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The Socioeconomic Impact of Hydroelectric Dams on Developing Communities: A Case Study of the Chalillo Dam and the Communities of the Macal River Valley, Cayo District, Belize, Central America

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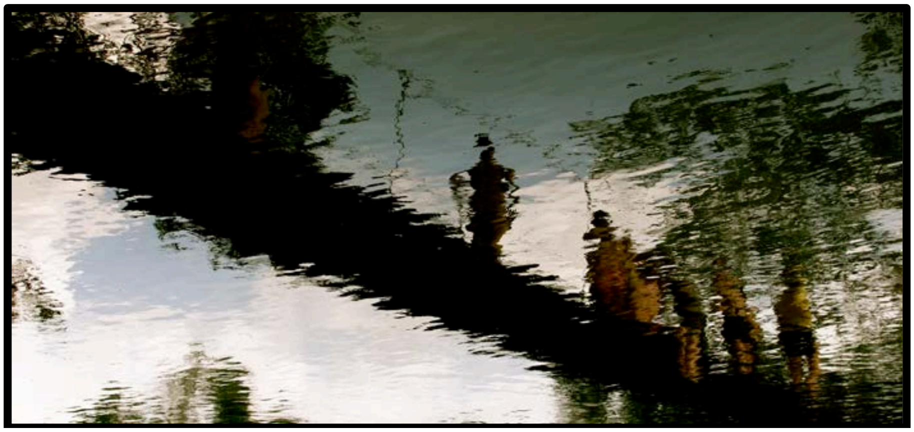

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Abstract

This undergraduate research thesis examines the socioeconomic impact of hydroelectric dams on developing communities through a case study of the Macal River Valley in Belize, Central America and the Chalillo Dam. By analyzing the sample population, as well as comparing demographics within the sample population, I determine the socioeconomic impact of hydroelectric dams on the communities of the Macal River and factors influencing levels of impact on the local people. I employed a questionnaire with a likert response scale as my research tool, which resulted in quantitative data. By statistically examining the quantitative data, I determine the overall impact of the dam, as well as variables that influence impact including: urban versus rural location, and occupation based on industry sector. This socioeconomic impact analysis of a large infrastructure development project provides insight into the relationship between a water body, the local people, and the local economy; it determines the portion of the population that benefits and the portion of the population that suffers the cost.

(images deleted in digital version; available in hard copy in the Environmental Program office)

Acknowledgments

My time spent in Belize, spring of 2010, was a paradigm shifting experience, which solidified my passion for sustainable development and environmental studies. I would like to first recognize CDAE's Belize Semester Abroad Program in Sustainable Development directed by Jay and Meg Ashman. This program taught me more about my passion as an environmentalist than a grade could ever quantify, and my experience abroad in Belize planted the idea for this thesis.

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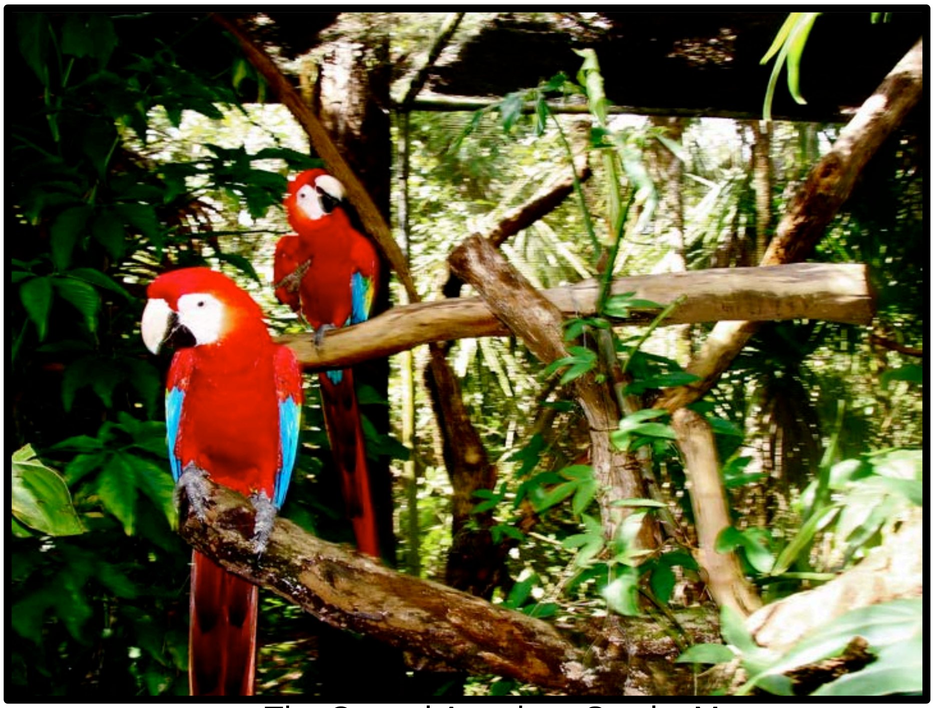
After high school graduation you told me "Congratulations! Today is your day. You're off to Great Places! You're off and away!" You have always believed in me to the extent that I now believe in myself. Sending you all my love and thanks.



The Central American Scarlet Macaw

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1. Introduction

Developing communities face a different level of cost benefit analysis than developed communities when it comes to large infrastructure developmental projects. Having a variety a socioeconomic status within a small geographic area presents opportunity for disparity in impact based on environmental changes. Dams are a primary example of a large infrastructure project that presents opportunity for economic development, while also engendering environmental changes that consequentially feedback to social and economic values of communities downstream. Dams have the potential to produce a variety of positive and negative impacts on the surrounding people and environment. In order to maximize the benefits of a dam, the valuable relationship between communities and their river networks must be accounted for. Often times limited funding, foreign investments, and time restrictions cause developers to cut corners leaving socioeconomic impact unaccounted for. With highly valued ecosystems and people who closely rely on the land for their livelihoods, it is important to take all possible impacts into account.

A case study of this is the Chalillo Dam located on the Macal River in Belize, Central America. The Chalillo Dam is the first dam built on the Macal River with a reservoir, and for that reason the Chalillo Dam inarguably changed the Macal River. Like all infrastructure development, the Dam presents direct costs and benefits to the country of Belize, while also placing externalized costs on the local communities supported by the Macal River and the surrounding environment.

Many agencies and researchers have analyzed the environmental impact of the dam post-construction. However, there is an information gap in the socioeconomic impact of the Chalillo

Dam based on the interpretation of the communities downstream (Gonzalez, 2012). This is attributed to Belize being a small country where funding limits the priority of socioeconomic impact analysis. As a researcher, this presented the opportunity for preliminary research. The ultimate research question was: with an ever-increasing demand for dam services and electricity in the developing world, what are the socioeconomic impacts engendered by dam projects and, within the population which groups experience the greatest degree of impact, and how can the analysis of the externalized costs mobilize local communities in future infrastructure decision-making? By attempting to answer this research question, I hope that local stakeholders in developing nations will be increasingly represented in the decision-making for future infrastructure projects.

The Upper Macal River

2. <u>Literature Review</u>

An Overview of Hydroelectric Dams & The Context of the Case Study

Humans have been shaping the Earth's landscape since the beginning of our existence. In the same way that trees are cut down to make way for roads, dams have been built to manipulate and divert water bodies for human benefit. The scale of dam projects has evolved along with the scale of human development and industry.

While the benefits of a dam project can be worthwhile, any interruption of natural processes brings economic, environmental, and social impact. This literature review will provide a brief historical context of dams followed by an introduction of the role of hydroelectric dams in modern development. Within the context of modern hydropower, the economics of hydropower will be presented, along with the broad array of economic impacts, both positive and negative. Following, the externalized costs and benefits of hydroelectric power will be discussed in the realms of environmental impact and social impact. The literature review will conclude with an overview of the case study location in Belize, Central America focusing on the Chalillo Dam and the developing communities downstream along the Macal River.

2.1 The History of Hydropower

Most communities, from a village to a city, are located adjacent to a body of water. Communities depended on rivers for basic needs until fossil fuels became the next most efficient source of available power for industrial development, pulling people away from networks of navigable waters, and sprawling communities across the landscape ("Modern hydropower," 2007a). As global energy production shifts away from fossil fuels, and domestic production of energy is increasingly desired. Decision-makers are revisiting hydroelectric dams as a means to increase energy security and support economic growth and development ("Modern hydropower," 2007a). Since hydropower is the original “fuel” of global development, looking back to the industrial revolution, it is no surprise that developing nations are increasingly turning to dams with the goal of increasing domestic electricity production and distribution ("Modern hydropower," 2007b).

2.2 Modern Hydropower

2.2.A. Modern Dams’ Role in Development

Dams can control flood patterns, divert rivers, store water for drinking and irrigation, and generate power (Workman, 2009). In terms of modern hydropower, dams are the primary way to manipulate a river for human benefit. Also, by controlling flood patterns, dams have allowed many civilizations to develop in extreme proximity to rivers, where volatile flood plains would otherwise not allow it ("Modern hydropower," 2007a). Dams are so to speak, a way to “budget” a river. They can ensure a reliable river flow year round and bring water to otherwise arid landscapes ("Modern hydropower," 2007a). However, dams intervene with the world’s natural hydrology in the same way deforestation fragments ecosystems, and the sustainability of this intervention is up for debate.

The presence of dams has increased globally due to the amazing ability humans possess to manipulate natural processes for their benefit. International Rivers states, “[At] the end of the twentieth century, the dam industry had choked more than half of the earth’s major rivers with more than 50,000 large dams” (International Rivers, n.d.). In the United States *alone*, the exact number of dams is unknown. It is estimated that there are more than 2.5 million small dams, 78,747 dam structures requiring federal hazard safety oversight, and additionally there are 99,000 state regulated dams (Workman, 2009). Modern dam development is driven by politics, economics, and energy demand. North America's largest dams were developed for a variety of purposes: navigation and recreation (24 percent), flood control (13 percent), irrigation (11 percent), hydropower (11 percent), water supply (10 percent), and for multiple purposes (30 percent) (Workman, 2009). Dams come in a broad range, built for various purposes, with various materials, and in various environments. On the contrary, modern decision-making and design for dam projects is quite generic, where the design of the dam may not fit the hydrology of the host river. Additionally, time and funding limits pre-construction cost benefit analysis for economic, environmental, and social factors. The cost benefit analysis of dams must be re-evaluated to maximize potential benefits and minimize costs.

2.2.B. Modern Hydropower & Hydroelectric Development

Historically, hydropower captures the energy of water movement to perform *work.* In a modern context, hydropower uses turbines to capture the energy of water movement to generate *electricity* ("Modern hydropower," 2007a). Hydroelectric generation accounts for 16 percent of worldwide electricity generation (Evans, Strezov, & Evans, 2009). Typically, hydroelectric facilities consist of a hydroelectric power plant stationed within a dam. Modern trends in hydropower development suggest, as the current energy crisis worsens, developers will increasingly resort to hydropower for electric production in both the developed and developing nations of the world ("Modern hydropower," 2007a). To quantify the costs and benefits of hydroelectric dams is a complex task, having an important role in energy security, yet producing sizable impacts on the local economy, environment, and communities.

2.3 The Economics of Hydroelectric Dams

2.3.A. The Economic Benefits of Hydroelectric Dams

Currently, 1.6 billion people are without access to electricity and 1.1 billion people are without a reliable drinking water supply (Yuksel, 2009). Water and electricity are both necessary resources for economic development, and dams can increase access to both, through irrigation, flood control, water supply, and electricity production (Yuksel, 2009).

Within the realm of electricity generation, hydroelectric power is so-to-speak, a low hanging fruit for economic development. “[Hydroelectric] potential exists in 150 countries, and about 70 percent of economically feasible potential remains to be developed” (Yuksel, 2009). The technology is established and available (Yuksel, 2009). Aside from the high upfront cost of dam construction and maintenance, the direct cost of hydroelectricity is virtually zero (Evans et al., 2009). Hydroelectric dams also have a lifespan of 50 years – 100 years, which allows enough time to pay back construction costs *and* produce a net profit (Yuksel, 2009).

Additionally, hydroelectric power is relatively low in cost and high in efficiency compared to other modes of electricity generation, both conventional energy (fossil fuels) and alternative energy (renewable). Cost wise, hydroelectric power is the most affordable form of alternative energy and comparable in price to conventional energy (*Table 2.1*). Efficiency wise, hydroelectric power is highly efficient over other conventional and alternative sources of electricity (*Table 2.1*). As a result, hydroelectric dams are a popular mode of economic development, especially in developing nations (Yuksel, 2009).

Table 2.1 Comparison of Cost and Efficiency for Modes of Electric Generation (Evans et al., 2009)

Type of Electric Generation	Mode of Electric Generation	Cost U.S. $ / kilowatt	Efficiency
Alternative/Renewable	Hydroelectric	0.05	>90%
Alternative/Renewable	Photovoltaic (solar power)	0.24	4% -22%
Alternative/Renewable	Wind	0.07	24% - 54%
Alternative/Renewable	Geothermal	0.07	10% - 20%
Conventional (Fossil Fuel)	Coal	0.042	32% - 45%
Conventional (Fossil Fuel)	Natural Gas	0.048	45% - 53%

2.3.B. The Economic Costs of Hydroelectric Dams

The economic costs of a hydroelectric dam depends heavily on political and economic drivers, generally determining the decision-making process of the project (Yuksel, 2009). A well planned, responsibly constructed, and politically transparent dam can engender amazing benefits. However, in developing nations, dams are often erroneous as a result of limited funding, resources, and quality assurance. Potential errors include faulty engineering, lack of geological planning, lack of consideration for seasonal change, and superficial environmental and socioeconomic impact assessment. As dams morph from a developmental solution to a costly endeavor, economic incentive to develop additional hydroelectric dams decreases (Hildyard, 2008).

The economic success of a dam depends on the contractor's ability to stay on budget and on schedule to minimize unforeseen costs. When this is not accomplished a dam becomes a money sink. This is known as *cost overrun*, when the actual cost of construction and maintenance exceeds the appraisal estimate (Hildyard, 2008). According to the World Bank, 70 percent of its large dam projects had a cost overrun of 27 percent (Hildyard, 2008). Cost overrun is a challenge in the hydroelectric industry because there is no "one-size-fits-all" method of dam production (Hildyard, 2008). Cost overrun is caused by *schedule slippage* and *lower-than-expected-output*, which can be avoided with effective planning. As a result, an average of 80 percent of the total cost of a dam is spent on planning and construction, making the economics of hydroelectric power increasingly less attractive (Hildyard, 2008).

Cost overrun increases as dam construction runs increasingly off schedule. This is known as *schedule slippage* (Hildyard, 2008). Essentially, schedule slippage delays generation of revenue from electricity production which would be used to pay back start-up costs (Hildyard, 2008). Additionally, schedule slippage can delay electric production that the country may have budgeted in to their energy portfolio, causing power outages and decreased economic production (Hildyard, 2008). If schedule slippage becomes too extreme, it can increase the cost of electricity production to an uncompetitive level within the market (Hildyard, 2008). An example of schedule slippage contributing to cost overrun is the Yacyretá dam in Argentina. The project finished eight years behind schedule putting electricity on the market at U.S. $.095 per kilowatt hour as opposed to the cost of electricity prior to the dam at U.S. $.04 per kilowatt hour (Hildyard, 2008). A dam project suffering from schedule slippage and cost overrun does more harm than good for the host nation's economic development.

In addition to schedule slippage, *lower-than-expected-output* contributes to cost overrun. Lower-than-expected-output results from poor planning in two ways: 1. Erroneous design of a dam results in unanticipated maintenance needs, which compromises 2. The revenue from electrical generation accounted for in the anticipated lifetime costs of the project. Output is compromised when the plant must shutdown for unanticipated repair and maintenance. As a result the dam's electric production capacity is overestimated and revenue is less than expected (Hildyard, 2008).

Further contributing to cost overrun, beyond our control, is climate change. As climate change increases, effective planning to avoid cost overrun will become nearly impossible. Climate change causes unpredictable fluctuations in rainfall and hydrology (Hildyard, 2008). The results are either increased stream flow leading to floods and devastation, or decreased stream flow leading to unviable electric production, energy shortages, and drought (Hildyard, 2008). Additionally, climate change presents increased evaporation, which increases the concentration of silt and sediment in impoundment (the reservoir or upstream water supply) (Workman, 2009) High concentrations of silt and sediment degrade the structural integrity and longevity of turbines, increasing dam maintenance costs (Workman, 2009).

The increasing economic risk of hydroelectric power is not attractive to investors. The World Bank states that investment in the hydroelectric industry has decreased, also known as *donor fatigue* (Hildyard, 2008). From 1970 – 1985, the World Bank funded 26 large dam projects per year (Hildyard, 2008). Since 1990, the World Bank decreased funding to just four large dam projects per year (Hildyard, 2008). The International Monetary Fund and the World Bank have also limited public expenditure on large infrastructure projects in developing countries, further eliminating public investment in hydroelectric dams (Hildyard, 2008). As a result, the private sector is predicted to provide 70 percent of investments in large infrastructure projects through pension funds, banks, and shareholders (Hildyard, 2008). The hydroelectric industry has shifted from majority of investors in the public sector to the private sector.

Increased private involvement in the hydroelectric industry changes the dynamics of decision-making and representation of stakeholders. Investment from the public sector aims to increase energy security and economic development for the host country. With decrease in public investors caused by donor fatigue, developing countries turn to private investors. The overarching goal of investors in the private sector is rapid return on investment accomplished by high insurance rates (Hildyard, 2008). Additionally, the investors' currency is typically of higher value than the investees' currency. In an attempt to return investment, the investee may experience *currency devaluation* (a decrease in currency exchange value) adding to the financial stress of hydroelectric development (Hildyard, 2008). High financial stress placed on the investee by the private sector makes hydroelectric development increasingly vulnerable to cost overrun and externalized costs.

2.4 The Externalized Costs & Benefits of Hydroelectric Power

Despite private investment, the question facing the public concerning hydroelectric dams is "Who pays and who benefits?" While the majority of hydroelectric dams are privately owned, the public often picks up the externalized costs. The externalized cost of a dam is the overall impact not accounted for in the cost of construction and/or not compensated for by generated revenue. Externalized costs of development may include degraded water quality, deforestation, or human health issues. On the other hand, benefits of development include increase in access to public goods and services, domestic security, and energy security. Externalized costs and benefits must be weighed to determine the overall impact of a developmental project in the social and environmental realm.

2.4.A. The Environmental Benefits of Hydroelectric Power

Energy production is primary global environmental concern. Conventional forms of electric production emit greenhouse gases such as carbon dioxide and methane, which are increasing the rate of climate change. Relatively speaking, hydroelectric generation is an environmentally low impact form of energy production, especially in comparison to fossil fuels such as coal or natural gas.

The environmental benefit of any given dam depends largely on its scale and geographic location. When constructed at the proper scale, dams are one of the lowest hanging fruits in renewable or alternative energy, especially for developing nations.

While certain dams may not be considered a “renewable” source of energy (depending on scale), hydroelectric dams provide a lesser of two evils as an alternative to fossil fuel electric generation (Evans et al., 2009). Hydroelectric generation only emits greenhouse gases when a reservoir is present with decomposing biomass (Evans et al., 2009). In a cooler climate with less biomass decomposition, carbon emissions are minimal. Conversely, a tropical climate with high biomass density and a small reservoir produce the most carbon dioxide emissions and typically generate less electricity (Evans et al., 2009). Even still, hydroelectric generation only produces 100 grams per kilowatt hour of carbon dioxide emissions, the same as photovoltaic solar power (Evans et al., 2009). Hydroelectric dams are an accessible alternative to fossil fuel based electric production (Yuksel, 2009).

