were imprecise and the social participation process was opaque, at times influding information that may have been falsified. For example, the ecological study for Paso Ancho only takes samples at two sites, one of which is at Paso Canoa, a site multiple kilometers down the river. It is difficult to imagine this data is applicable to the Paso Ancho site. It is possible the hydrological study was lackluster because the Paso Ancho EIA was written before ANAM's Resolution in 2007 to improve the quality of hydrologic studies of hydroelectric projects (Resolution AG-842-2007). However, it is important to assess the data from hydrologic studies in the EIAs for precision and scope. Little follow up seems to be required, and post dam effects are not examined. In terms of the social participation sections, some EIAs contained specific information about where and when interviews took place but some did not mention this information (Paso Ancho, Pedregalito I and II). It is likely that there was falsification of the social survey for Pedregalito II as interview results were presented for ten people of age 18, ten people of age 24, ten people of age 32, and nine people of age 45, but no other ages were represented. A similar pattern exists for the interviews in neighboring Tijeras. This suggests forgery (See Appendix).

*5.2 Comparison of EIA Results with Social Diagnostic Findings*

For Paso Ancho, Pedregalito, Macano, and Bajo Frio, we found that the information in the EIA about public participation processes was noticeably inconsistent with what we found in our social diagnostic. The main differences include:

1. Public perceptions of employment
2. General support for the project
3. Attendance at related meetings
4. Representation in public participation process

While many of the differences between the EIA data and our data are possibly due to differences in timing and methodology, it is interesting to note the discrepancies in the data (sometimes quite extreme) and changes over time in the public's perception of hydroelectric projects. Perceptions of employment and general support for the project change drastically between the EIA data and our data. We also compared data regarding meeting attendance to see how thoroughly the Promotors have conducted the public participation process. Our result was a large discrepancy in the EIA stated objectives and the public's actual participation.

The EIA for Paso Ancho was written by the consulting company Tierra Feliz, S.A., for the Promotor INTERCARIB, S.A, in July 2000. We could not find information in the EIA regarding sample size or where people were interviewed for the social participation process. In the social participation section of the EIA, employment in the community is mentioned as one of the main community concerns. According to Tierra Feliz's community survey, 100% of people in the community believed that employment would be generated for the community. The EIA itself states "ello [el proyecto] contribuiría de manera decisivo a incrementar los bajos niveles de empleo y educación que el área posee" (Section 15). On the contrary, during our survey of Paso Ancho only 40% reported that local employment had been generated by the hydroelectric project. Tierra Feliz's survey survey also found that 95.8% of the community supported the project as they believed the community would benefit (pg. 4, Section 15). Our survey found that not a single person supported the project, and no one reported meaningful community benefit. As mentioned in the introduction of this section, this might be due in large part to the difference in timing and a post-hoc change in opinion of the dam. In terms of actual public participation, Tierra Feliz claimed the hydroelectric company would hold a number of periodic meetings as part of the social participation process. The EIA states that *"a través de reuniones periódicas, en las cuales participaran todos los representantes de las comunidades ante el comité general, y se contara por la empresa con un representante autorizado y lo suficientemente ilustrado respecto al proyecto, avances, proyecciones u otros aspectos que pueden ser de interés para las comunidades"* (Section 15). These periodic meetings were to be directed towards *"todas las comunidades localizadas en el área de influencia del proyecto hidroeléctrico"* (Section 15). Paso Ancho is specified as the community in the principal area of Project influence, as stated earlier in the EIA: *"Esta comunidad [Paso Ancho] se encuentra parcialmente entre ambos* *corregimientos, y es el área de mayor influencia del Proyecto”* (pg. 1, Section 10). The total affected population of Paso Ancho is considered to be 850 inhabitants in the EIA. In our study, we found that not a single person reported having heard of or attended a community meeting. Of those who answered the question, not one person felt they had been represented in the public participation process. This is understandable, because although the EIA identifies Paso Ancho as an affected area there do not appear to have been any community meetings held in Paso Ancho. Again, it may be that people are unaware of this process as the EIA was written in 2000.