2.4.B. The Environmental Costs of Hydroelectric Power

Although considered a “renewable” energy resource, hydroelectric generation often engenders significant environmental impact. Dams impact existing habitat, stream hydrology, stream chemistry, sediment transport, and migratory patterns (Yuksel, 2009). Essentially, dams fragment river ecosystems, degrading the ecosystem upstream and downstream from the dam (International Rivers, n.d.).

Fragmented river ecosystems change the “climate” of the river making upstream and downstream into essentially different ecosystems (International Rivers, n.d.). This results in habitat change leading to extinction of aquatic species (International Rivers, n.d.). Changes in flood plain and the natural flood pattern has contributed to a disappearance of many bird species (Barcott, 2008). In many scenarios tributary and floodplain disturbance has led to a decline in wetlands adjacent to riparian zones (International Rivers, n.d.). Lack of wetlands removes many environmental services such as flood control, habitat, and natural water filtration.

These impacts are magnified as the dam holds back sediment and deprives the downstream waters of nutrients. When a river is deprived of nutrients and sediment it adjusts course to gain sediment by eroding downstream riverbanks. This leads to the deterioration of natural flood plains, which would otherwise be regularly replenished by the natural flood cycle of the river (International Rivers, n.d.).

On a broader scope, reservoirs from large dams have a significant contribution to climate change through greenhouse gas emissions. In 2007, it was estimated that methane from dams is responsible for 4 percent of anthropogenic climate change (International Rivers, n.d.). Decomposition of biomass is rich in carbon dioxide and methane; it sinks into the atmosphere from the surface water of the reservoir, but is also emitted as the water travels through turbines and continues emissions downstream (International Rivers, n.d.) In some cases, relative to its generation capacity, hydroelectric power is much more dangerous to our climate than fossil fuel electric generation (International Rivers, n.d.). The impact a dam has on climate change depends heavily on the shape, climate, and depth of the dam (International Rivers, n.d.).

2.4.C. The Social Benefits of Hydroelectric Power

Dams are not built without good reason. Where economic incentive exists; typically social benefits exist as well. Dam projects have the potential to manipulate rivers to benefit local populations. Flood protection is an important service that allows communities to live comfortably along a river without fear of volatile flood patterns (Yuksel, 2009). In some scenarios dams provide increased water supply for arid populations and increase livelihood value (Workman, 2009). In many scenarios, a dam used for hydroelectric production supports other uses such as irrigation contributing to occupations in the agricultural industry (Workman, 2009). Dams also have the potential to increase navigability of waterways allowing increased river transportation of goods and services for the local people (Yuksel, 2009).

In many developing nations, hydroelectric power provides electricity generation where other forms are not possible due to limited infrastructure or limited import of fossil fuels (Evans et al., 2009). Hydropower avoids price fluctuations, providing a reliable form of electricity, while fossil fuel prices are constantly fluctuating and in general, increasing with time (Evans et al., 2009).

2.4.D. The Social Costs of Hydroelectric Power

While economic incentive leads to social benefit, environmental costs lead to social costs. It is evident historically and currently that dams produce social costs because the rate of large scale hydroelectric dam construction has slowed (Evans et al., 2009). Construction has slowed for a variety of socially related reasons; politicians and civilians alike are mobilizing against dam construction (Hildyard, 2008). Historically, the social impact of dams has been overlooked and underestimated. Since the 1900s, 40 - 80 million people have been displaced by dams worldwide (Workman, 2009). While electricity is a tool for development, it presents a tradeoff detrimental to local livelihoods.

With increased mobilization against dams, private companies own more dams than public entities. When a privately owned dam is constructed, public funding must be reallocated to compensate for externalized costs, taking away from funding for public goods and services such as healthcare and education (Hildyard, 2008). The private company is often reliant on a public utility for distribution. However, due to cost overruns and other unforeseen expenses, the hydroelectricity rates are often higher than what the public can afford, leaving the private firm bankrupt (Hildyard, 2008). In this case, after the public entity has compensated for the externalized costs of the dam, they are unable to reap the benefits of increased energy security. Also, at the end of a dam’s lifespan, the public typically must pay for the cost of decommissioning for risk of collapse and flooding, regardless of whether the dam was publically or privately owned (Hildyard, 2008). Cost of decommissioning is often as high as the cost of construction alone (Hildyard, 2008). Based on these trends, it is obvious that the public is placed in the most vulnerable position within the context of dam construction.

Dams also strain the relationship between communities and their water bodies. Communities are centered around rivers and other bodies of water because they rely on the water as a resource. A dam interrupting a river leads to unpredictable social impact. First, many communities must resettle to provide land for the dam and the reservoir (Yuksel, 2009). Hydropower dams restrict navigability of a river at any scale. From a three meter dam and a canoe, to the Three Gorge Dam and a barge, dams fragment rivers and limit its navigation (Yuksel, 2009). In some scenarios, communities could become isolated from others if river travel is the easiest and most efficient form of transportation. Isolating communities could have detrimental impacts on livelihoods by limiting trade of goods and services (Yuksel, 2009).

In addition to decreased navigability, dams prove to deprive communities of water, especially downstream. With interrupted hydrology, dams cause deepening of riverbeds (International Rivers, n.d.). This leads to a depletion of groundwater and local wells (International Rivers, n.d.). It is typical after the closing of a dam, that there is an increased need for irrigation downstream for lack of groundwater supply (International Rivers, n.d.). More directly, each kilowatt hour of hydroelectric generation requires 36 kilograms of water (Evans et al., 2009). This is relatively high compared to other renewable energy resources such as wind, which requires only 1 kilogram of water per kilowatt hour (Evans et al., 2009). In a community where water is scarce, dams present an increased risk to water security.

In many scenarios, dams can lead to scarcity of water after contractors claim it will improve water supply. Post dam construction, irrigation may be necessary for agriculture downstream where it was once a water rich land. This is a result of redistribution of water resources and must be managed (Yuksel, 2009). For example, if more water is needed for irrigation, then less drinking water will be available to the local communities. In addition to water, other natural resources providing income for local people will be impacted. Forest health will reduce the production of non-timber resources such as honey or medicinal plants (Yuksel, 2009). Lack of fish migration and eventual extinction of species will degrade fisheries productivity (International Rivers, n.d.). Even the general decrease in biodiversity could have a deadly impact on the local ecotourism industry (Barcott, 2008).

2.5 Context of the Case Study: An Overview of Belize, Central America

In the context of the developing world, many dams are poorly constructed so that the benefit of electric production does not exceed the socioeconomic and environmental costs (Hershowitz, 2008). The following research will examine these tradeoffs in the context of Belize, Central America and the construction of the Chalillo Dam on the Macal River.

2.5.A. Overview of Belize: Water & Electricity

Belize, Central America is a small country, approximately the size of Massachusetts with a population comparable to the state of Vermont (Barcott, 2008). Belize is nestled on the coast of the Caribbean Sea just south of Mexico and east of Guatemala. It was once a British Colony and recently earned its independence in 1981. The nation is rich in resources with a tropical climate and diverse cultures. In fact, the majority of the nations Gross Domestic Product (GDP) is from the tourism and agricultural industry sectors (Inter-American Development Bank, 2010). Despite its paramount beauty and peaceful nature, Belize faces the same challenges that any developing nation would face: sustainable growth and resource management.

Belize's energy consumption per capita is ranked second in Central America (Inter-American Development Bank, 2010). Due to infrastructure and funding limitations, the energy industry is nationalized, being privately produced and publically distributed (Inter-American Development Bank, 2010). Belize Electricity Limited (BEL) is responsible for transmission, distribution, and some generation of electricity for the nation (Inter-American Development Bank, 2010). BEL purchases 46 percent of its energy from Mexico and 50 percent from domestic producers (generally Belize Electric Company) (Inter-American Development Bank, 2010). Fortis, Incorporated, a Canadian company, owns 70 percent of BEL in interest and fully owns Belize Electric Company (BECOL), which generates Belize's hydroelectric power (Inter-American Development Bank, 2010). Currently, it is more cost effective for BEL to import electricity, despite the fact that Belize's generation capacity (117 megawatts) greatly surpasses peak demand (76 megawatts) (Inter-American Development Bank, 2010). The reason why imported electricity is more cost effective in Belize is that the market is so small that "economies of scale" or larger producers such as Mexico can produce electricity at a less expensive rate (Inter-American Development Bank, 2010). In the case of Belize, domestic fuel resources are limited and the cost of importing such fuels is too high for the size of the market (Inter-American Development Bank, 2010). Currently in Belize the cost of electricity is U.S. $.2205 and in order to decrease the price of electricity, the government would need to reduce domestic production and increase reliance on neighboring large-scale markets (Inter-American Development Bank, 2010).

On the other hand, Belize is rich in water as a natural resource. Water in Central America and Belize in particular is plentiful through ground and surface resources (Inter-American Development Bank, 2010). Belize consists of 18 watersheds with high access to potable water access compared to the rest of the Caribbean and Latin America (Inter-American Development Bank, 2010). In Belize, 91 percent of people have reliable access to water, and as a piece of Belize's Millennium Development goals, the goal is to reach universal access to water at 100 percent (Inter-American Development Bank, 2010). Currently, the government is drafting a bill framing the new Water Resources Management Plan to inventory water resources and estimate future demand (Inter-American Development Bank, 2010). The major issue with water resources in Belize is unequal distribution of access, sanitation, and sewerage services between urban and rural communities (Inter-American Development Bank, 2010). Rural water access is approximately 80 percent while urban areas access is close to 100 percent, making the national access 91 percent (Inter-American Development Bank, 2010). Additionally, urban areas have 85 percent sewerage service coverage, compared to only 32 percent sewerage service coverage in rural areas (Inter-American Development Bank, 2010). Rural areas generally rely on put latrines and septic tanks to treat waste, or it is directly drained into bodies of water (Inter-American Development Bank, 2010). Nationally, only three municipalities have the infrastructure to collect and treat sewerage (Inter-American Development Bank, 2010). These facilities collect and treat at the most basic level of sanitation and release the wastewater into the rivers. The reason for general lack of infrastructure across the nation is low population density and fragmentation of populations (Inter-American Development Bank, 2010). One-third of Belize's population lives in 190 villages with less than 4,000 inhabitants (Inter-American Development Bank, 2010). There is no economically feasible way for these small communities to fund expensive small-scale sewerage treatment facilities (Inter-American Development Bank, 2010). As a result of infrastructure limitations, the rivers of Belize are not as resilient to development putting the ecological health and human health of communities who rely on the rivers at risk.

Despite the general water quality issue in Belize, the Belize Rural Development Programme is increasingly investing in river intakes and catchment dams (Inter-American Development Bank, 2010). The goal is to address infrastructure issues in water access. However, most of the infrastructure aims to increase irrigation to improve agricultural production (Inter-American Development Bank, 2010). Belize’s rivers are already in a vulnerable state and the presence of dams and other water catchment projects will only hinder the rivers natural ability to replenish its environmental health.

2.5.B. The Chalillo Dam and the Macal River, Cayo District, Belize

The Chalillo Dam is the second of three dams built on the Macal River. The first dam built on the Macal River is the Mollejon Dam in 1995 followed by the Chalillo Dam in 2005 and the Vaca Dam in 2008. The following research focuses on the Chalillo Dam, being the only dam on the Macal River with a reservoir. Also, the planning, decision-making, and politics behind the Chalillo Dam present controversy putting the environment, social, and economic values of the local communities at risk within the context of infrastructure development.

In efforts to localize electric generation, BECOL along with Fortis, Incorporated invested in the Mollejon hydroelectric “run-of-river” dam in 1995 (Worrall, 2002). While the Mollejon dam is capable of producing enough energy for most of Belize during peak electricity use, the dynamic nature of the Macal River prevented the dam from functioning at peak level

(Hershowitz, 2008). Investors proposed a the “Macal River Upstream Storage Facility” (MRUSF) also known as the Chalillo Dam to mitigate river flow as the “least-cost” option to fix this issue, since the Mollejon Dam had already been built (Hershowitz, 2008). This brings light to the issue behind the Mollejon Dam: if the Mollejon Dam were correctly engineered from the beginning stages, the Chalillo Dam would not be necessary to generate electricity efficiently.

The Chalillo Dam became a controversial project when the Environmental Impact Assessment (EIA) was completed in a non-transparent manner. The proposed Chalillo Dam underwent an EIA mandated by the National Environmental Policy Act (NEPA) and written by the Canadian International Development Agency (Barcott, 2008). Belize Institute for Environmental Law and Policy (BELPO) argued that the preliminary EIA was not thorough and inaccessible to the public (Gonzalez, 2012). As a response, the EIA was rewritten as multi-volume, ~2,000 page document in English and placed in several libraries throughout Belize (Gonzalez, 2012). Due to the length of the document many government officials signed off on the EIA without reading the entire document, disregarding the potential harms of the project (Gonzalez, 2012). Public access to the EIA was also limited in a country where portions of the population are not English speakers and/or illiterate.

Adding to the controversy, there is speculation that the EIA altered geological information including the deletion of a fault line adjacent to the dam location and false classification of bedrock on location (Gonzalez, 2012). The argument was that lack of geological consideration for erosion and earthquakes could cause a breach in the dam structure. If the dam were to break communities downstream would be isolated from flooding, or even worse destroyed. In fact, the second largest urban center of Belize with a population of about

20,000 people would be washed out. These risks were “mitigated” by flood evacuation signs and a flood alert system giving an evacuation window of 15-45 minutes. During an evacuation drill many noted that rural communities were not well informed and alarms could not be heard without diligently listening (Barcott, 2008).

Despite public outrage and legislative uncertainty, the dam’s construction proceeded first, with an access road fragmenting the fragile and biologically diverse riparian rainforest of the Macal River Valley, followed by the construction of the Chalillo Dam and its reservoir (Hershowitz, 2008). Post construction of the Chalillo Dam the public does not seem impressed by the project’s role in the local economy.

The Chalillo Dam has not proven to contribute positively to the local economy. The construction process brought in primarily Asian workers and did not provide many Belizeans with long-term jobs (Barcott, 2008). Additionally, the flooding of the Chalillo Reservoir increased cross-border access between Guatemala and Belize. Valuable natural resources such as highly valued timber, Central American Scarlet Macaw fledglings, and ornamental plants were stolen from Belize for sale in Guatemala (Barcott, 2008). Downstream, the local people experienced changes in the color of the river from green to brown. Often times the river was not swimmable producing an odor and causing rashes on children. In addition, fish such as tilapia were not recommended for fishing out of the river due to a jump in mercury levels associated with the dam (Barcott, 2008). As the public began to notice the impacts of the dam without reduced electricity rates a negative attitude toward the dam spread throughout the communities downstream.

Through extensive research of the Chalillo Dam issue and in examining several case studies, it is apparent that the environmental impacts, both positive and negative, are well accounted for. It appears that the information gap lies in quantifying the socioeconomic impact correlated with construction of the Chalillo Dam based on the opinions and livelihood changes of the communities downstream.

Dams produce costs and benefits in the local economies, environment, and communities. It is necessary to conduct a well-rounded cost-benefit analysis prior to construction and incorporate the results into decision-making process. While dams contribute largely to development, they can also engender unforeseen impacts on fragile environments and the local people who rely on the environment for their livelihood. In the context of Belize, Central America, the Chalillo Dam proves to be an intersection of electricity generation and water supply issues with a complex array of impacts. By bridging the information gap on the Chalillo Dam's socioeconomic impact on communities downstream, the developing country of Belize and other similar nations may benefit from considering the potential socioeconomic impacts, both negative or positive, in decision-making and planning of large scale infrastructure development.

(images deleted in digital version; available in hard copy in the Environmental Program office)

3. Methodology Socioeconomic Impact Analysis

3.1 Research Goal

The research aimed to quantify the socioeconomic impact of hydroelectric dams, on developing watershed communities and to identify demographic variables that shape level of impact. The result is a case study of the Macal River Valley and the communities downstream from the Chalillo Dam. My research examined the following demographic variables:

1. Level of Development: Urban versus rural communities
2. Industry of work: The agricultural industry versus the tourism industry

By utilizing a local, watershed approach to collect data, the research demonstrated the relationship between communities and their waterways, and the tradeoffs of altering said bodies of water as a consequence of development.

3.2 Methodology and Work Plan

Socioeconomic impact analysis examines how an act of development could potentially impact a community, the social and economic aspects of the potential impact, and the community's attitude towards resulting changes (Edwards, n.d.). Potential impact outcomes include: demographic changes in the community, changes in retail/service and housing market, demand for public services, employment and income levels, and aesthetic quality for the community (Edwards, n.d.). Each potential outcome was further examined through indicators accounting for a broad range of potential impacts on a specific project. My research considered the social and economic values of the Macal River and the Chalillo Dam, along with the resulting tradeoffs experienced by the local economy. As a result, the indicators selected to

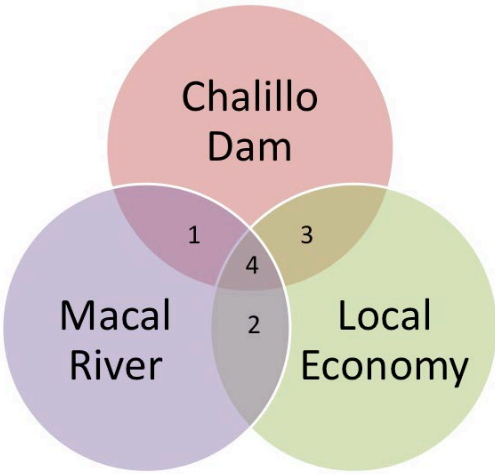


Figure 3.1: The relationship between the Macal River and the Chalillo Dam with the local economy.

examine the potential socioeconomic outcomes are specific to the relationship between (*Figure 3.1*):

1. The Macal River and the Chalillo Dam
2. The Macal River and the Local Economy
3. The Chalillo Dam and the Local Economy

Resulting in:

4. The overall socioeconomic impact

The selected indicators were drawn from the Latinobarómetro survey 2010 used to gather data on socioeconomic changes in Latin America (Latinobarómetro Corporation, 2010). Utilizing the socioeconomic impact analysis methodology combined with relevant indicators from the Latinobarómetro survey 2010, the following socioeconomic outcomes were selected for the research:

1. Domestic security and energy security
2. Natural disaster resiliency and preparedness
3. Public services and availability of goods and services in the local economy
4. River uses and associated values
5. Food source access, availability, and cost
6. Quality of life: health and vacation time

3.3 Research Tool: Questionnaire

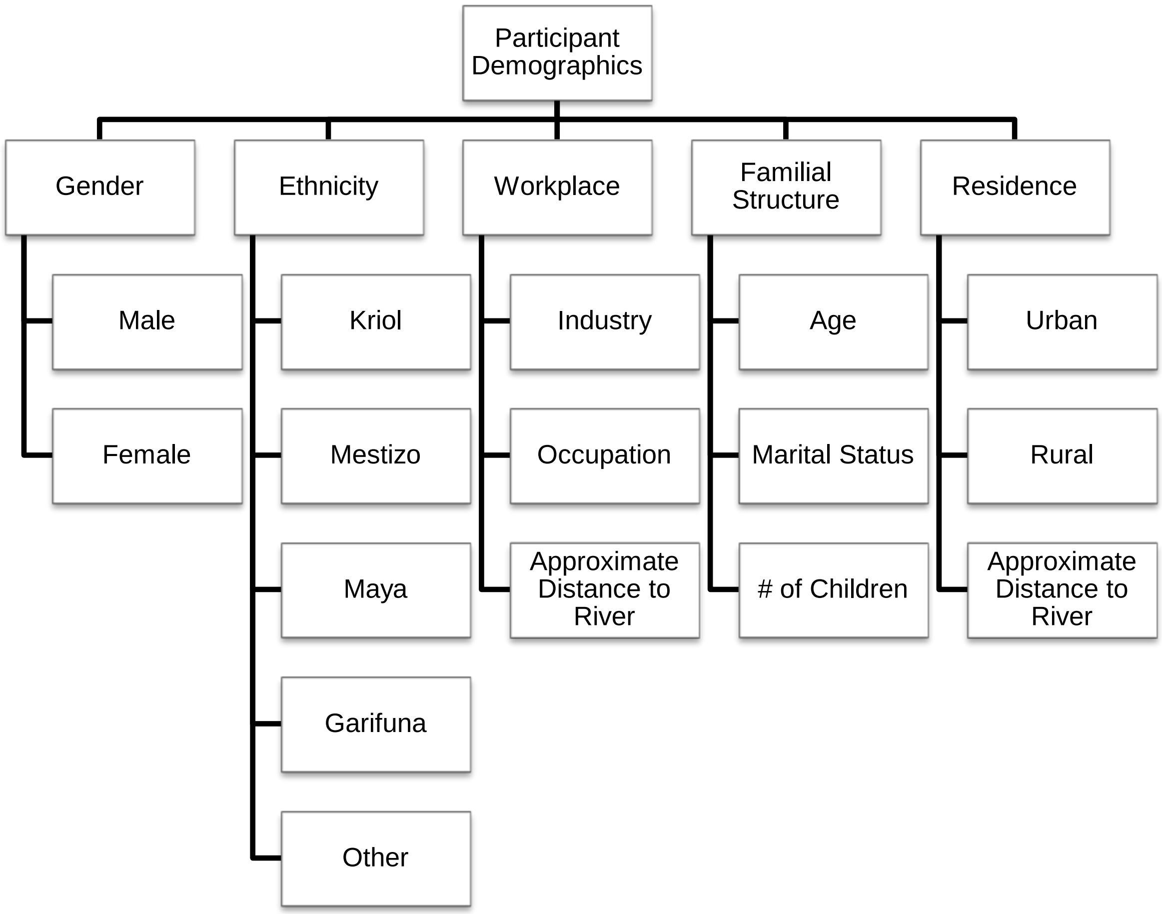
Socioeconomic impact analysis can be completed with a variety of tools. In this case, the socioeconomic impact analysis is retroactive, and the research aimed to quantify impact that has already occurred across a broad population. A questionnaire is the most efficient option and allowed me to cover a broad sample size, in a minimal time period, while generating uniform results (Saris & Gallhofer, 2007). Additionally, questionnaires are designed to include demographic data for each participant, making it possible to statistically analyze the results by demographic variables such as: level of development, industry of occupation, and location of home and/or workplace. Use of a questionnaire allowed the research project to evaluate perceived socioeconomic impact on the local community, gather participant demographics, and examine factors that determine perceived level of impact within the target population.

Design of Questionnaire

The goal of the questionnaire was to generate quantitative data linked to demographic data in a time efficient manner. Each questionnaire captured the participant's demographic background, their attitude toward the Chalillo Dam, and perceived impact for the target outcome indicators. To achieve this goal the questionnaire was brief, having only one page for collection of participant demographics (*Appendix 3.1 Questionnaire: Participant Demographics*) and one page socioeconomic impact analysis (*Appendix 3.2 Questionnaire: Socioeconomic Impact Analysis*).

Participant demographics were selected based on the research goal to analyze demographic variables that shape perceived level of impact. To ensure that demographic information covered a broad spectrum for later statistical analysis a variety of variables were accounted for (*Figure 3.2 Participant Demographics*).

Figure 3.2 Participant Demographics



Following the collection of participant demographics, the questionnaire began with four multiple-choice questions (*Appendix 3.2 Questionnaire: Socioeconomic Impact Analysis Q1-Q4*). The goal of these questions was to ease the participant into the questionnaire with simple closed response questions. These questions also provided insight on the background knowledge of the participant and the legitimacy of their input on the Chalillo Dam. Also, these simple questions detected the participants' attitude and any underlying biases toward the Chalillo Dam.

The final section of the questionnaire was designed to collect quantitative information reflecting the socioeconomic impact of the Chalillo Dam based on the socioeconomic impact analysis methodology (*Appendix 3.2 Questionnaire: Socioeconomic Impact Analysis Q5-Q10*). This section contained six categories based on impact outcomes (Q5-Q10) each with subsections based on socioeconomic indicators. Each question asked the participant to rate impact as "positive, negative, or no change" over the past 5-10 years based on their perception from living and/or working in the Macal River Valley. These questions were answered using the likert response scale. The likert response scale is a tool used to transform what would usually be considered qualitative data, such as an opinion, into quantitative ordinal data expressed as a number (Saris & Gallhofer, 2007). The likert scale was depicted as a bracketed spectrum, and in this case the spectrum ranged from *very negative* to *very positive*. The response scale was designed to reduce bias by giving as much opportunity for a negative response as a positive response with no impact/change in the center. The likert scale range originally selected for the questionnaire was 1 to 7 allowing for variations of positive and negative but was simplified during data analysis (*Table 3.1 Likert Response Scale*).

Rate the following indicators (1-7) based on observed impact since the construction of the Chalillo Dam in 2005:	**Very Negative**	**Negative**	**Mildly Negative**	**None**	**Mildly Positive**	**Positive**	**Very Positive**
Q5. Domestic Security							
a. Income/year	1	2	3	4	5	6	7
b. Housing Security	1	2	3	4	5	6	7
c. Energy Security	1	2	3	4	5	6	7
d. Cost of Electricity	1	2	3	4	5	6	7

Table 3.1 Likert Response Scale (1-7)

3.4 Target Sample & Method of Sampling

The target sample for the research included participants in the labor force who live and/or work within the Macal River watershed. According to the 2010 Belize Population and Housing Census, the labor force includes the population ages 14 and older (Statistical Institute of Belize, 2011). Belizeans are required by law to attend school until the age of 14 resulting in an overall labor force 14 years and older (Statistical Institute of Belize, 2011). To participate in the research, individuals must were required to be 18 years or older due to ethical considerations instated by the Institutional Review Board (IRB). Also, an individual was considered to live and/or work within the Macal River Valley if located in a village/town along the Macal River, the Branch Mouth region of the Mopan River, and the upper Belize River (*Map 3.1 The Cayo District*). Target urban centers in this area included: San Ignacio, Santa Elena, and Benque Viejo. Target rural villages included: Bullet Tree, Cristo Rey, San Antonio, Succotz, and Santa Familia.

Map 3.1 *The Cayo District* deleted in digital version; available in hard copy in the Environmental Program office)

For usable research results, the sample must be statistically significant. To consider a result statistically significant the sample size must be at least 30 individuals (n=30) (Saris & Gallhofer, 2007). In the case of this

research, the goal was for each sample group to include at least 30 participants.

Sample groups included:

1. Residence in urban center
2. Residence in rural village
3. Occupation in tourism/hospitality industry
4. Occupation in agricultural industry

Due to the nature of the research, there was overlap in sample groups. For example, a participant may have lived in an urban center, and worked in the tourism industry. The intention was that in comparing outcome variables each sample group would include at least 30 representatives. In order to ensure sample groups of 30 or more participants the overall sample size goal was around 80-90 participants.

Additionally, the sample must be representative of the overall population of the Cayo district to ensure statistically significant results. In order to indicate the accuracy of the sample, the sample demographics were compared to the Cayo District population in the following sectors: age, ethnicity, gender, marital status, urban/rural, and industry of occupation (*Appendix 3.3 The Sample* (n) *as a Representation of the Cayo District, Belize* (N)).

For the research the method of sampling selected was convenience sampling. Convenience sampling is a non-probability method of sampling meaning that the probability of any individual of the overall population being included in the research is unknown. Generally, convenience sampling does not result in statistical conclusions, but is used for forming hypotheses (Kolodinksy, 2008). While this method of sampling was not ideal to generate statistically significant results, it was the best option given the limitations of the research. Individuals were invited to participate in the research in public common areas during the workday (9:00 AM – 5:00 PM). The research compensated for convenience sampling by comparing the sample with the population to ensure a representative result.

Distribution of Questionnaire

I distributed the questionnaire on a voluntary, individual basis in the form of a 20-minute long structured interview. My role as a researcher was uniform for each questionnaire to provide consistent results. Each structured interview began with an introduction of the research project, its purpose, and the individual rights of the participant based on IRB protocol (*Appendix 3.4 Information Sheet & Contact Card for Voluntary Participation* (*IRB*)). Following, I recorded the demographics of the participant. I delivered the questionnaire verbally to the participant. Verbal delivery of the questionnaire ensured the questionnaire was not rushed through and that each item was correctly interpreted. To complete the questionnaire, I explained the likert response scale with a visual representation of the spectrum from *very negative* to *very positive*.

3.5 Data Entry & Analysis

Completed questionnaires were assigned an identification number and entered into an excel spreadsheet. The spreadsheet accounted for the demographics, multiple choice questions, and likert response questions (*Appendix 3.5 Excel Data Entry*). Questionnaire responses that were nominal and ordinal were assigned number values, which were outlined in an attached codebook (*Appendix 3.6 Codebook*). For example, under gender, females were assigned a value of 1 and males were assigned a value of 2. In addition, the likert response scale was consolidated from 1-7 to 1-5 to account for the relatively small sample size of n=80. The consolidated likert response scale combines 1 and 2 for *very negative*, and 6 and 7 for *very positive* (*Table 3.2 Consolidated Likert Scale* (*1-5*)).

Table 3.2 Consolidated Likert Response Scale (1-5)

Original Likert Scale (As seen in questionnaire)	Original Likert Value	Consolidated Likert Scale (Used in Analysis & Results)	Consolidated Likert Value
1	Very Negative	1	Very Negative
2	Negative		
3	Mildly Negative	2	Mildly Negative
4	No Change/Impact	3	No Change/Impact
5	Mildly Positive	4	Mildly Positive
6	Positive	5	Very Positive
7	Very Positive		

Once data was entered into the excel spreadsheet with numeric values, these data were exported to the software program *Statistical Package for the Social Sciences* (SPSS). Once imported into SPSS, these data were labeled based on numeric value. Following, the sample was statistically analyzed to compare the sample to the population and to identify sample groups. Next, the multiple-choice questions were analyzed using pie charts as visual aid for the total sample.

Finally, the likert response questions, addressing socioeconomic impact, were analyzed using frequency bar graphs. Based on the bar graph trends observed, criteria was developed to categorize level of impact into the following groups: very negative, mildly negative, no impact, mildly positive, and very positive (*Table 3.3 Categories of Socioeconomic Indicators Based on Impact Results*). Each socioeconomic indicator was categorized by the results of the overall sample and as a comparison of sample groups. By categorizing the results of these data, the overall socioeconomic impact of the Chalillo Dam will be determined based on weight of responses in the negative or positive spectrum.

Following, the sample was divided into sample groups. Socioeconomic impact was determined through analysis of cluster bar graphs (*Appendix 6.2and Appendix 6.1.C. – 6.24.C.*). Then I created a table to record impact by sample group (*Appendix 7.1*). Cells on the table were highlighted in yellow where impact was not equal between sample groups. These sample groups were then compared by level of impact to determine which sample group experienced the greatest degree of negative impact.

Table 3.3 Categories of Socioeconomic Indicators Based on Impact Results

Category	**Criteria**
Very Negative Impact	Majority of responses are very negative, ≅ 50%
Mildly Negative Impact	% of responses in negative spectrum > % of responses in the positive spectrum
No Impact	Equal distribution of responses in positive and negative spectrum, or majority of responses are no impact
Mildly Positive Impact	% of responses in the positive spectrum > % of responses in the negative spectrum
Very Positive Impact	Majority of responses are very positive, ≅ 50%

3.6 Risk Management & Ethical Issues

The research conducted was based on the socioeconomic impact of the Chalillo Dam, which is a politically controversial piece of infrastructure. That being said, the research was not exempt from IRB review. After review, IRB determined that the research could be done with verbal consent. The protocol I developed was to read aloud to the participant the *Informational*

Sheet on the research approved by the University of Vermont's IRB (*Appendix 3.4 Information Sheet & Contact Card for Voluntary Participants* (*IRB*)). The Informational Sheet explained the purpose of the research and the rights of the voluntary participants. A copy of the *Information Sheet* was available upon request and in addition a small contact card was available for each participant if they had questions in the future. I limited sampling strictly to adults ages 18 and older. In addition, questionnaire responses remained anonymous with only a numeric identification number recorded. All research was done after I was awarded IRB certification (*Appendix 3.7 IRB Certificate*).

3.7 Limitations & Biases

As an undergraduate female student from the United States conducting research abroad in Belize, Central America, I had several cultural limitations. Cultural limitations included my role as a female in a chauvinistic society, occasional language barriers, and from time to time trust as a foreign researcher. Another limitation to the research was the political controversy behind the Chalillo Dam, which added political risk to participation. On the other hand, many Belizean participants commented that this research would not work with a local researcher because participants would be reluctant to participate with a local researcher that is part of the political arena. As a result, the cultural limitation was a trade-off for political neutrality.

The method of sampling was a major limitation to the integrity of my research. I was researching alone with limited funding, a limited time frame, and with limited transportation and therefore utilized the convenience method of sampling. As a result, convenience sampling sacrificed some of the statistical dignity of the research as a trade-off for safety and efficiency.

Another limitation was that the research was retroactive with no baseline data. Typically, socioeconomic impact analysis is conducted prior to approval of a development project providing baseline data (Edwards, n.d.). In the case of this research, the Chalillo Dam was already constructed and the research had no baseline data. The baseline for socioeconomic impact was substituted with local interpretation based on observed noticeable changes since dam construction. Consequentially, the local peoples' "baseline" for impact is based on memory and can easily be influenced by the media and politics.

Finally, the most important factor considered as a bias and/or limitation was the public's bias against the Chalillo Dam. The Chalillo Dam received a lot of negative publicity during the construction and is often blamed for the majority of water quality issues and biodiversity degradation downstream and surrounding the reservoir. This is demonstrated by the questionnaire in Q2 "Is your overall view of the dam positive or negative?" where 76 percent of the sample answered negative. In this case it is almost impossible for the results of the research to be considered free of bias.

4-7. <u>Results</u>

4. Sample Results: The Sample as a Representation of the Cayo District

The resulting sample from the questionnaire included 80 participants (n=80). This is not a statistically significant sample size compared to the overall population of the Cayo District being 72,899 individuals (N=72,899) (Statistical Institute of Belize, 2011). To determine how accurately the sample matches the population, the sample demographic is compared to the population of the Cayo District by ethnicity, gender, urban/rural location, marital status, and occupation by industry sector (*Table 4.1 The Sample* (n) *as a Representation of the Cayo District, Belize* (N)).

4.1. Sample Discussion

Based on the comparison between the sample demographics and the demographics of the Cayo District depicted in *Table 4.1*, the sample is representative of the population despite the small sample size of n = 80. The distribution of gender within the labor force is accurately represented in the sample having slightly more men than women. The sample representation of urban and rural residents is not closely accurate to the population. This is a result of sampling primarily in urban centers as a convenience measure, while sampling in primarily rural villages would be an issue of access (*Map 4.1 Distribution of Sample Towns/Villages*). Also, within the urban sample group, Belmopan was not included in sampling, being located further down the Belize River. Finally, employment of the sample by industry sector is extremely accurate with the two majority industries being tourism and agriculture. Overall, the sample is comparable to the population and as a researcher I feel confident drawing conclusions from the questionnaire results.

Table 4.1 The Sample Demographic as a Representation of the Cayo District, Belize
Source: 2010 Housing & Population Census, The Statistical Institute of Belize

Ethnicity	**Cayo Total Population = N**	**70,157**	**% of N**	**% of n**
	Mestizo	44,445	63%	60%
	Kriol	10,247	15%	8%
	Maya	4,813	7%	18%
	Garifuna	975	1%	3%
	Other	9,647	14%	13%
Gender	**Cayo Total Labor Force = N**	**29,470**	**% of N**	**% of n**
	Male	18,056	61%	57.5%
	Female	11,414	39%	42.5%
Urban/Rural	**Cayo Total Population = N**	**72,899**	**% of N**	**% of n**
	Cayo Urban	**36,152**	**50%**	**62%**
	San Ignacio/Santa Elena	16,977	23%	54%
	Benque Viejo	5,824	8%	8%
	Belmopan (not sampled)	13,351	18%	0%
	Cayo Rural	**36,747**	**50%**	**38%**
Marital Status	**Belize Total Population = N**		**% of N**	**% of n**
	Never Married		58%	49%
	Married/Once Married		42%	51%
Industry Sector	**Belize Total Population = N**		**% of N**	**% of n**
	Tourism		25%	21%
	Agriculture		19%	22%
	Other		56%	57%

Map 4.1 Distribution of Sample Towns/Villages not available in digital version; available in hard copy at Environmental Program office

4.2 Sample Groups

The sample (n) is divided into sample groups: Urban Residents = n_1, Rural Residents = n_2, Employees in Tourism = n_3, and Employees in Agriculture = n_4 to test impact variables (*Table 4.2 Sample Groups*). The goal was for each sample group, n_x to be greater than or equal to 30 making each comparison statistically viable. The urban and rural sample groups are statistically viable. The exceptions are the agricultural industry and tourism industry sample groups which are less than 30 each, making the comparison of the two groups technically statistically unviable, which must be considered in evaluating the results for these groups.

Table 4.2 Sample Groups

Sample Groups		Frequency
Urban Residents	n_1	50
Rural Residents	n_2	30
Employment in Tourism Sector	n_3	21
Employment in Agricultural Sector	n_4	22

5. Multiple Choice Question Results

Question 1

Have you heard of the Challillo Dam?
Yes or no.

Results (*Chart 5.1*)

97.5% of the sample has heard of the Chalillo Dam.

Discussion

Nearly the entire sample was aware of the Chalillo Dam. This indicates that the Dam is well known in the Cayo District. I speculate that awareness of the Chalillo Dam is high due to its controversial status in the media during construction. It also indicates that the majority of the results are viable having a sample largely aware of the dam.

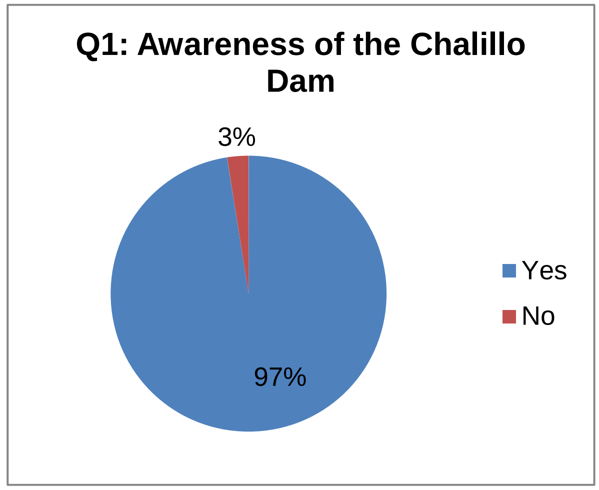


Chart 5.1 Response to Multiple Choice Question 1

Question 2

Is your attitude toward the Chalillo Dam positive or negative?

Results (*Chart 5.2*)

94% of the total sample responded to this question.
6% of the total sample preferred not to answer this question.
Of the 94% who responded to the question, 24% answered positive and 76% answered negative.

Discussion

An overwhelming majority of the sample has a negative attitude toward the dam. Still, a fourth of the sample found the dam to be positive. The fact that 6% preferred not to answer the question demonstrates the controversial nature of the dam and the hesitant nature of the local people to speak out about it.