The EIA for Pedregalito I was written by ECO – CONSULTORES, S.A., for the Promotor Genderadora Pedregalito, S.A., in May 2006. The EIA for Pedregalito II was written by the same consulting company for Promotor Generadora Rio Chico S.A. The EIA of Pedregalito I states that semi-structured interviews were given in Chacarero, Pedregalito, Bajo La Arena and Sitio Lazaro. According to the results of these interviews, 100% of people said that the community would benefit from employment generation (pg. 294). For Pedregalito II we could not find specific information about the total number of people interviewed, but a lesser 86% believed the community would benefit from employment. This difference over the course of a few years shows the perception that hydroelectric projects bring local employment has diminished. Our study found that, of individuals who answered the question, 70% of interviewees in Pedregalito and Victoria believed the community would benefit from employment. In terms of general support for the project, the Pedregalito I EIA states that 91% agreed with the project while the Pedregalito II EIA states that only 43% agreed with the project. These findings shows a clear drop in support for hydroelectric projects over time, a result emphasized by our own finding that only 6% of people in Pedregalito and Victoria support the project. Both EIAs included stipulations for community meetings in Pedregalito, and our study showed that 70% of people in Pedregalito were aware of community meetings. However, in Pedregalito only 10% of people felt represented in the public participation process as they felt their opinions had not been taken into account at meetings. In Victoria not a single person felt represented in the public participation process despite suffering consequences from the hydroelectric projects.

The EIA for Macano was written by D.A.F. CONSULTING, S.A. for the Promotor HIDROBOQUERON, S.A., in May 2006. The EIA states that 100 people were interviewed in Santa Marta and Santa Rita. Interviewees were not asked about employment, although our study found a high level of people who saw employment as an effect of the dam (60% in Paraiso). In the EIA interviews, 71% believed the community would benefit while in our study not one person in Paraiso believed the dam had predominately positive community impacts. The EIA contains many stipulations for community meetings, stating that a meeting in Paraiso took place in which "participaron la comunidad, el concejo municipal, el señor alcalde municipal" (pg. 355) as well as the dam's legal representative. Indeed, in our study we found that 76% were aware of a community meeting. However, while the EIA states that 86% agreed with the construction of the dam, our study found that only about 5% felt represented in the public participation process as most felt their opinion had not been taken into consideration.

The EIA for Bajo Frio was written for the Promotor Fountain Intertrade Corp. The EIA states that 73 total interviews were conducted in Altos de Chiriqui, San Pedro, Gariche, Porton, Salsipuedes, and Aserrio. The interviews did not specifically mention employment, but it was noted as a benefit discussed by community members. Indeed, our survey found that 100% of people in Altos de Chiriqui believed the community had benefited from employment. The EIA found 45% of people were in favor of the construction of the dam, while we found 33% were in favor. These are quite similar results, and indeed are comparable as we had the same sample size in Altos de Chiriqui as the EIA did (15 individuals). In terms of community meetings, we found that 93% of people in Altos de Chiriqui were aware of meetings and about 47% felt represented in the public participation process.

The EIAs we studied were of variable quality. Our overall results for the comparison between EIA data and our own social survey show a large gap, with EIAs stating that a high degree of the population believes it will benefit from employment and agrees with the dam while our results often showed the contrary. The comparison also shows an interesting pattern where even in towns where people knew about community meetings, they did not feel represented in the public participation process.

*5.3 Public Participation and Equity of Benefits*

This section discusses the available literature on public decision making processes, which highlights involvement of the public as a way to manage and mitigate the negative social impacts of small hydroelectric projects (Soden, 1985). As shown by the lack of public participation in many of the EIA processes and relative discontent of the population regarding hydroelectric projects, this is an area that could definitely be improved upon in Panama. Traditionally little effort has been made by hydroelectric companies to improve public knowledge, so the public lacks balanced and objective information off of which to base their own decisions. As Frans (2002) states, “dams have become controversial and large amounts of information and misinformation about them has been widely disseminated. It has become more difficult to know where the truth lies and to form a balanced, objective opinion about these issues.” Indeed, this is certainly the case in the communities of Paso Ancho, Altos de Chiriqui, Sam Andres, Paraiso, Victoria, and Pedregalito. Where there is little balanced information, dams become a source of conflict (WCD 2000; McCully, 1995). Aguilar (2000) comments that the main reasons for conflict over hydroelectric projects in Costa Rica are an absence of integrated planning that takes the entire watershed into account, concessions based on demand as opposed to availability, and problems with the EIA protocol that include lack of clarity and limited participation of human communities in impact assessments. These critiques ring true for Panama as well, and are key points to be improved upon if the process of hydroelectric projects is to improve in the future.

In their 2008 study of a public participation process surrounding the La Yesca dam in Jalisco and Nayarit, Mexico, Chavez and Bernal highlight the importance of involving the public despite the challenges encountered in an institutional context where public participation is not a priority. Chavez and Bernal comment that in Mexico "both public and private organizations lack the experience needed to deal with public participation. The planning culture of the past 80 years was based on authoritarian decision-making and on a discourse of modernization that privileged the contribution of technical knowledge over any input that could be brought to the process by local knowledge and citizen participation." A similar statement could certainly be made about the view of public participation in Panama, as demonstrated by ANAM's lack of regulation of the public participation process and lack of value for citizens' real input. Indeed, a public participation process that occurs after the EIA is already approved fails to address the concerns of residents and ignores local knowledge and social preferences (Chavez & Bernal, 2008). Highlighting this case is a story told to us by a young man, from Paraiso. When he asked the Promotores from Bajo Frio whether they would stop the dam construction if everyone in the community opposed dam, they told him that even if everyone was against the dam nothing would change (Personal Interview, March 25th 2012). Many residents in the towns we interviewed mentioned a similar view. In such an institutional context where public participation is a mere formality, discontent regarding hydroelectric development is certain to continue.

To create alternatives that benefit both the community as well as the hydroelectric dam, stakeholders should be invited to collaborate rather than merely be informed about the project that is to occur. The results of community surveys showed a great disparity in the way the community and the EIA viewed environmental and social impacts. This demonstrates a need for greater sharing and meaningful public participation, not only so the community can be more informed but for the mutual benefit of the promotor. As mentioned in the social literature review, hydroelectric projects may bring about important macroeconomic benefits so long as they are well situated and designed. Yet these benefits must be shared to fully realize the local and regional benefit of hydropower. Some suggestions for sharing development benefits from hydropower are noted by Trussart, et al (2002):

- Developing equity-sharing partnership solutions with local and regional institutions.
- Creating a jointly managed environmental mitigation and enhancement fund.
- Setting up a regional economic development committee with local economic stakeholders.
- Splitting construction contracts, in order to allow smaller regional companies to bid.
- Encouraging large contractors to use local businesses to supply part of the services.
- Preferential hiring of local workers for construction work and ancillary services and provision of training for local workers in order to improve their chances of employment.
- Design and implementation of river basin management plans that take into account the water needs of concerned stakeholders, in the reservoir area and downstream.

· Long-term efforts to develop and sustain reservoir fisheries and drawdown agriculture, as well as associated infrastructure and commercial and public services, such as recreational navigation, sport fishing or tourism.

· Ensuring that project-affected people actually become beneficiaries of new development schemes, by ensuring their access to new job opportunities during the early years of such schemes.