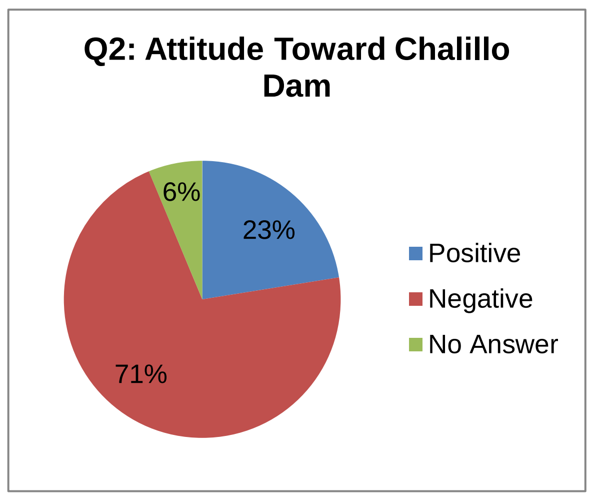


Chart 5.2 Response to Multiple Choice Question 2

Question 3 (*Chart 5.3*)
What is the purpose of the Chalillo Dam?
Answers: Electricity Generation, Flood Control, Water Supply, or Not Sure

Results
70% responded Electric Generation
8% responded Flood Control
19% were not sure of the purpose

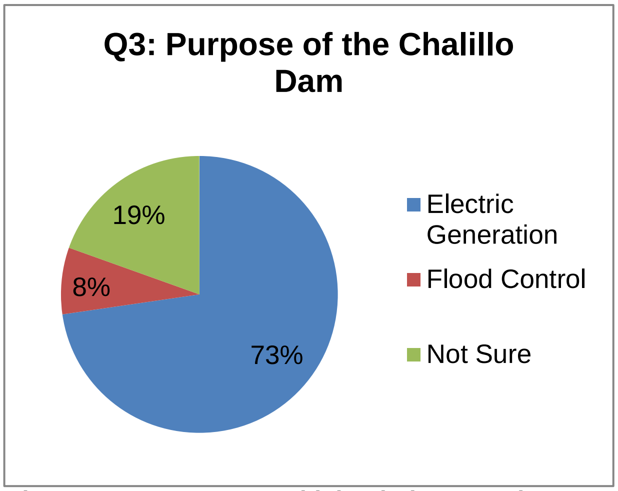


Chart 5.3 Response to Multiple Choice Question 3

Discussion

The majority of the sample knew that the Chalillo Dam was intended to contribute to hydroelectric generation. However, electric generation was not the primary purpose of the Chalillo Dam on its own, but was intended to work in conjunction with the Mollejon Dam. This could explain why the majority of the population has a negative attitude toward the dam post-construction: they expected cheaper electricity rates despite the fact that the dam does not have a significant contribution to the grid.

Also, the 8% that responded with flood control most likely did so because there has not been significant flooding since the dam was constructed. The Macal River has a natural flood cycle and floods nearly every rainy season. Based on the responses of the surveys, flooding has not been a major issue since 1999. Although the dam was not designed to mitigate flooding, the reservoir consequently holds back a great deal of runoff from the upper Macal River Valley.

20% of the sample was unsure of the purpose of the dam. This is likely due to the confusing media surrounding the dam during construction and an overall lack of transparency for the project. Also, since there is no real correlation with cheaper electricity rates, some of the population may assume that electric generation is not the purpose.

Question 4 (*Chart 5.4*)
Do you feel threatened by the Chalillo Dam's location upstream from your community or workplace? Yes or no.

Results
61% of the sample responded "Yes"
39% of the sample responded "No"

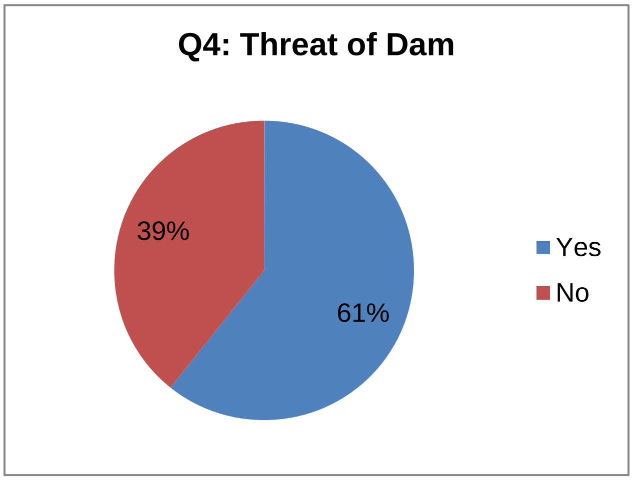


Chart 5.4 Response to Multiple Choice Question 4

Discussion

A majority of the population of Cayo has a concern that the Chalillo Dam could malfunction. A number of influences including flood evacuation signage, media, word of mouth, and political debate could attribute to this result. Whatever the reason for such a high level of concern, it is obvious that communities at close proximity to the Macal River would be concerned if a dam were built upstream associated with controversial politics.

On the other hand, 39% of the sample responded no. This is most likely based on the fact that the dam has been operating for 6 years now without malfunction, breakage, or any major floods.

Conclusions of Multiple-Choice Questions for Total Sample

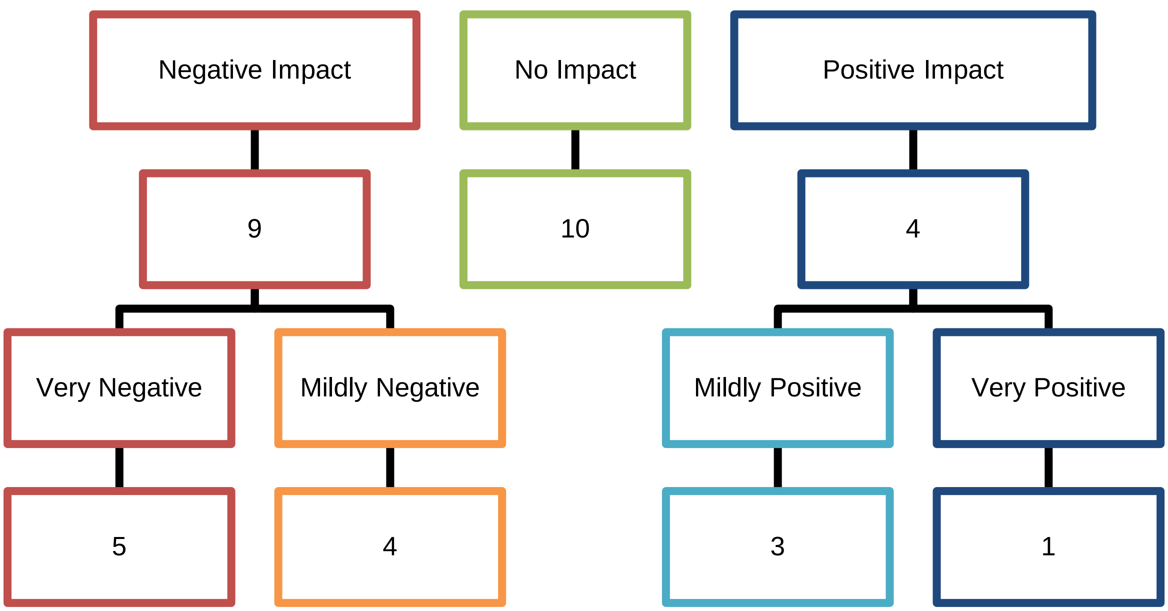
Based on the responses of the total sample to the multiple-choice questions I can conclude that the population of the Cayo district is well aware of the Chalillo Dam with the knowledge that it is related to hydroelectric generation. However, it seems that there is concern surrounding the politics behind the dam and for the reliability of the dam, giving it a mildly negative reputation.

6. Overall Socioeconomic Impact Analysis Results

The questionnaire was used to conduct socioeconomic impact analysis based on 24 indicators. After analyzing the bar charts for the total sample each indicator was placed in a category based on the results of the questionnaire (*Appendix 6.1 Bar Charts for Total Sample of Socioeconomic Indicators*). Indicators were categorized by level of impact including: Very Negative, Mildly Negative, No Impact, Mildly Positive, and Very Positive.

As seen in *Figure 6.1*, 9 indicators fell into the negative spectrum. Of the 9 indicators in the negative spectrum, 5 were considered very negative and 4 were considered mildly negative. Ten indicators demonstrated no significant impact. Finally, 5 indicators fell into the positive spectrum. Of the 5, 4 were considered mildly negative and only 1 was considered very positive.

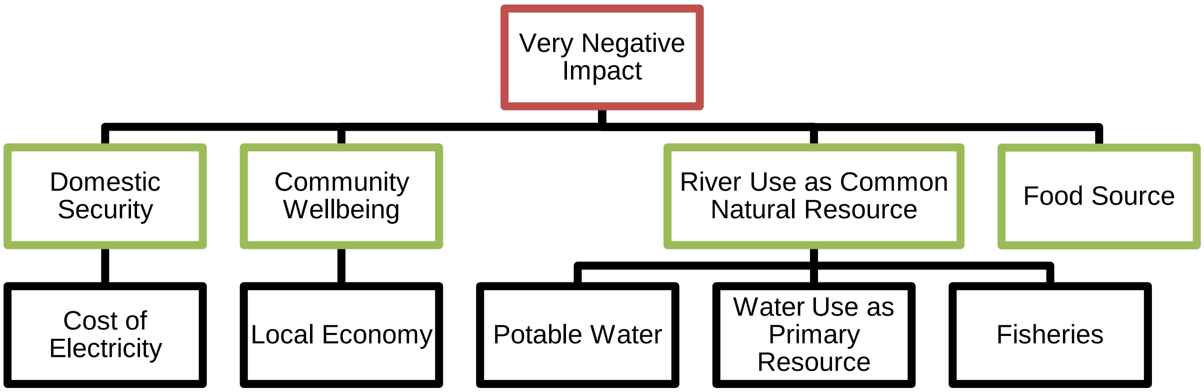
Figure 6.1 Socioeconomic Impact Analysis categorized by Questionnaire Results



6.1.A. Results: Indicators Showing Very Negative Impact

Five socioeconomic indicators resulted in very negative impact (*Figure 6.2 Indicators Showing Very Negative Impact*). Socioeconomic indicators that demonstrated a very negative impact caused by the Chalillo Dam include cost of electricity, the wellbeing of the local economy, access and quality of potable water, river use as a primary water source, and fisheries as a food source. Cost of electricity is an indicator of domestic security. Wellbeing of the local economy is an indicator of community wellbeing. Potable water and river use as a primary water source are indicators of river use as a common natural resource. Finally, fisheries as a food source are an indicator of food security, as well as river use as a common natural resource.

Figure 6.2 *Very Negative Impact* Indicators Categorized by Socioeconomic Output
(Domestic security, community wellbeing, river use as a common natural resource, and food source)



6.1.B. Discussion: Indicators Showing Very Negative Impact

Based on the results of the questionnaire, the Chalillo Dam had the most negative impact on communities downstream through energy prices, damage to the local economy, access and quality of potable water, river use as a primary resource, and fisheries.

Cost of Electricity

The Chalillo Dam was built primarily to increase the efficiency of hydroelectric generation at the Mollejon Dam. The driver for domestic electricity production is to increase Belize's energy independence and therefore, reduce the cost of electricity. Since the dam has been built, the local people have not observed any decrease in electricity rates. While this could be attributed to a variety of issues, it appears that the presence of the Chalillo Dam is correlated with increased electricity rates.

Local Economy

Based on the results of the questionnaire, the local economy has been very negatively impacted by the Chalillo Dam. For businesses that use the Macal River directly, changes in hydrology and water quality since the dam was constructed could be to blame. A tour company conducting canoe tours is a good example of a business that directly utilizes the river. Additionally, businesses that are highly reliant on electricity may blame the dam for their loss of revenue. Several participants in the food service industry complained that regular power outages led to spoiled food and therefore lack of revenue. Based on these factors, the Chalillo Dam has had a very negative impact on the local economy.

Potable Water

Most of the communities sampled from have access to pipe water. Many participants complained that since the dam was built, water from their pipes occasionally runs brown, especially after a large storm event. As a result, the local people do not trust what should be considered potable pipe water. Many participants expressed that over the past 5 years (correlated with the construction of the dam) they need to increasingly purchase purified drinking water due to changes in pipe water.

River Use as a Primary Water Source

The results show a very negative impact since the Chalillo Dam was built on the river as a resource for water. Rivers in Cayo are often used as a resource for water if pipe water is not accessible or if purified water is too expensive. A majority of the participants stated that the Macal River is no longer a safe resource for direct water use. This is largely attributed to the construction of the Chalillo Dam.

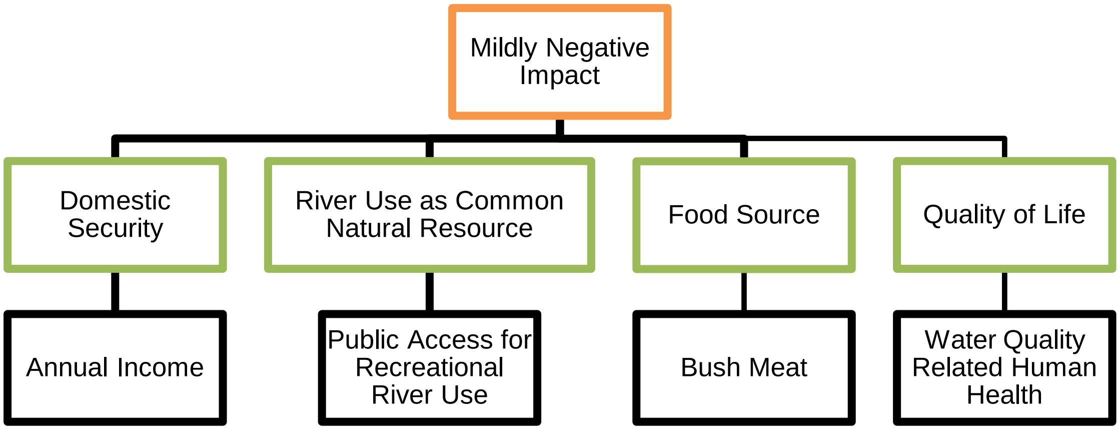
Fisheries as a Food Source

Since the construction of the dam, public notices have been instated forbidding patrons from eating fish found in the Macal River. Since the dam was built, there has been a jump in mercury levels in the Macal River. Using fish from the river as a food source would be dangerous for human health. Additionally, those who are recreational fishers expressed that the diversity of fish found in the Macal River has dropped. Primarily tilapia and bottom dwellers such as catfish are found, both of which can survive in poor water quality.

6.2.A. Results: Indicators Showing Mildly Negative Impact

Four socioeconomic indicators resulted in mildly negative impact (*Figure 6.3 Indicators Showing Mildly Negative Impact*). Socioeconomic indicators that show mildly negative impact from the Chalillo Dam include annual income, public access to the river for recreational use, availability of bush meat as a food source, and water quality related human health. Annual income is an indicator of domestic security. Public access to the river for recreational use is an indicator of river use as a common natural resource. Availability of bush meat as a food source is an indicator of food security. Finally, water quality related human health is an indicator of water quality and quality of life.

Figure 6.3 *Mildly Negative Impact* Indicators Categorized by Socioeconomic Output
(Domestic security, river use as a common natural resource, food source, and quality of life)



6.2.B. Discussion: Indicators Showing Mildly Negative Impact

Annual Income

The results of the questionnaire show a mildly negative impact on annual income from the Chalillo Dam. Based on my background knowledge, this is likely not a direct impact, but a ripple effect from the dam's impact on the local economy and higher electricity prices. As discussed under "wellbeing of the local economy" changes in the Macal River may have impacted individuals who make a living off of tourism related to the river. Also, unreliable electricity in conjunction with increased electricity rates may decrease household revenue and indirectly impact an individual's annual income.

Public Access for Recreational River Use

Recreational use of the Macal River experienced a mildly negative impact from the construction of the Chalillo Dam. This is attributed to changes in water quality. Participants embellished their response to this stating that people often got swimmers rash after recreating in the river. Others complained that the river developed an offensive odor that comes and goes, but historically was never an issue. Recreational fishing has been impacted with a drop in biodiversity of fish found in the Macal River. Finally, canoers and kayakers along the river stated that the dams have lowered the depth of the river in many areas making portions of the river impassable. The fact that this impact is expressed as *mildly* negative and not *very* negative is attributed to the fact that recreation is not a livelihood *necessity* for most participants.

Bush Meat

The questionnaire resulted with a mildly negative impact of the dam on the availability of bush meat as a food source. Bush meat is how the local people refer to wild game. Due to the nature of the Macal River Valley, most of the forestland is riparian tropical rainforest. Since the Chalillo Dam was built, the natural flood cycle of the river has stopped and this has impacted the surrounding forests that would otherwise be replenished by regular flooding. In addition, the forestland upstream from the dam has drastically changed with the presence of the reservoir. This presents potential impacts on the biodiversity of flora and fauna along the Macal River and consequentially, the availability of wild game. Other factors may influence this including unregulated/over-hunting of wild game and deforestation caused by development not related to the dam. It is likely that this impact is *mildly* negative and not *very* negative because less people turn to bush meat as a food resource than in the past due to development and a shift from hunting/gathering and subsistence agriculture to purchasing food.

Water Quality Related Human Health

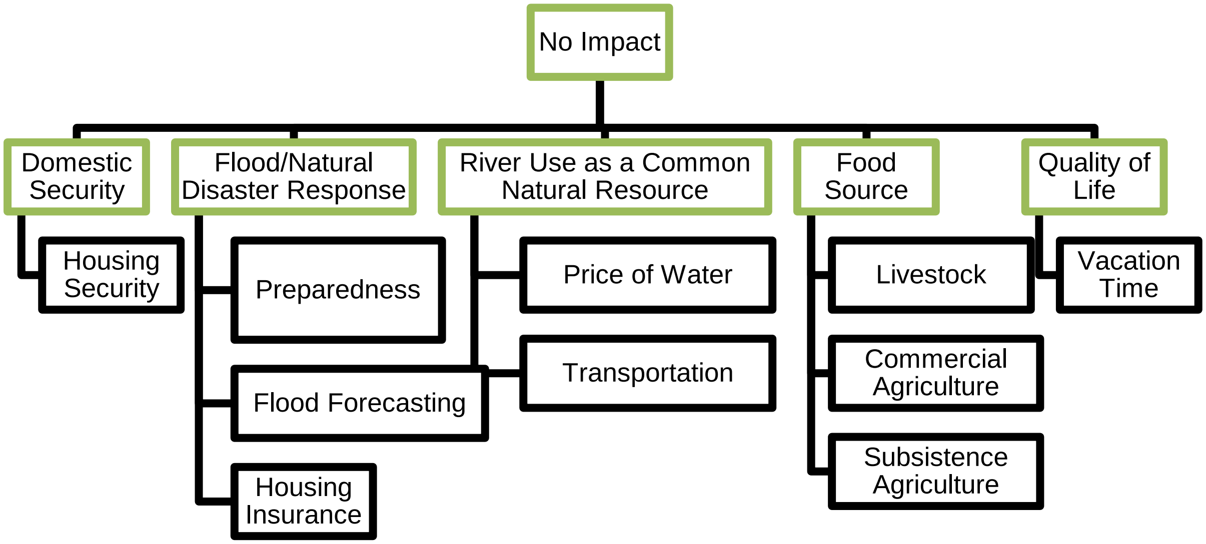
The questionnaire determined a mildly negative impact on water quality related human health by the Chalillo Dam. With poorer water quality in the Macal River, and imperfect access to potable water, the presence of some water quality related human health issues is not surprising. However, it would be wrong to say that all water quality issues are attributed to the dam, because storm drains, sewage, and riparian deforestation also contributes to these issues.