## 6. Recommendations and Future Directions

### *6.1 Ecological Reccomendations*

Based on the results of our research over the past 4 months, we recommend that future ecological studies incorporate the following aspects:

1) Temperature and conductivity: our measurements for these two parameters suggest that the dams may have important impacts on the physical conditions of the river. A more rigorous assessment of these parameters should be carried out. If significant changes in conductivity are discovered, it will be worthwhile to conduct more intensive chemical analysis.
2) Ecological flow: given the diversion design of the dams in Chiriqui, this is an extremely important parameter. Our results suggest that special focus should be given to the ecological flow after Paso Ancho and Pedregalito. The ecological flow that we measured for Paso Ancho was below the legal limit, and the communities close to Pedregalito protest inadequate access to drinking water. There is reason to believe that groundwater recharge in the Pedregalito region may be significantly reduced. It will be important to determine to what degree the lack of water in Victoria and Pedregalito can be attributed

to the dam reducing groundwater recharge or to inadequate infrastructure provided by IDAAN.

3) Measurement of suspended sediments: the EIAs mentioned sedimentation as an important problem for the rivers in Chiriqui. We did not have appropriate equipment to measure suspended sediment; however, based on observations of the rivers we conclude that doing so would be very relevant and important.

Furthermore, we recommend the following strategies for improving the ecological health of the Chiriqui river systems:

1) Adjustment of the minimum ecological flow requirement: the current requirement of 10% of the average annual discharge is based on the French system. It is not sufficient for tropical rivers that exhibit high temporal variability. It would be more appropriate if the minimum ecological flow was a percentage of the average monthly, weekly or daily discharge. The more specific the time-frame the more accurately the natural flow variability of the river will be mimicked. In order to carry out this adjustment more reliable, extensive and precise measurements of discharge will be essential.
2) Promote initiatives to support sustainable agriculture, which will limit runoff of sediment, fertilizer and pesticide into the river system: this would be a highly effective mitigation strategy which would benefit the communities of Chiriqui as well as the hydroelectric company itself. Sedimentation into the river poses a serious problem for hydroelectric projects as it shortens the lifespan of the dam without dredging, and damages the project's machinery eventually reducing hydropower generation (Anderson, 2006). Reforestation is an accepted method for reducing sedimentation, but Chiriqui produces the majority of agricultural produce for Panama and it is not reasonable to consider

reforesting agricultural land. Instead, efforts towards sustainable practices will reduce topsoil erosion and runoff of chemical fertilizer and pesticides. The water quality of the rivers will be significantly improved, agricultural practices will be more sustainable and the good physical condition of the dam will be maintained.

3) Prevent construction of dams on uninterrupted tributaries: this would minimize the isolation of upstream aquatic populations and would prevent further fragmentation of the watershed. For example, dams on low-order streams can trap up to 95% of sediment and organic matter, leading to depletion in the lower reaches of the watershed (Waters, 1995). Construction of dams on a river that already supports many projects would have a relatively less severe impact.
4) Get researchers involved to increase the scientific literature available for hydroelectric development on tropical river systems. Specifically, promote studies that consider the cumulative impacts of multiple dams.

### *6.2 Social Recommendations*

Based on the results of the social component of our study, we suggest that further research be conducted into:

1) The extent of specific impacts on one or a few communities affected by dams. A more in-depth study of how these dams impact communities would be valuable for the development of strategies to mitigate the social impacts of dams.

Furthermore, we recommend that action be taken to:

1) Strengthen ANAM's EIA requirements, specifically for public participation, and implement follow-up procedures to ensure that the requirements are being followed as outlined in section *5.3 Public Participation and Equity of Benefits.*

2) Implement a project to increase the amount of accurate and unbiased knowledge that the local community has access to. This would greatly empower community members and give them more control, if not over whether dams are built, perahaps over how dams are built and how they can make the most out of the opportunity.