Participants commented on skin rashes when in contact with the river water. Also, high levels of mercury in the water could have potential impacts on human health especially if fish were consumed from the river despite public health notice. Also, participants recall that when the reservoir was flooded, there was an increase in breeding grounds for vector insects and a brief spike in dengue fever.

6.3.A. Results: Indicators Showing No Impact

Ten socioeconomic indicators showed no significant impact from the construction of the Chalillo Dam (*Figure 6.4 No Impact Indicators Categorized by Socioeconomic Output*). No impact indicators resulting from the questionnaire fall under the categories of domestic security, flood/natural disaster response, river use as a common natural resource, food source, and quality of life.

Figure 6.4 *No Impact* Indicators Categorized by Socioeconomic Output
(Domestic security, flood/natural disaster response, river use as a common natural resource, food source, and quality of life)



6.3.B. Discussion: Indicators Showing No Impact

The indicators shown in *figure 6.4* demonstrated no impact from the Chalillo Dam based on the results of the questionnaire. The majority of the indicators that experienced no impact fall under the categories of flood/natural disaster response and food source.

Flood/Natural Disaster Response

Based on the results flood/natural disaster response has not changed since the dam was built. However, I would expect a great improvement to flood preparedness due to the measures of Belize Electric Company Limited (BECOL) to create

Figure 6.5 Flood Evacuation Efforts of BECOL for the Chalillo Dam

a flood evacuation plan in case the dam were to break as seen in *figure 6.5.* This shows that the efforts to improve flood preparedness were not effective and the public would be at risk if the dam were to break.

Food Source: Livestock, Commercial Agriculture, and Subsistence Agriculture

Indicators of livestock, commercial agriculture, and subsistence agriculture categorized as food sources show no significant impact because the Chalillo Dam has not had an outstanding impact on where patrons source their food. As mentioned before, the Cayo district has largely shifted food supply from hunting/gathering and subsistence agriculture to purchasing food. Therefore, the food security of participants in the research reflected no impact.

The farmer's market is a main source of food for the Cayo District

Commercial Agriculture in Cayo

Housing Security

Housing security, falling under domestic security has not been directly impacted by the dam because the dam has not changed the materials used or the cost of housing.

River Use as a Common Natural Resource: Price of Water & Transportation

River uses including transportation and the price of water have not been significantly impacted. Transportation, aside from recreational boating, is not common in modern Cayo. Also, the price of pipe water is set a fixed rate and therefore the cost of water has not been impacted. The only impacts in price of water are for bottled water, which many participants are increasingly turning to as the quality of pipe water decreases.

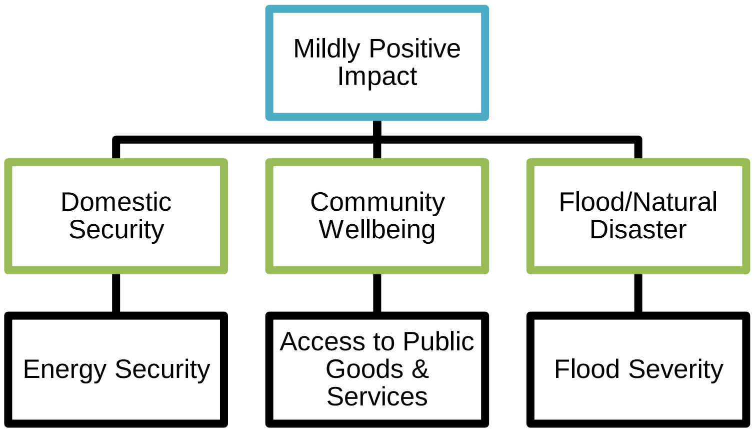
Vacation Time

Vacation time is an indicator of job security and quality of life not impacted by the Chalillo Dam. In general, Belizeans that are employed do not want vacation, because they want to work as much as possible. This indicator proved to be moderately irrelevant in the research.

6.4.A. Results: Indicators Showing Mildly Positive Impact

Based on the questionnaire, 3 indicators resulted in a mildly positive impact. These indicators include energy security, severity of flooding, and access to public goods and services (*Figure 6.6 Mildly Positive Impact Indicators Categorized by Socioeconomic Output*). Energy security is an indicator of domestic security showing reliable energy supply. Severity of flooding is an indicator of flood/natural disaster preparedness showing proper flood zone development. Finally, access to public goods and services such as healthcare, education, and emergency response is an indicator of community wellbeing.

Figure 6.6 *Mildly Positive Impact* Indicators Categorized by Socioeconomic Output
(Domestic Security, Community Wellbeing, and Flood/Natural Disaster Preparedness)



6.4.B. Discussion: Indicators Showing Mildly Positive Impact

Energy Security

Energy security shows a mildly positive impact from the Chalillo Dam. This is most likely due to the increase in supply of electricity on the grid. Many Belizeans still complain about the number of power outages that occur regularly, but the questionnaire actually shows a slight improvement. Regardless of how much hydroelectric production results from the Mollejon, Chalillo and Vaca Dam, it is still contributing additional energy to the grid.

Access to Public Goods & Services

Access to public goods and services showed a mildly positive impact from the Chalillo Dam. However, based on the dialogue with the participants this was not directly related to the Chalillo Dam. Rather, this is most likely attributed to the rural participants who have observed increase in access to services since the dam was built which, were commonplace in urban centers prior to dam construction.

Flood Severity

The severity of flooding showed a mildly positive impact from the Chalillo Dam. While the Chalillo Dam was not designed to control flooding, it does hold back runoff from the Upper Macal River Valley. Participants commented that no major floods have happened since 1999. While floods are necessary to replenish a river's water quality, developing communities with limited flood insurance and financial safety nets perceive less severe flooding as a positive impact.

6.5.A. Results: Indicators Showing Very Positive Impact

The only indicator that resulted in a very positive impact from the questionnaire is Flood Zoning in Waterfront Development. Flood zoning is the consideration for the natural flood cycle of a river in development to reduce costs associated with flooding. This indicator falls under the category of flood/natural disaster response.

6.5.B. Discussion: Indicators Showing Very Positive Impact

I am not sure how closely related flood zoning is to the Chalillo Dam, but with increased awareness of flood zones post dam construction the public seems to believe flood zones are increasingly considered in developmental decision-making.

7. Socioeconomic Impact Analysis Results: Comparing Sample Groups

7.1. Results of Urban & Rural Sample Group Comparison

Downstream from the Chalillo Dam exists several communities both urban and rural. To detect inequity in the socioeconomic impact of the Chalillo Dam on communities downstream, the urban sample group is compared to the rural sample group. When comparing the 2 sample groups any indicators showing inequity of negative impact are noted (*Table 7.1*). The urban sample group showed inequitable negative impact with a score of -12. The rural sample group showed inequitable negative impact with a score of -1.

Table 7.1 Inequities in Impact Between the Rural and Urban Sample Groups
(Very Negative -2, Mildly Negative -1, No Impact 0, Mildly Positive +1, Very Positive +2)

Indicators With Unequal Impact	**Rural Score**	**Urban Score**	**Inequitable Negative Impact**	
Housing Security	+1	0		
Energy Security	0	+1		
Flood/Natural Disaster Preparedness	+1	0		
Wellbeing of Local Economy	-1	-2		Urban -1
Flood Zoning in Waterfront Development	+1	+2		
Access to Public Goods and Services	+1	0		
Potable Water Access & Quality	0	-2		Urban -2
River Use as a Primary Water Source	0	-2		Urban -2
Public Access to River for Recreational Use	-1	-2		Urban -1
Aesthetic Value of the River	0	-2		Urban -2
Fisheries as a Food Source	-1	-2		Urban -1
Bush Meat as a Food Source	-1	0	Rural -1	
Subsistence Agriculture as a Food Source	+1	0		
Water Quality Impact on Human Health	0	-2		Urban -2
Vacation Time	0	-1		Urban -1
Total Impact Comparison			**-1**	**-12**

7.2 Results of Agriculture & Tourism Sample Group Comparison

Within the target population for the research, the two major industries of employment are the tourism and agricultural industries. To detect inequity in the socioeconomic impact of the Chalillo Dam based on occupation, the tourism employment sample group is compared to the agricultural employment sample group. When comparing the 2 sample groups any indicators showing inequity of negative impact are noted (*Table 7.2*). The tourism employment sample group showed inequitable negative impact with a score of -13. The rural sample group showed inequitable negative impact with a score of -1.

Table 7.2 Inequities in Impact Between the Agriculture & Tourism Sample Groups
(Very Negative -2, Mildly Negative -1, No Impact 0, Mildly Positive +1, Very Positive +2)

Indicators With Unequal Impact	Agriculture Score	Tourism Score	Inequitable Negative Impact	
Housing Security	+1	0		
Energy Security	+1	0		
Flood/Natural Disaster Preparedness	+2	0		
Flood Forecasting	+1	0		
Flood Zoning in Waterfront Development	+2	0		
Potable Water Access & Quality	0	-1		Tourism -1
River Use as a Primary Water Source	0	-2		Tourism -2
Price of Water	0	-1		Tourism -1
Public Access for Recreational Use	0	-2		Tourism -2
Aesthetic Value of River	0	-2		Tourism -2
Transportation by River	-1	-2		Tourism -1
Commercial Agriculture as Food Source	-1	0	Agriculture -1	
Water Quality Impact on Human Health	0	-2		Tourism -2
Vacation Time	0	-2		Tourism -2
Total Impact Comparison			**-1**	**-13**

8. Conclusions:

8.1 Conclusion: Overall Socioeconomic Impact of the Chalillo Dam

Assuming that all socioeconomic impact analyzed by the research is directly related to the Chalillo Dam, **the overall socioeconomic impact of the Chalillo Dam on communities downstream is negative**. There are 9 indicators that reflect a negative impact, while only 5 indicators reflect a positive impact. The greatest negative impact is reflected by socioeconomic indicators related to river use as a common natural resource, cost of electricity, and wellbeing of the local economy.

This research shows that a large infrastructure project, being the Chalillo Dam, placed externalized social, environmental, and economic costs on the communities downstream. Unfortunately, the socioeconomic impact analysis was not completed before the construction of the dam. However, by accounting for the negative socioeconomic impact of the Chalillo Dam, this research has the potential to mobilize developing communities as stakeholders for future infrastructure development projects.

8.2 Conclusion: Comparison of Urban & Rural Sample Groups

Assuming that the socioeconomic impacts determined by the research are directly reflected from the Chalillo Dam, the following assumptions can be made:

- The rural communities experience a negative impact on **bush meat as a food source** more so than the urban communities downstream from the Chalillo Dam.
- The urban communities experience a negative impact on **access and quality of potable water** more so than the rural communities downstream from the Chalillo Dam

- The urban communities experience a negative impact on the **use of the river as a primary water source** more so than the rural communities downstream from the Chalillo Dam.
- The urban communities experience a negative impact on **public access to the river for recreational uses** more so than the rural communities downstream from the Chalillo Dam
- The urban communities experience a negative impact on **aesthetic value of the river** more so than the rural communities downstream from the Chalillo Dam
- The urban communities experience a negative impact on **fisheries as a food source** more so than the rural communities downstream from the Chalillo Dam
- The urban communities experience a negative impact on **water quality related human health** more so than the rural communities downstream from the Chalillo Dam
- The urban communities experience a negative impact on **vacation time** more so than the rural communities downstream from the Chalillo Dam

Based on these assumptions, the Chalillo Dam has a greater degree of negative socioeconomic impact downstream on urban communities than on rural communities.

8.3 Conclusion: Comparison of Tourism & Agriculture Sample Groups

Assuming that the socioeconomic impacts determined by the research are directly reflected from the Chalillo Dam, the following assumptions can be made:

- Those working in the agricultural industry experience a negative impact on **commercial agriculture as a food source** more so than those working in the tourism industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on **access and quality of potable water** more so than those working in the agricultural industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on **river use as a primary water source** more so than those working in the agricultural industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on **the price of water** more so than those working in the agricultural industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on **recreational uses of the river** more so than those working in the agricultural industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on the **aesthetic value of the river** more so than those working in the agricultural industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on **river use for transportation** more so than those working in the agricultural industry from the Chalillo Dam.

- Those working in the tourism industry experience a negative impact on **water quality related human health issues** more so than those working in the agricultural industry from the Chalillo Dam.
- Those working in the tourism industry experience a negative impact on **vacation time** more so than those working in the agricultural industry from the Chalillo Dam.

Based on these assumptions, the socioeconomic impact of the Chalillo Dam is negatively dispersed among employees of the tourism industry more so than employees of the agricultural industry.

9.1 Recommendations for Further Research

In comparing the socioeconomic impact of the Chalillo Dam within the target population, it is obvious that within the population of the Cayo District there is disparity in negative impact. The research determines that urban communities experience negative socioeconomic impact more so than rural communities. The research also determines that those employed within the tourism industry experience negative socioeconomic impact more so than those employed within the agricultural industry.

Having an understanding for development in the context of Belize, I, as the researcher, can make several assumptions explaining the disparity of negative impact within the target population. However, there are countless external factors beyond the Chalillo Dam that potentially influence socioeconomic impact disparity and any assumption I make at this point is a mere hypothesis.

I recommend, for future research, to further examine the factors that contribute to the unequal distribution of negative socioeconomic impact within the population. This would further determine the demographic of a population that is put at greatest socioeconomic risk for future developmental projects.

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APPENDIX 3.1 Questionnaire: Participant Demographics

Challillo Dam Social Impact Questionnaire

Participant Demographics			
Gender	Female		
	Male		
Ethnicity	Kriol		
	Mestizo		
	Garifuna		
	Maya		
	Menonite		
	Caucasian		
	Other:		
Work Place	Occupation		
	Industry		
	Distance to River		
Home	Marital Status		
	# of Children		
	Distance to River		
Village			Rural
			Urban

#	
Date	
Age	

APPENDIX 3.2 Questionnaire: Socioeconomic Impact Analysis

Chalillo Dam Socioeconomic Impact Questionnaire (Also known as the Macal River Upstream Storage Facility)

Q1. Have you heard of the Chalillo Dam? (If yes, answer Q2-Q4)

- Yes
- No

Q2. Is your overall view of the dam positive or negative?

- Positive
- Negative

Q3. What is the purpose of the Chalillo Dam? (Check all that apply)

- Water Supply
- Flood Control
- Irrigation
- Electric Generation
- Recreation
- Not Sure

Q4. Do you feel threatened by the presense of the Chalillo Dam upstream?

- Yes
- No

Rate the following indicators (1-7) based on observed impact since the construction of the Chalillo Dam in 2005:		Very Negative	Negative	Mildly Negative	None	Mildly Postive	Positive	Very Positive
Q5. Domestic Security								
a.	Income/year	1	2	3	4	5	6	7
b.	Housing Security	1	2	3	4	5	6	7
c.	Energy Security	1	2	3	4	5	6	7
d.	Cost of Electricity	1	2	3	4	5	6	7
Q6. Flood and Natural Disaster								
a.	Severity of Flooding	1	2	3	4	5	6	7
b.	Flood / Natural Disaster Preparedness	1	2	3	4	5	6	7
c.	Flood Forecasting	1	2	3	4	5	6	7
d.	Insurance (Residential/Life)	1	2	3	4	5	6	7
Q7. Community								
a.	Local businesses (goods and services)	1	2	3	4	5	6	7
b.	Flood Zoning / Waterfront Development	1	2	3	4	5	6	7
c.	Access to public goods and services	1	2	3	4	5	6	7
Q8. River Use								
a.	Drinking water	1	2	3	4	5	6	7
b.	Water supply: Irrigation, Laundry, Other	1	2	3	4	5	6	7
c.	Price of water	1	2	3	4	5	6	7
d.	Public Access for Recreational Use	1	2	3	4	5	6	7
e.	Aesthetics	1	2	3	4	5	6	7
f.	Transportation by river	1	2	3	4	5	6	7
Q9. Food Source								
a.	Livestock	1	2	3	4	5	6	7
b.	Fisheries	1	2	3	4	5	6	7
c.	Bush meat	1	2	3	4	5	6	7
d.	Commercial agriculture	1	2	3	4	5	6	7
e.	Subsistence agriculture	1	2	3	4	5	6	7
Q10. Quality of Life								
a.	Health	1	2	3	4	5	6	7
b.	Vacation time	1	2	3	4	5	6	7

APPENDIX 3.3

The Sample (n) as a Representation of the Cayo District, Belize (N)
Source: 2010 Housing & Population Census, The Statistical Institute of Belize

Ethnicity	**Cayo Total Population = N**	**70,157**	**% of N**	**% of n**
	Mestizo	44,445	63%	60%
	Kriol	10,247	15%	8%
	Maya	4,813	7%	18%
	Garifuna	975	1%	3%
	Other	9,647	14%	13%
Gender	**Cayo Total Labor Force = N**	**29,470**	**% of N**	**% of n**
	Male	18,056	61%	57.5%
	Female	11,414	39%	42.5%
Urban/Rural	**Cayo Total Population = N**	**72,899**	**% of N**	**% of n**
	Cayo Urban	**36,152**	**50%**	**62%**
	San Ignacio/Santa Elena	16,977	23%	54%
	Benque Viejo	5,824	8%	8%
	Belmopan (not sampled)	13,351	18%	0%
	Cayo Rural	**36,747**	**50%**	**38%**
Marital Status	**Belize Total Population = N**		**% of N**	**% of n**
	Never Married		58%	49%
	Married/Once Married		42%	51%
Industry Sector	**Belize Total Population = N**		**% of N**	**% of n**
	Tourism		25%	21%
	Agriculture		19%	22%
	Other		56%	57%

APPENDIX 3.4 Information Sheet & Contact Card for Voluntary Participation (IRB)

INFORMATION SHEET

Title: **The Socioeconomic Impact of Dams on Developing Communities: A Case Study of the Macal River Watershed**

Principal Investigator: **Emily Bird**

Faculty Sponsor: **Saleem H. Ali**

Sponsor: Department of Environmental Studies, University of Vermont

You are being invited to take part in a research study because of your social and economic experiences along the waterways downstream of the Chalillo Dam.

This study is being conducted by an *Undergraduate Degree* student in the Department of Environmental Studies at the University.

The purpose of the research is to quantify the socioeconomic impact of the Chalillo Dam on communities downstream based on the interpretation of the local population within the work force (ages 18+).

You will be asked to take part in a questionnaire, which should take about 10 minutes to complete. **(Questions of discussion: flood security, energy security, community impact, river use, and food source)**

There may be no direct benefit to you for participating in this study; however, others may benefit by the results of the study for future developments such as dam construction.

The only potential risk to participation in this interview is the possibility for an accidental breach of confidentiality.

In order to protect your confidentiality data collected will be numbered and entered into a password-protected database. The audio recordings (if applicable) will be used to accurately collect data and destroyed once the information has been transcribed.

Your participation in the interview is fully voluntary and you may choose not to participate or discontinue at any time.

Your name will not be used in any publications. The information obtained during this study is confidential**.**

Questions concerning your rights as a participant in this research can be directed to Nancy Stalnaker, Director of the Research Protections Office at the University of Vermont, 230 Waterman Building, UVM, Country Code 001 + (802) 656-5040.

If you have any questions concerning your participation please contact Emily Bird, Emily.bird@uvm.edu

If you wish to have this contact information I can provide you with a contact card.

Contact Card:

Title: The Socioeconomic Impact of Dams on Developing Communities: A Case Study of the Macal River
Principal Investigator: Emily Bird
Faculty Sponsor: Saleem H. Ali

Questions concerning your rights as a participant in this research can be directed to Nancy Stalnaker, Director of the Research Protections Office at the University of Vermont, 230 Waterman Building, UVM, Country Code 001 + (802) 656-5040.

If you have any questions concerning your participation please contact Emily Bird at Emily.bird@uvm.edu

APPENDIX 3.5 Excel Data Entry

#	Age	Gender	Ethnicity	Occupation	Industry	Dist River Wrk	Marital Status	# Children	Dist River Home	Urban/ Rural	Village	Q1	Q2	Q3	Q4	Q5A	Q5B
1	23	1	2	VENDOR	1	1	3	0	1	1	CRISTO REY	1	2	2	1	3	3
2	50	2	3	FARMER	1	2	2	2	6	1	SAN ANTONIO	1	2	1	2	3	3
3	47	1	2	HOUSE WIFE	7	4	2	7	4	2	BENQUE	1	2	1	1	3	2
4	40	1	2	VENDOR	1	1	2	3	4	2	SANTA ELENA	1	2	1	1	1	5
5	27	2	3	ENGINEER	6	2	2	3	4	2	SAN IGNACIO	1	2	1	2	1	3
6	35	2	5	MARKETING	2	1	1	0	1	1	BARTON CREEK	1	2	1	1	1	3
7	26	1	1	WAIT STAFF	2	4	1	0	5	2	SAN IGNACIO	1	2	1	1	2	2
8	18	2	2	WAIT STAFF	2	4	1	0	2	1	BULLET TREE	1	2	1	1	2	2
9	26	2	2	HOTEL MANAGER	2	4	3	1	3	2	SANTA ELENA	1	2	1	1	3	5
10	24	1	2	ADMIN	4	2	2	0	3	2	SAN IGNACIO	1	2	1	1	4	5
11	49	1	2	FARMER	1	2	2	6	2	1	BULLET TREE	1	2	1	1	1	2
12	44	2	2	VENDOR	1	1	2	3	3	2	SANTA ELENA	1	2	4	1	1	2
13	55	2	2	BUTCHER	2	1	2	4	3	2	SANTA ELENA	1	1	2	2	1	4
14	24	2	3	FARMER	1	6	1	0	4	1	SEVEN MILES	1	1	4	2	5	1
15	40	1	2	VENDOR	1	1	2	5	2	1	SUCCOTZ	2			2	1	1
16	54	2	3	VENDOR	1	1	2	6	3	2	SAN IGNACIO	1		1	2	1	2
17	35	1	5	HUMANITARIAN	6	4	2	4	4	2	SAN IGNACIO	1	2	1	1	3	4
18	24	2	2	ADMIN	2	1	1	0	5	2	SANTA ELENA	1	2	2	2	3	3
19	24	2	2	CLERK/STUDENT	3	2	1	0	5	2	SAN IGNACIO	1	2	1	2	4	4
20	60	2	5	FARMER	1	5	2	2	5	1	BULLET TREE	1	2	1	2	2	4
21	55	1	2	HOTEL OWNER	2	2	2	3	2	2	SAN IGNACIO	1	2	1	1	2	2
22	31	1	2	VENDOR	3	1	2	2	1	2	SANTA ELENA	1	2	1	2	1	5
23	45	1	2	VENDOR	3	1	2	2	5	1	SUCCOTZ	1	2	4	1	4	4
24	47	2	2	TEACHER	4	3	2	2	2	1	SUCCOTZ	1	2	1	1	2	4
25	58	1	2	HOUSE WIFE	7	3	2	5	3	1	SUCCOTZ	1	2	1	1	3	5
26	44	1	2	VENDOR	3	1	2	2	5	1	SUCCOTZ	1	2	4	1	1	3
27	25	2	2	GUIDE	2	4	1	0	4	2	SAN IGNACIO	1	2	1	1	2	1
28	21	2	2	ARCHAEOLOGY	2	1	1	0	2	1	SUCCOTZ	1	2	4	1	3	1
29	31	1	2	VENDOR	3	1	2	2	1	1	SUCCOTZ	1	2	1	2	1	3
30	23	1	2	VENDOR	3	1	2	1	2	1	SUCCOTZ	1	2	4	1	2	3
31	20	1	2	WAIT STAFF	2	2	1	2	5	2	SAN IGNACIO	1	2	1	1	3	3

APPENDIX 3.6 Codebook

Data Entry Code Book

PARTICIPANT DEMOGRAPHICS

GENDER	ETHNICITY	INDUSTRY	MARITAL STATUS	RURAL/URBAN
1 - FEMALE	1-KRIOL	1-AGRICULTURE	1-SINGLE	1-RURAL
2 - MALE	2-MESTIZO	2-TOURISM/HOPSITALITY	2-MARRIED	2-URBAN
	3-MAYA	3-RETAIL	3-COMMON LAW	
	4-GARIFUNA	4-EDUCATION		
	5-OTHER	5-GOVERNMENT		
	6-MENONITE	6-NGO		
		7-DOMESTIC		
		8-Utility		

DISTANCE TO RIVER:

ZONE	DISTANCE
1	<100 YARDS
2	<1/4 MILE
3	<1/2 MILE
4	<1 MILE
5	<3 MILES
6	>3 MILES

Multiple Choice Questions:

Q1	Q2	Q3	Q4
1-YES	1-POSITIVE	1-ELECTRIC GENERATION	1-YES
2-NO	2-NEGATIVE	2-FLOOD CONTROL	2-NO
	3-NO ANSWER	3-WATER SUPPLY	
		4-NOT SURE	
		5-ALL	

APPENDIX 3.7 IRB Certificate

The UNIVERSITY of VERMONT
Committees on Human Subjects
Serving the University of Vermont
and Fletcher Allen Health Care

RESEARCH PROTECTIONS OFFICE
213 Waterman Building, 85 South
Prospect Street
Burlington, VT 05405
Ph:802-656-5040
Website: http://www.uvm.edu/irb/

Protocol Exemption Certification

Gale Weld

TO:	Emily Bird
FROM:	Gale Weld, Research Review Administrator
DATE OF CERTIFICATION:	22-Dec-2011
SUBJECT:	CHRBS: B12-093 The Social Impact of Dams on Developing Communicaties: A Case Study of the Macal River Valley, Belize

According to federal regulations, certain types of research activities are "exempt" from formal Committee review and approval, however, University policy requires that all projects which involve human subjects be submitted to the Committee office for exemption determination.

Following such a review of your project, it has been determined that it qualifies for exemption, as indicated below, under Section 45 CFR 46.101(b) of the Federal Policy for the Protection of Human Subjects.

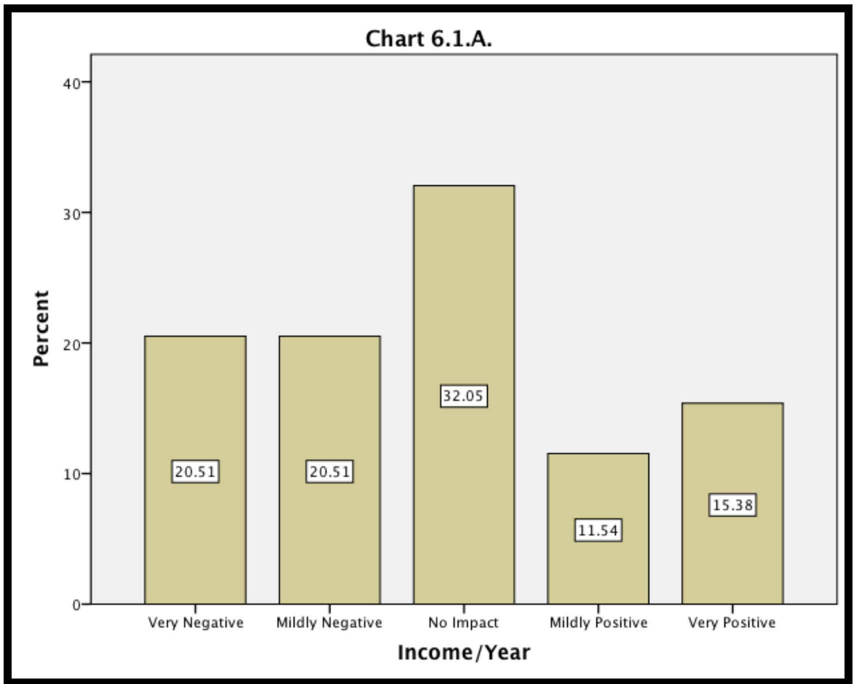
Exemption Number: 2
"Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation."

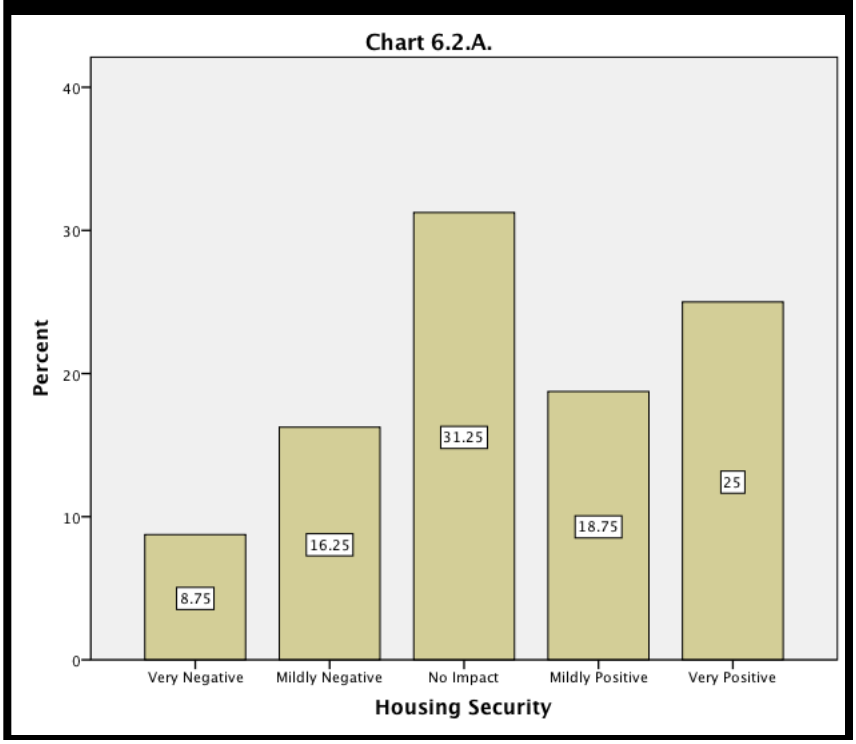
It is University policy to require all research to be conducted in accordance with the Belmont Report, which sets forth ethical principles for research involving humans as subjects. A copy of this report is available on our website under Rules, Regulations, and Guidance.

Modifications may affect the original determination of exemption, therefore, you must submit any proposed project modifications which affect human subjects for review prior to implementation (i.e. surveys, questionnaires, changes to on-line interventions, etc.).

This exemption is effective for the duration of the project UNLESS modifications are made that affect

Appendix 6.1 Bar Chart Results for Total Sample of Socioeconomic Indicators (Charts 6.1.A. – 6.24.A)





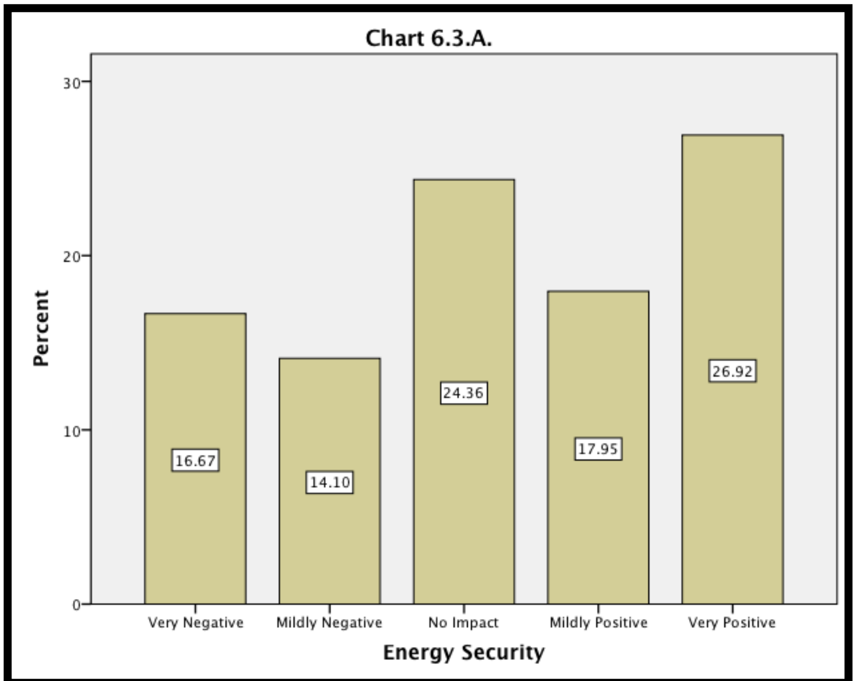


Chart 6.3.A.
Percent
30
20
10
0
16.67
14.10
24.36
17.95
26.92
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Energy Security

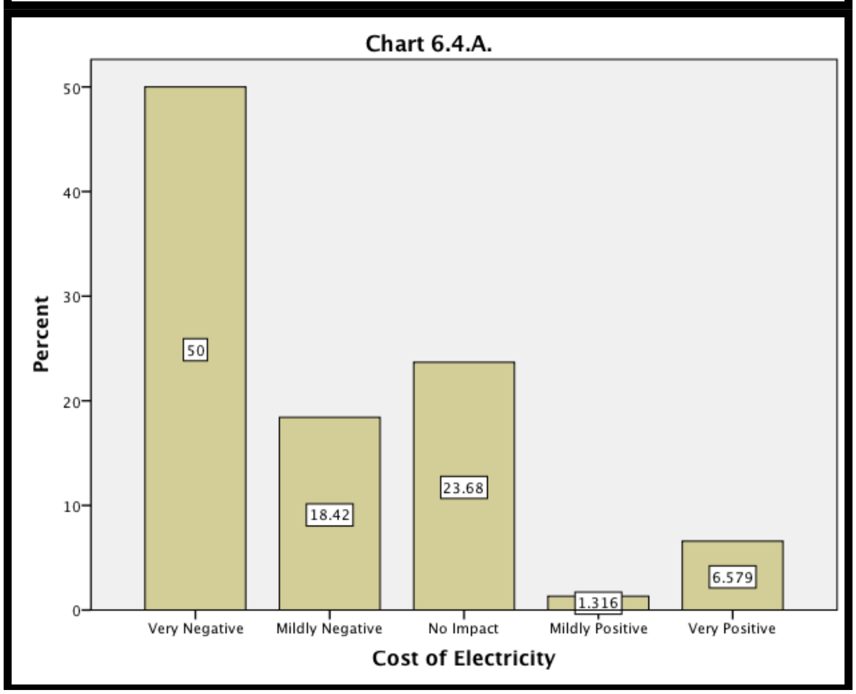


Chart 6.4.A.
Percent
50
40
30
20
10
0
50
18.42
23.68
1.316
6.579
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Cost of Electricity

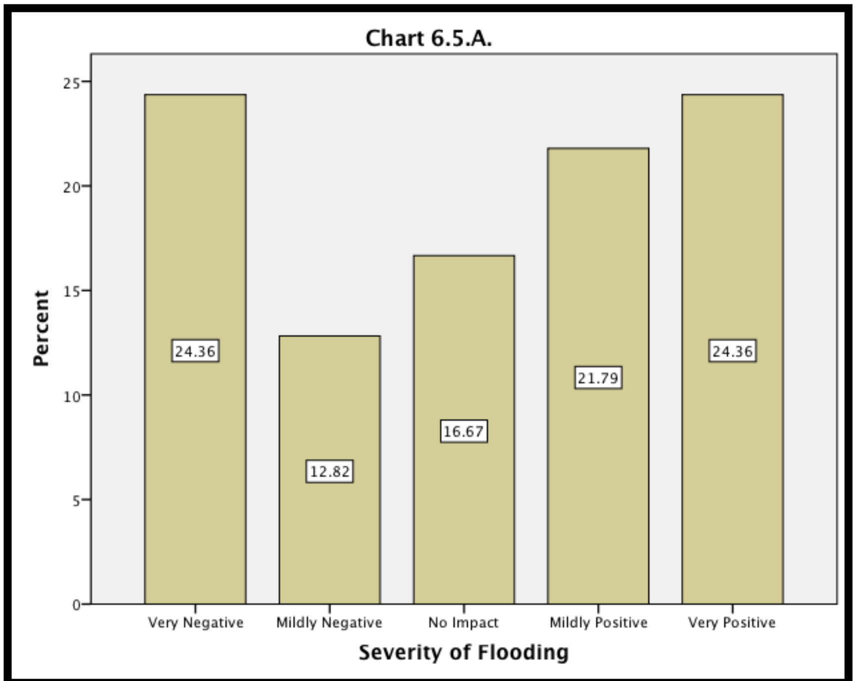


Chart 6.5.A.
Percent
0
5
10
15
20
25
24.36
12.82
16.67
21.79
24.36
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Severity of Flooding

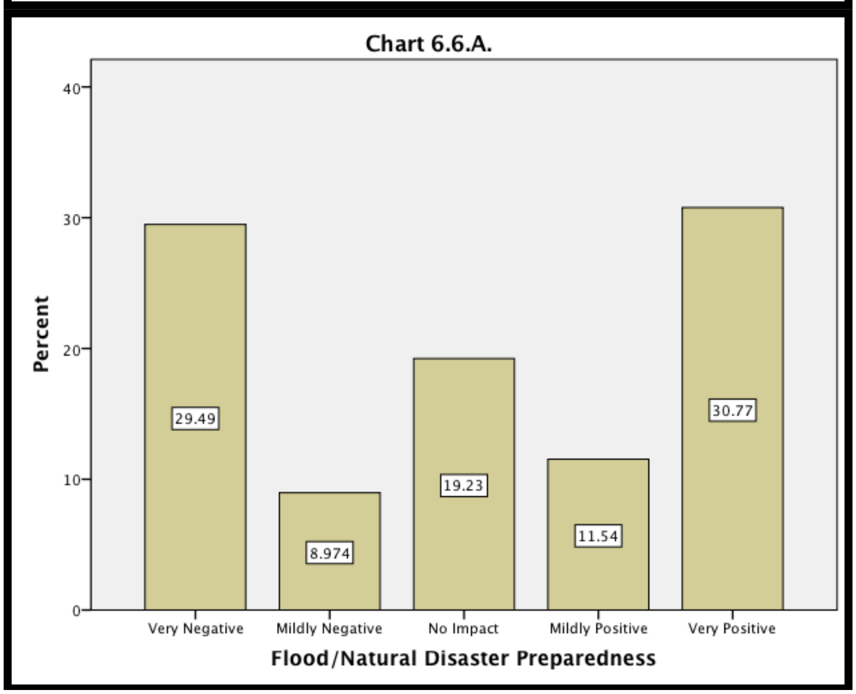


Chart 6.6.A.
Percent
0
10
20
30
40
29.49
8.974
19.23
11.54
30.77
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood/Natural Disaster Preparedness

Chart 6.7.A.