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## 8. Appendix

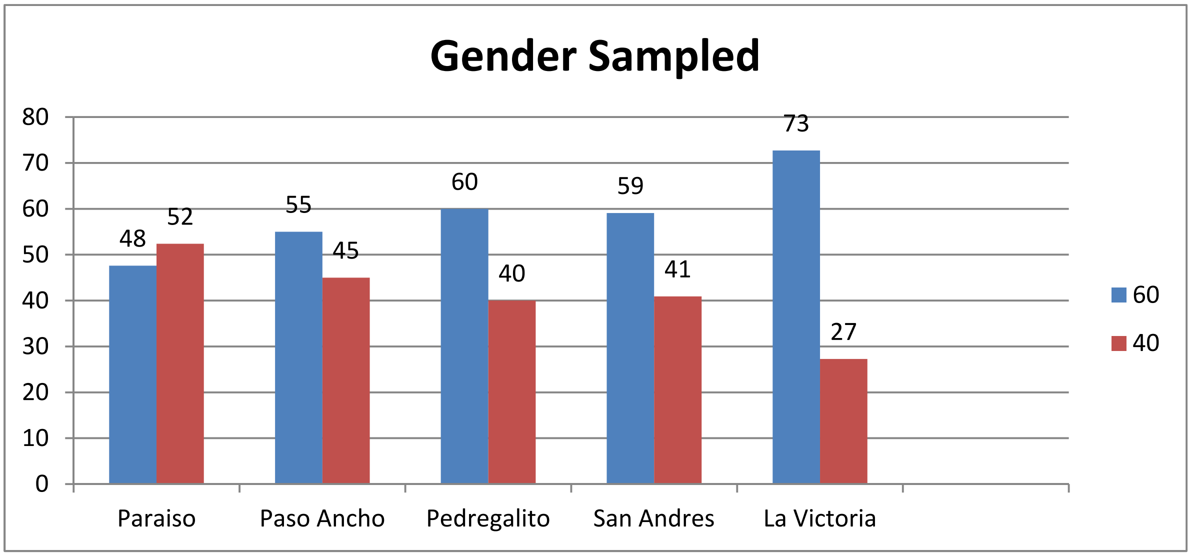


**Figure 17**

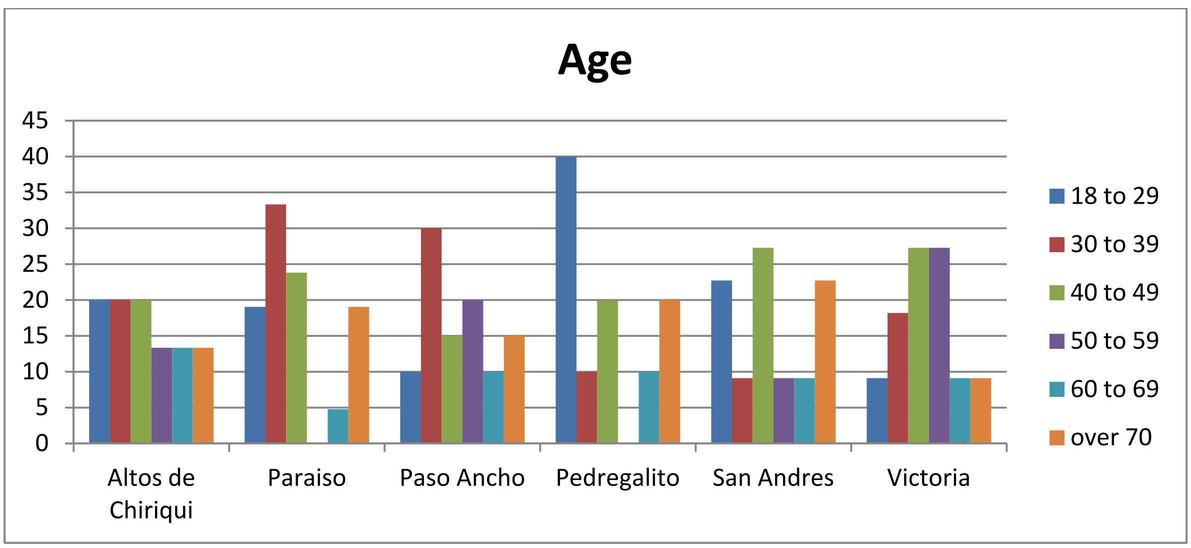


**Figure 18**

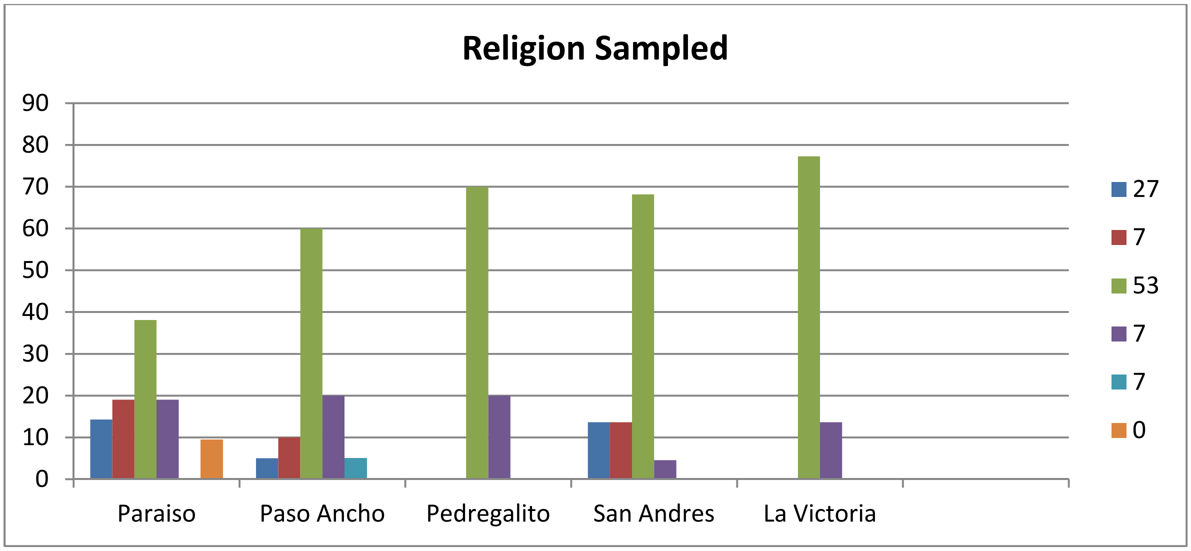


**Figure 19**

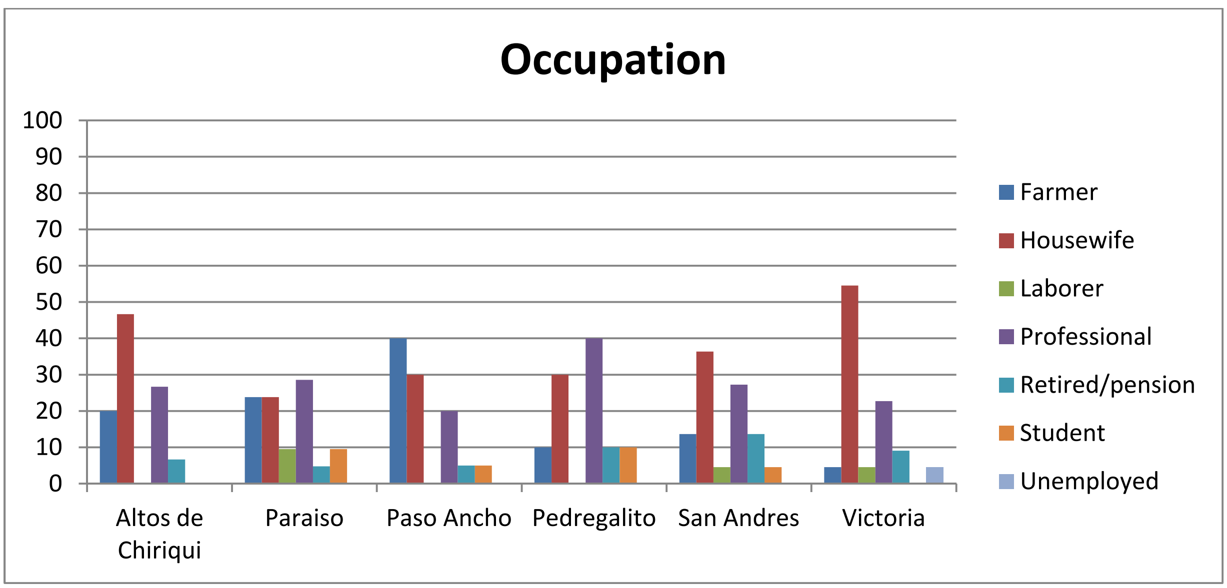


**Figure 20**

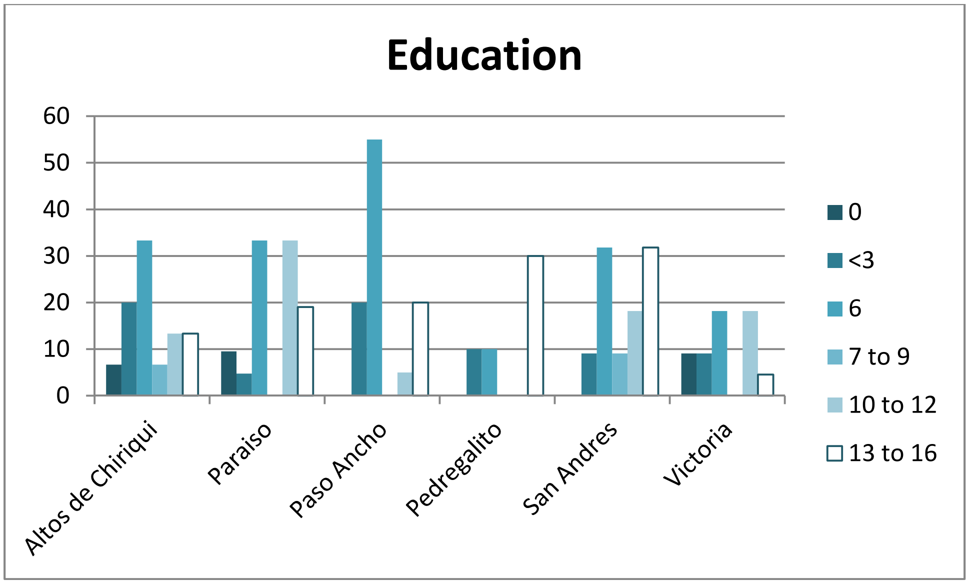


**Figure 21**

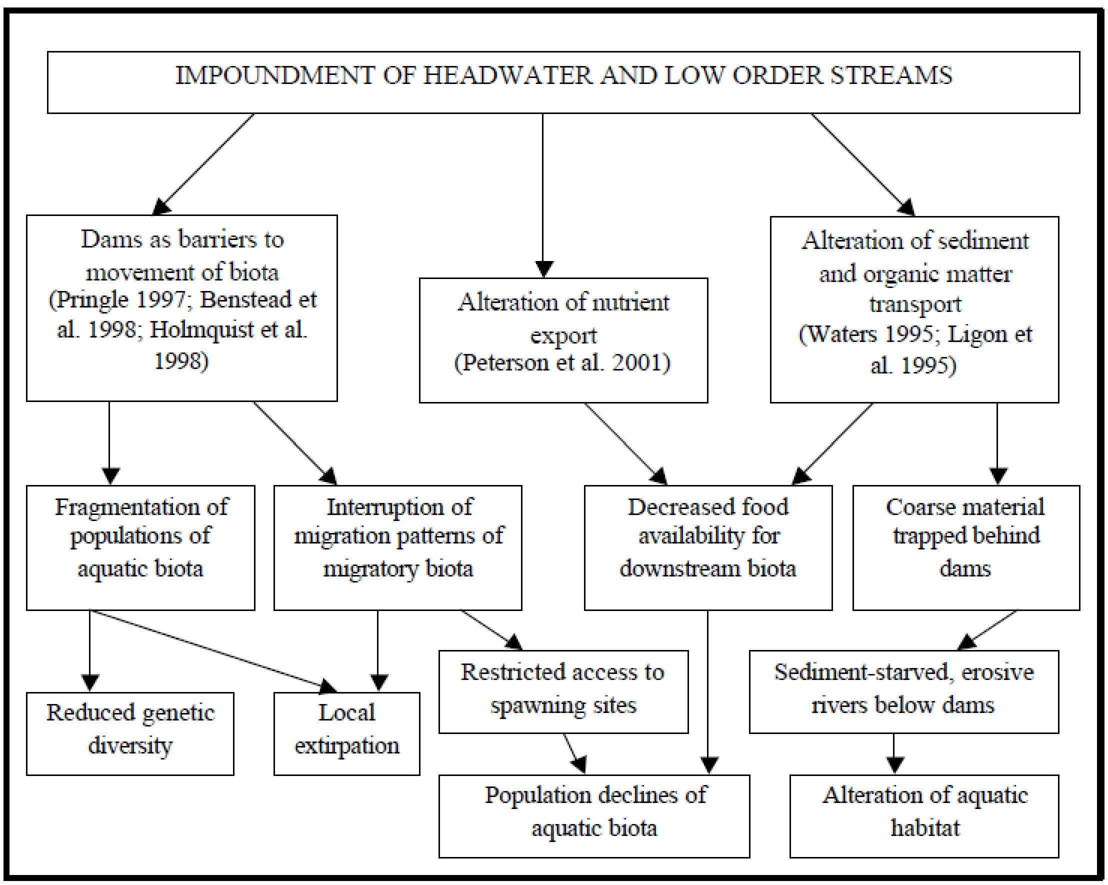


**Figure 22 (Olivas, 2004 unpublished)**

## <u>Encuesta</u>

**I. Información Básico**
Comunidad:
Nombre:
Edad:
Religión:

**II. Información del Domicilio**
Estado civil:
Niños:
¿Cuantos niños tiene usted?
¿Cuantos están en la escuela?
¿Cuántos años de escuela tiene usted?
¿Por cuantos años ha viviendo en este domicilio? ¿En la Comunidad?
¿Donde vivió antes?
¿Cuál es su ocupación?

**III. Usos del rio**
¿Según usted, cuales son los usos que tiene el rio para la gente de su comunidad?

**VI. Preguntas sobre la represa**
A. *Información y reuniones comunitarias*
¿Cuál es su conocimiento de los proyectos hidroeléctricos en el rio Chico? ¿De qué fuente vino esa información? (por ejemplo de un libro, la escuela, una promotora, etc.)
¿Ha sido informado sobre las represas hidroeléctricas por cualquier promotor/a del proyecto? ¿Cómo y cuándo?
¿Tuvo lugar una reunión comunitaria con representativas de la represa sobre el EIA y plan de manejo? ¿Asistió usted? ¿Cuántas personas asistieron? ¿Cuál es su opinión de la reunión?
¿Usted se siente que ha estado representado en el proceso de participación publico en la aprobación de le represa?

B. *Impactos Familiares/Comunitarias*
¿Cuáles son los impactos comunitarias de la represa? (e.g. conflicto, empleo...)
¿Cómo ha sido afectado usted o su familia por la represa? ¿Cómo estarán afectados en el futuro?
¿La compañía encargada de la represa ha apoyado algún proyecto comunitario? ¿Cuál?

C. *Economico*
¿La represa ha creado empleos en la comunidad? ¿Cuántos? ¿Esos empleos son temporales o permanentes?
¿Cuál es la destinación de la electricidad que es/será generada por la represa?
¿Su casa tiene electricidad? ¿De donde viene ese electricidad?

D. *Medioambiente*
¿La compañía encargada de la represa ha tomado acciones para mitigar impactos ambientales?