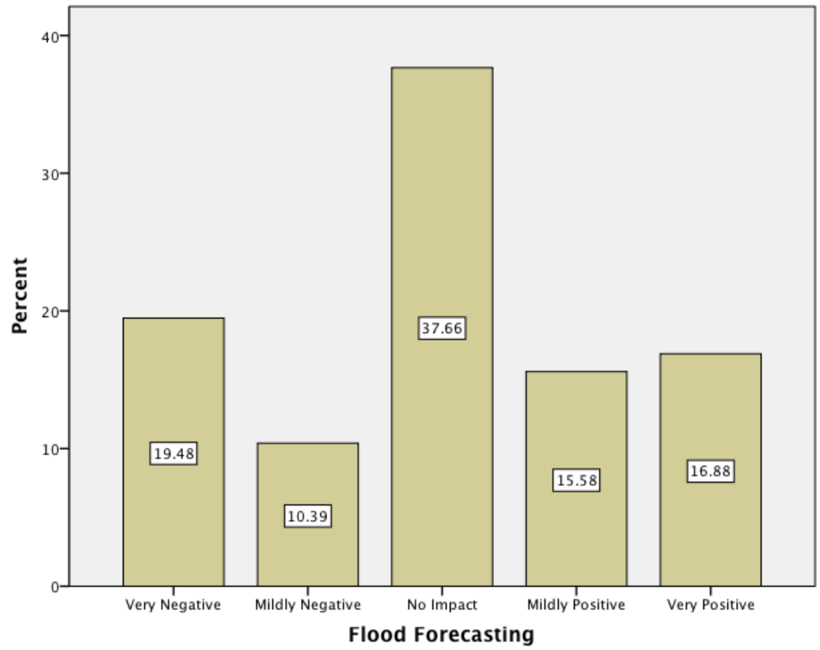
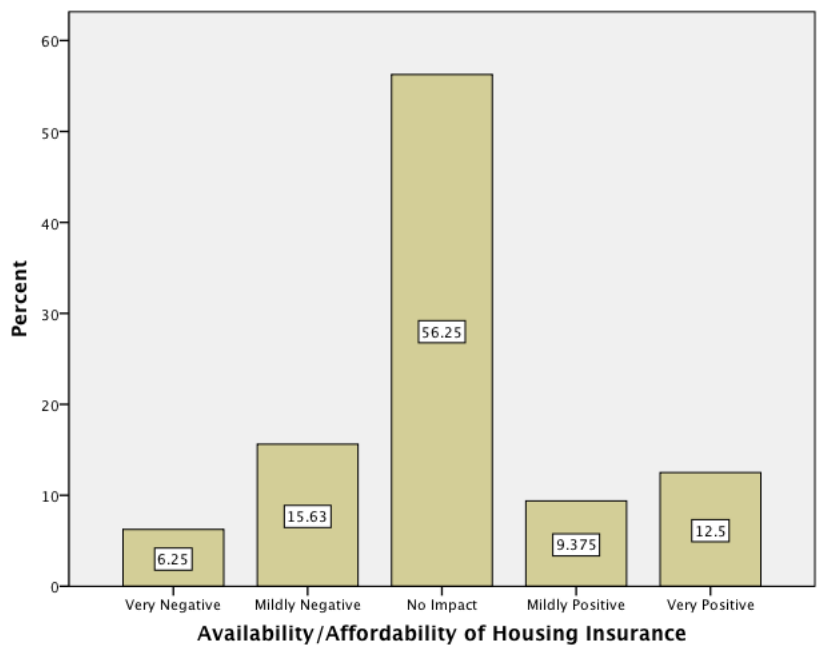


Chart 6.8.A.



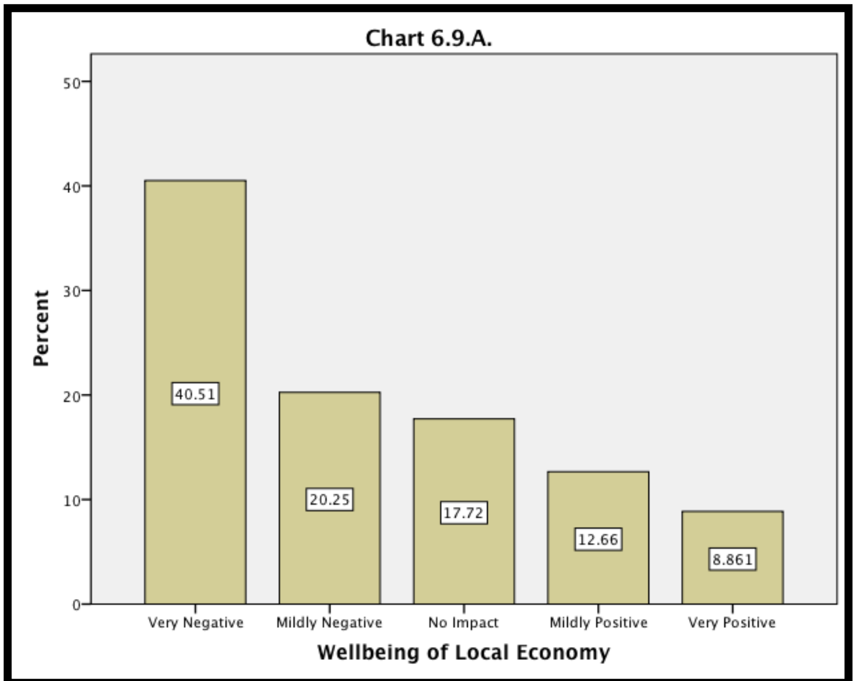


Chart 6.9.A.
Percent
0
10
20
30
40
50
40.51
20.25
17.72
12.66
8.861
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Wellbeing of Local Economy

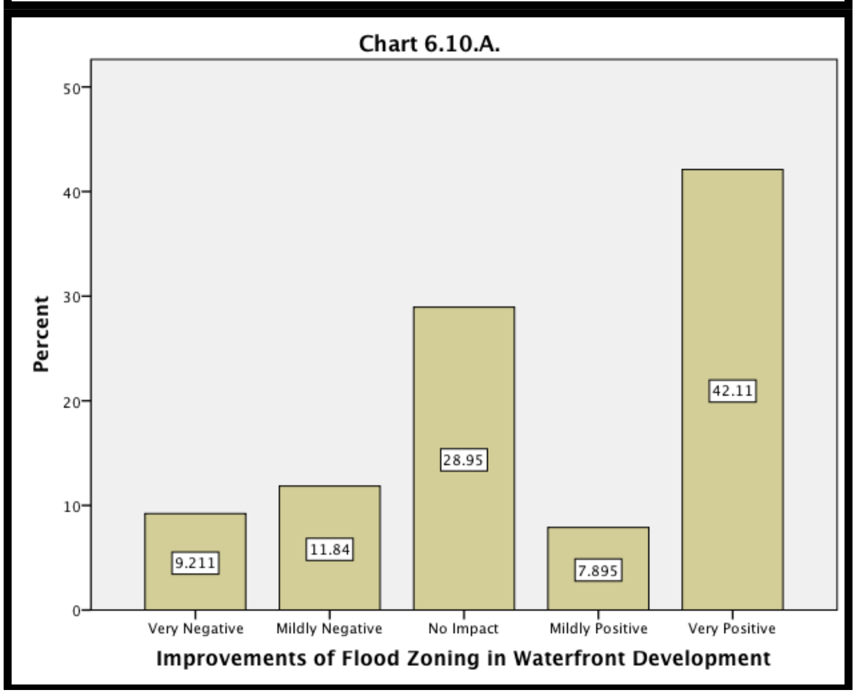


Chart 6.10.A.
Percent
0
10
20
30
40
50
9.211
11.84
28.95
7.895
42.11
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Improvements of Flood Zoning in Waterfront Development

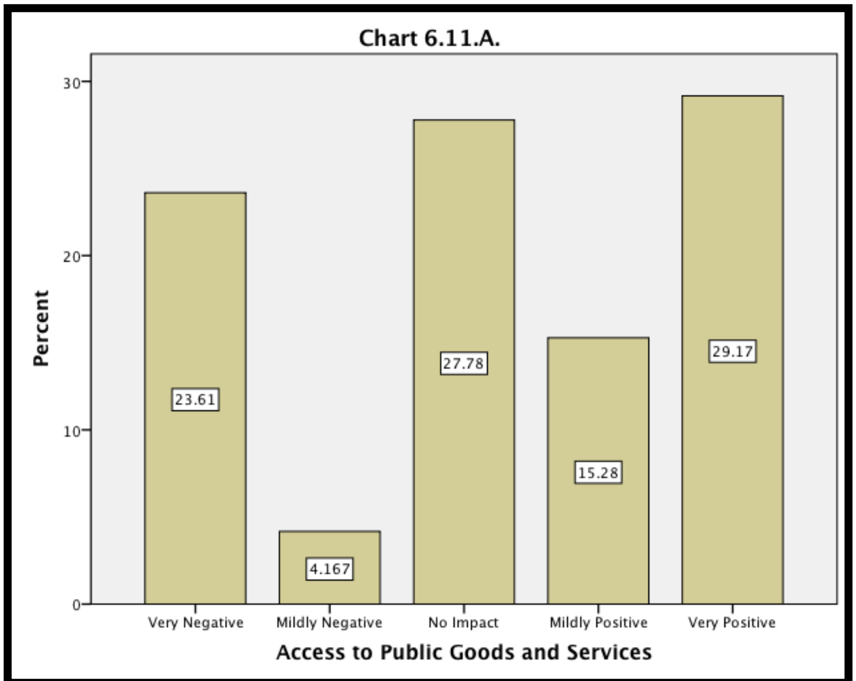


Chart 6.11.A.
Percent
30
20
10
0
23.61
4.167
27.78
15.28
29.17
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Access to Public Goods and Services

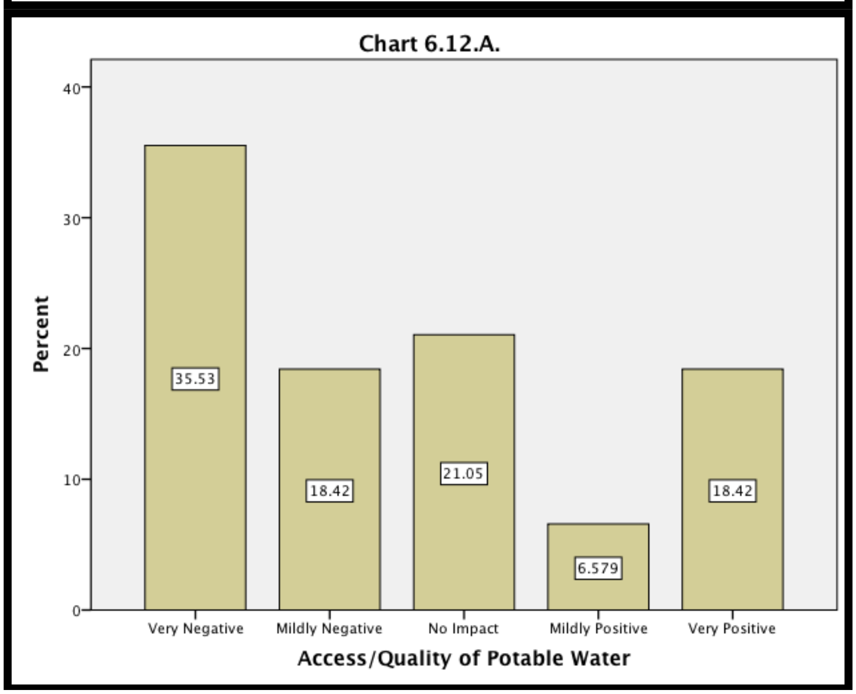


Chart 6.12.A.
Percent
40
30
20
10
0
35.53
18.42
21.05
6.579
18.42
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Access/Quality of Potable Water

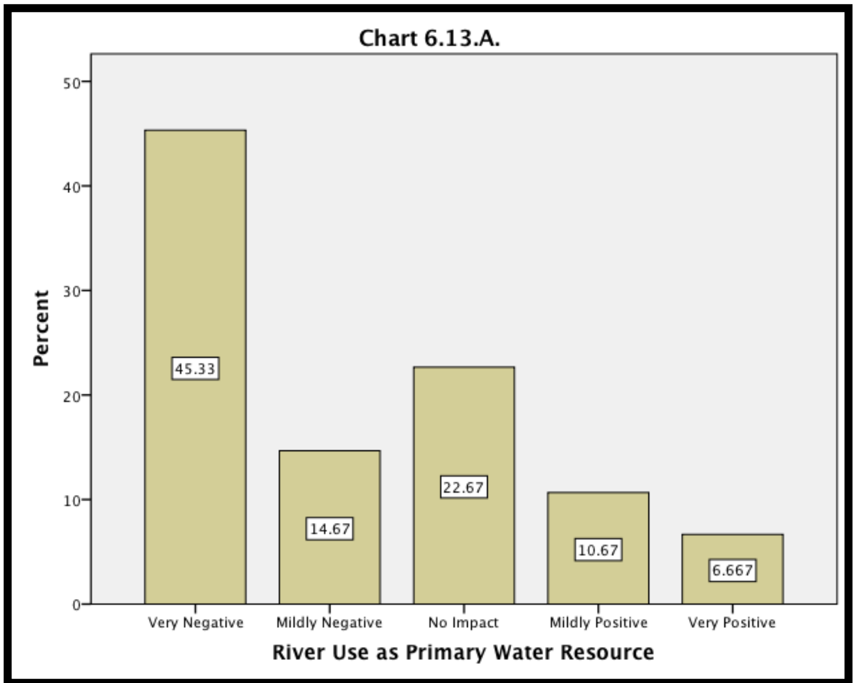


Chart 6.13.A.
Percent
0
10
20
30
40
50
45.33
14.67
22.67
10.67
6.667
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
River Use as Primary Water Resource

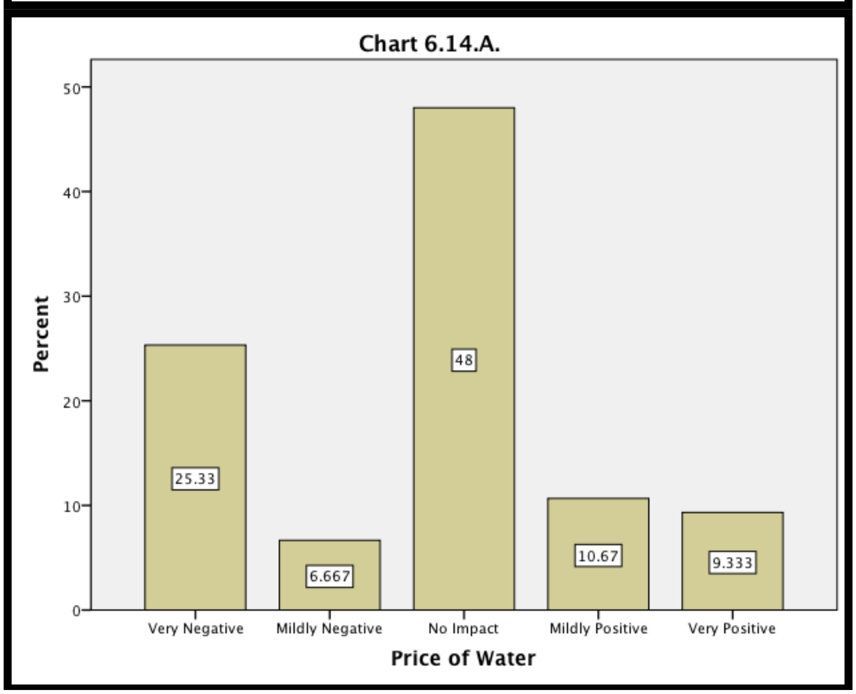


Chart 6.14.A.
Percent
0
10
20
30
40
50
25.33
6.667
48
10.67
9.333
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Price of Water

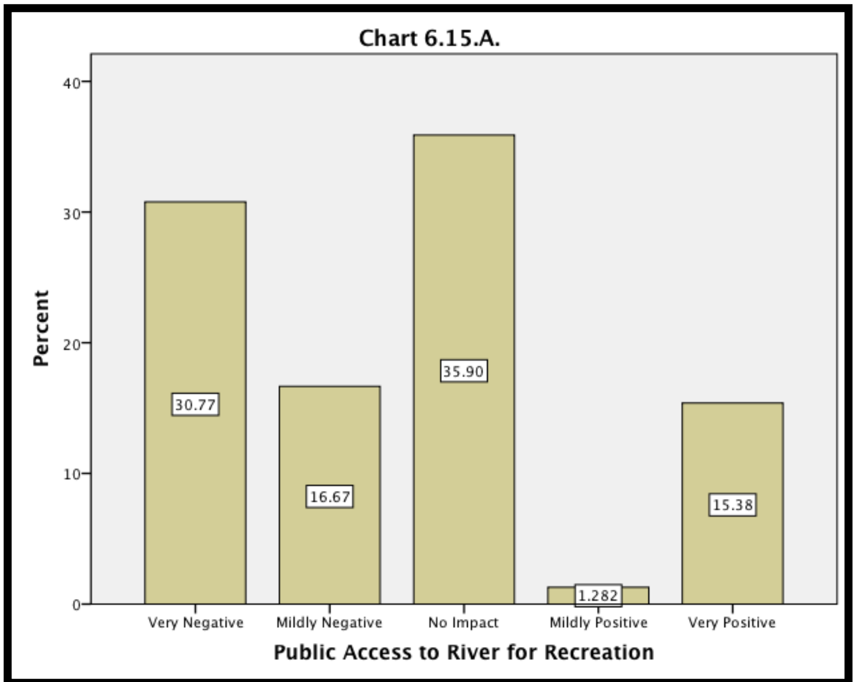


Chart 6.15.A.
Percent
40
30
20
10
0
30.77
16.67
35.90
1.282
15.38
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Public Access to River for Recreation

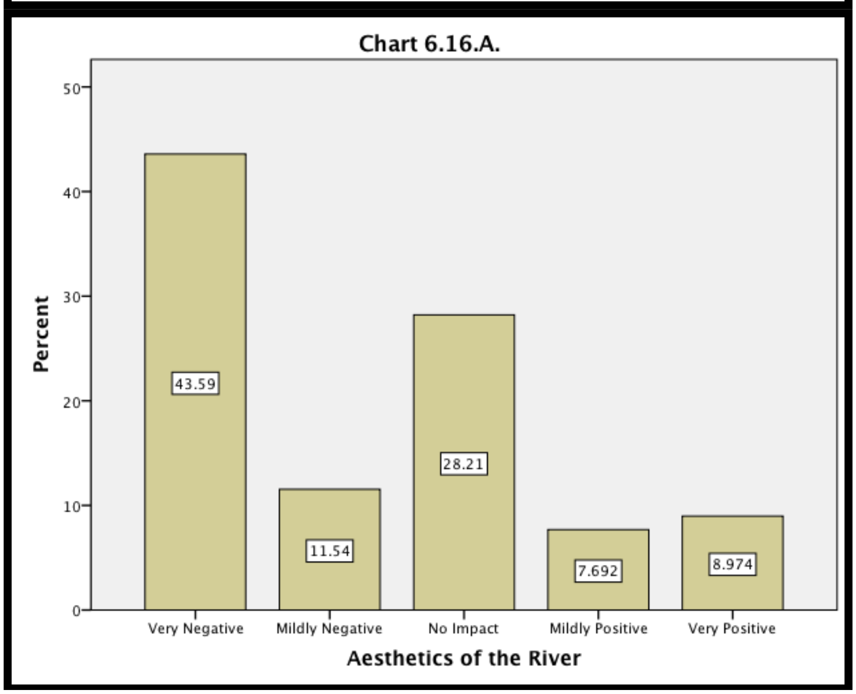


Chart 6.16.A.
Percent
50
40
30
20
10
0
43.59
11.54
28.21
7.692
8.974
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Aesthetics of the River

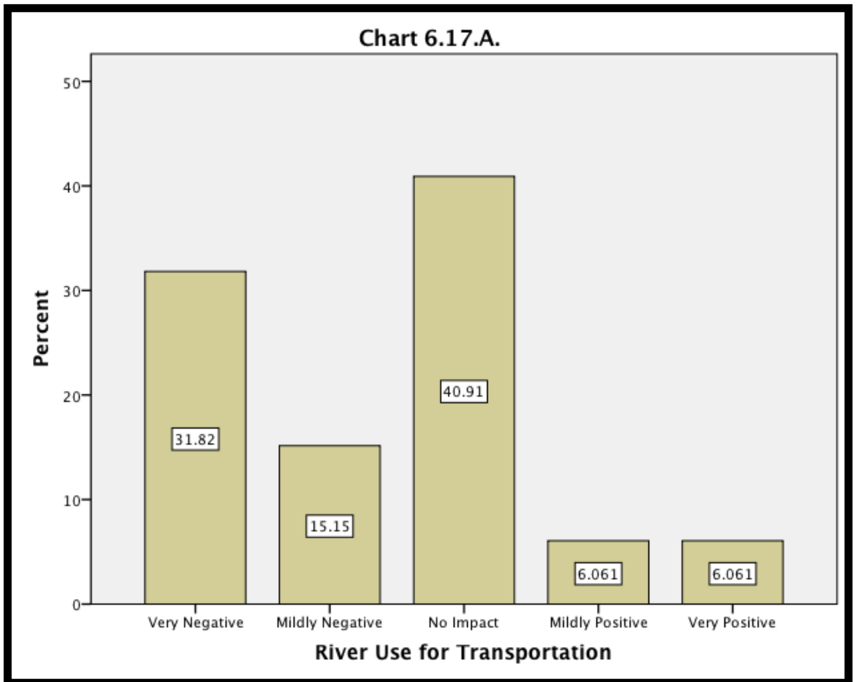


Chart 6.17.A.
Percent
50
40
30
20
10
0
31.82
15.15
40.91
6.061
6.061
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
River Use for Transportation

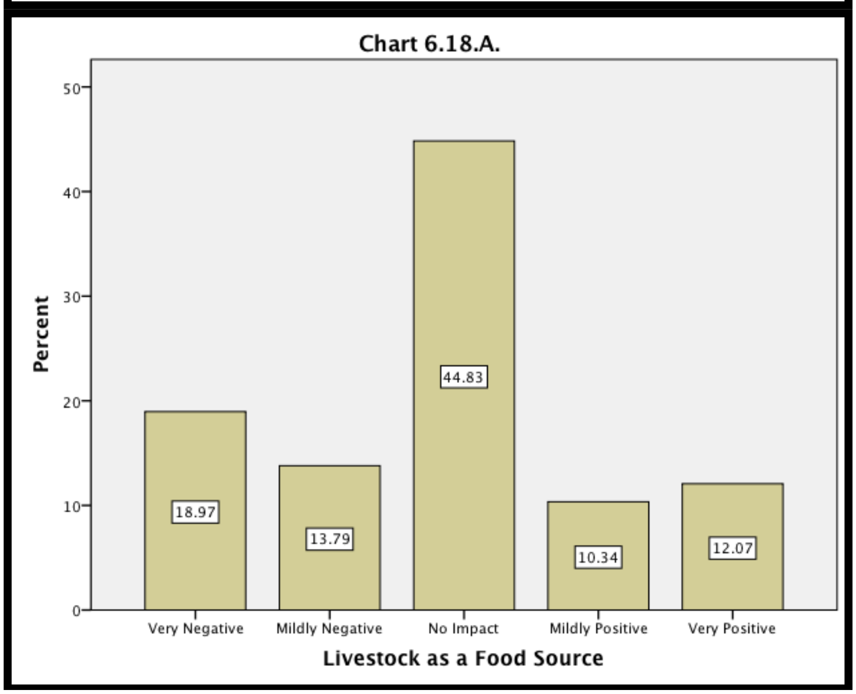


Chart 6.18.A.
Percent
50
40
30
20
10
0
18.97
13.79
44.83
10.34
12.07
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Livestock as a Food Source

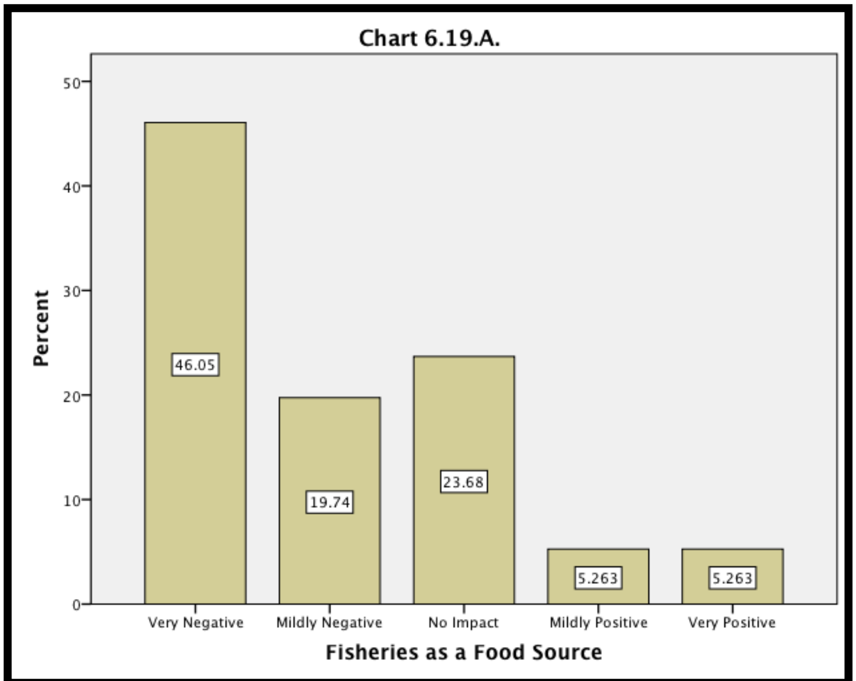


Chart 6.19.A.
Percent
50
40
30
20
10
0
46.05
19.74
23.68
5.263
5.263
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Fisheries as a Food Source

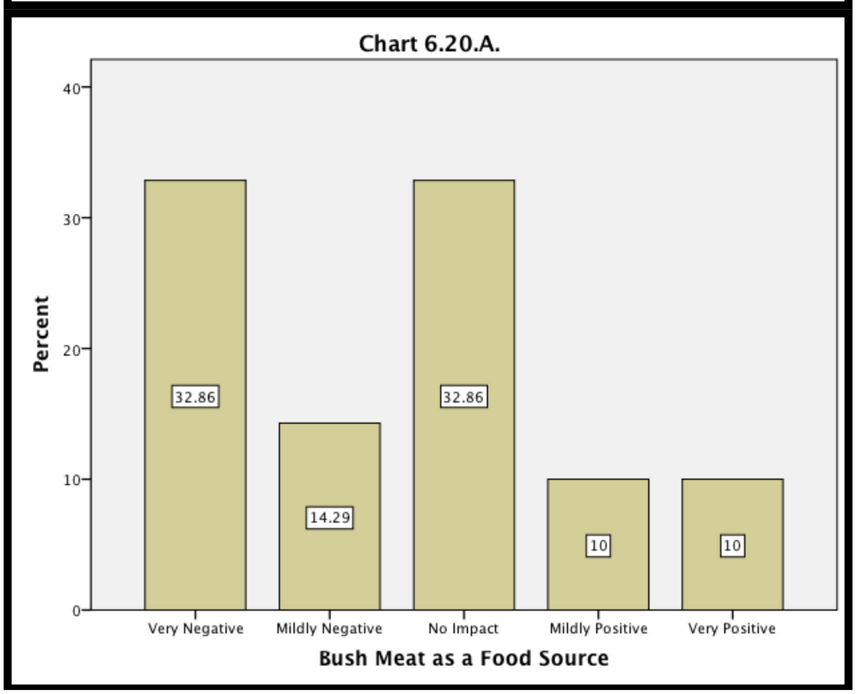


Chart 6.20.A.
Percent
40
30
20
10
0
32.86
14.29
32.86
10
10
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Bush Meat as a Food Source

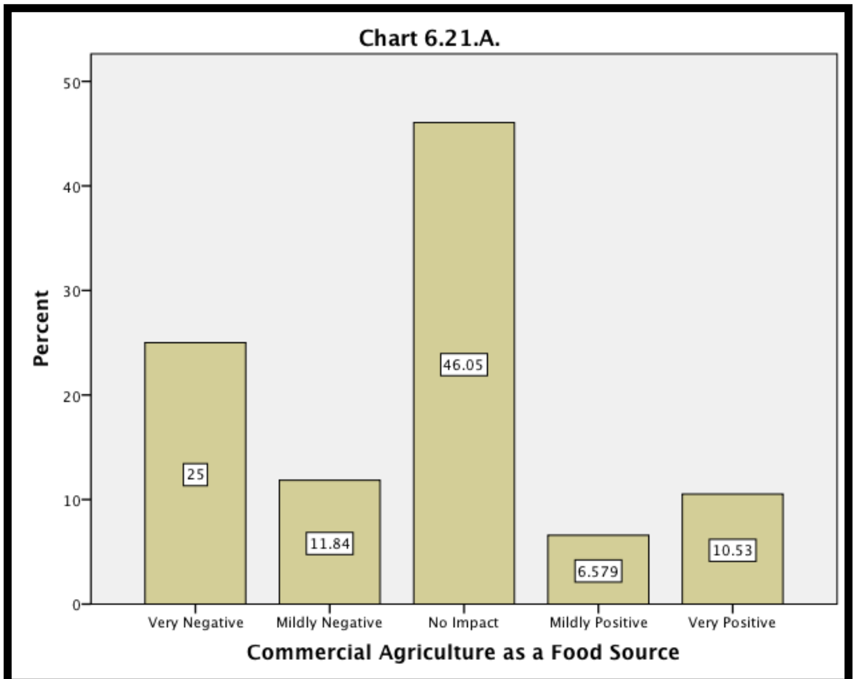


Chart 6.21.A.
Percent
50
40
30
20
10
0
25
11.84
46.05
6.579
10.53
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Commercial Agriculture as a Food Source

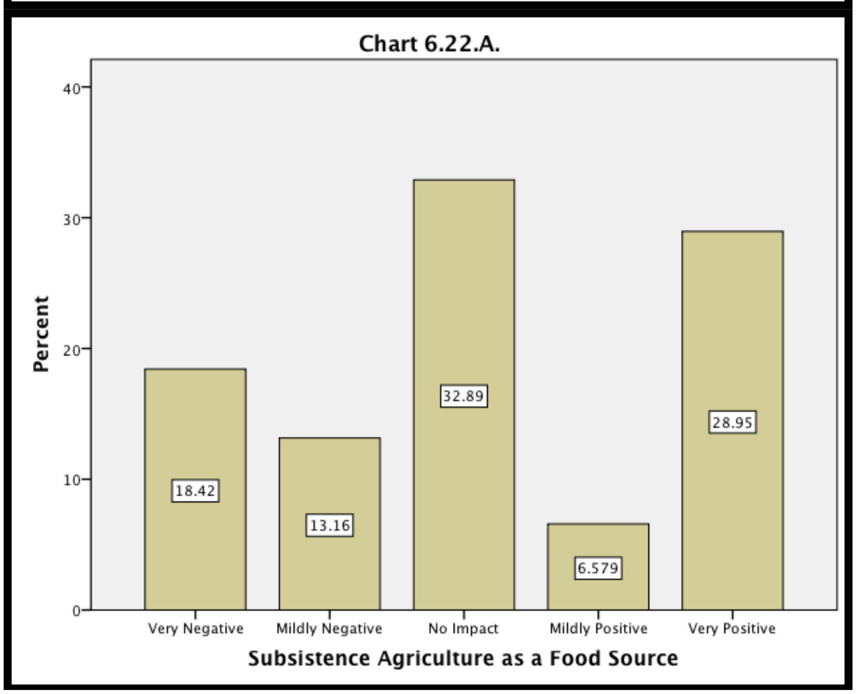


Chart 6.22.A.
Percent
40
30
20
10
0
18.42
13.16
32.89
6.579
28.95
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Subsistence Agriculture as a Food Source

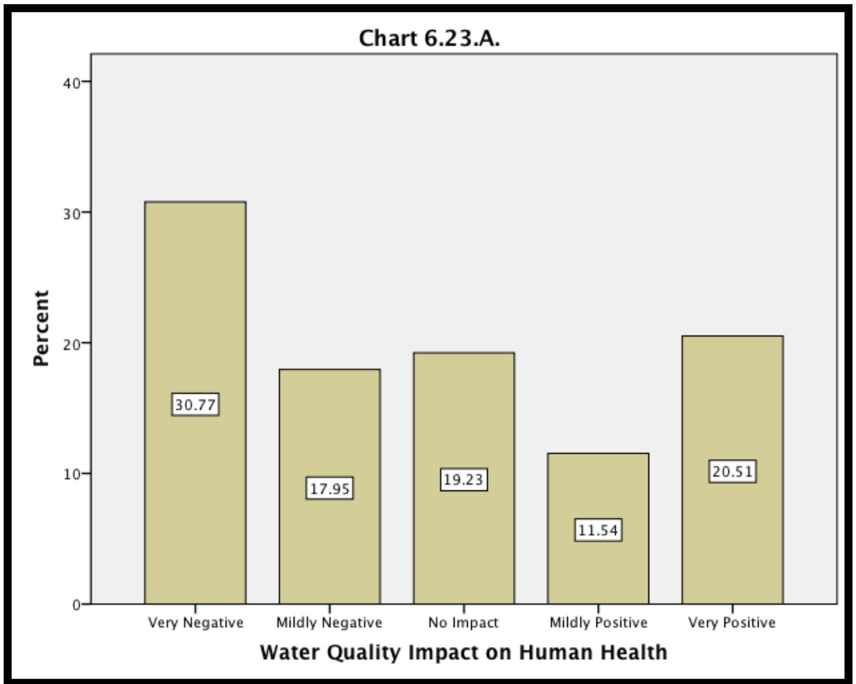


Chart 6.23.A.
Percent
40
30
20
10
0
30.77
17.95
19.23
11.54
20.51
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Water Quality Impact on Human Health

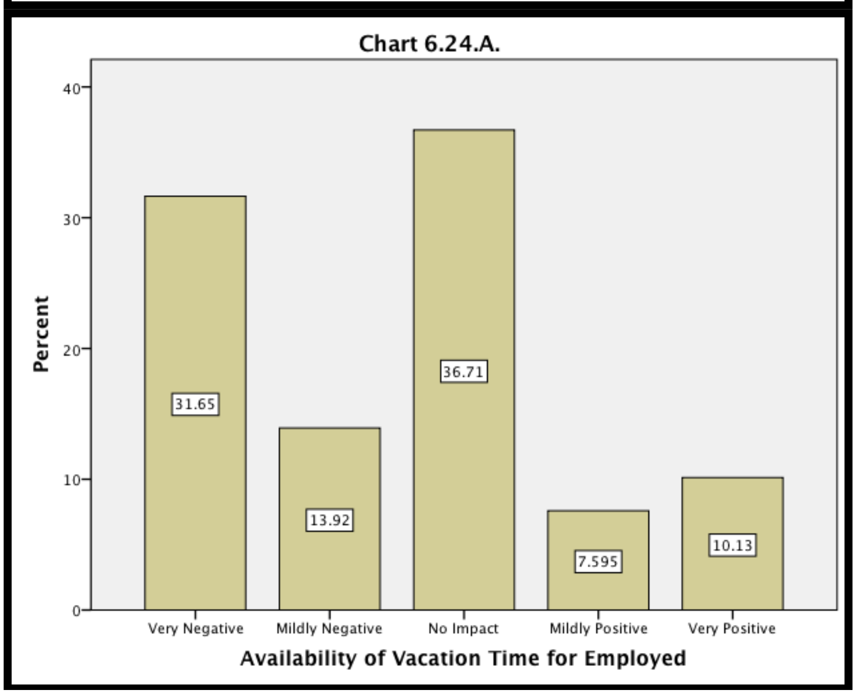
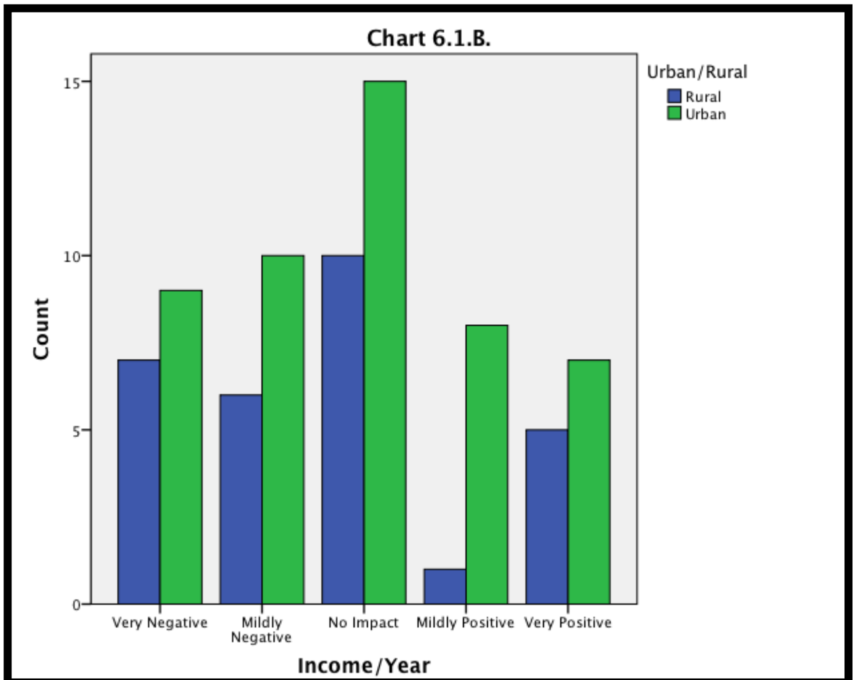
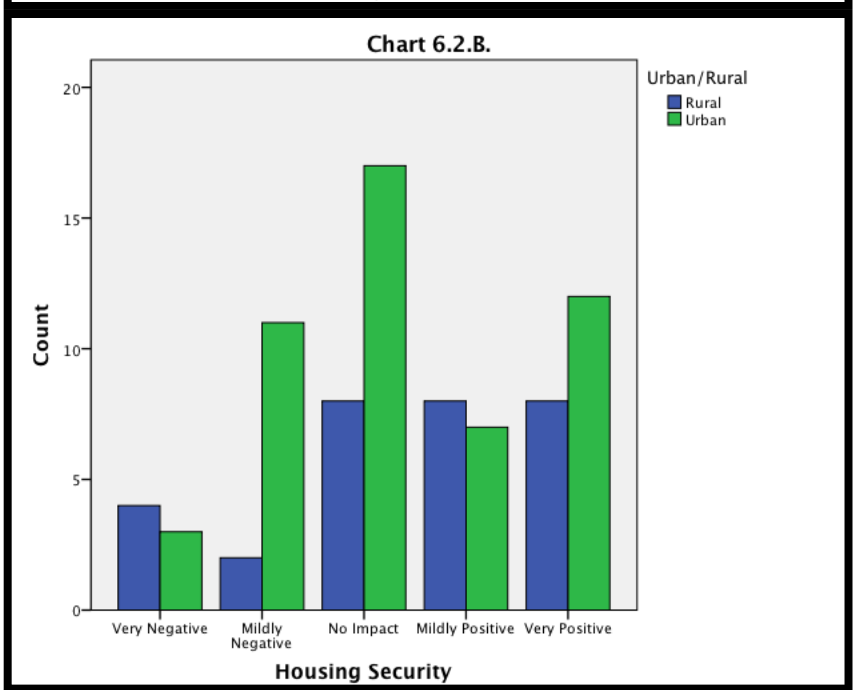


Chart 6.24.A.
Percent
40
30
20
10
0
31.65
13.92
36.71
7.595
10.13
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Availability of Vacation Time for Employed

Appendix 6.2 Bar Chart Results for Socioeconomic Indicators Comparing the Urban and Rural Sample Groups (Charts 6.1.B. – 6.24.B.)





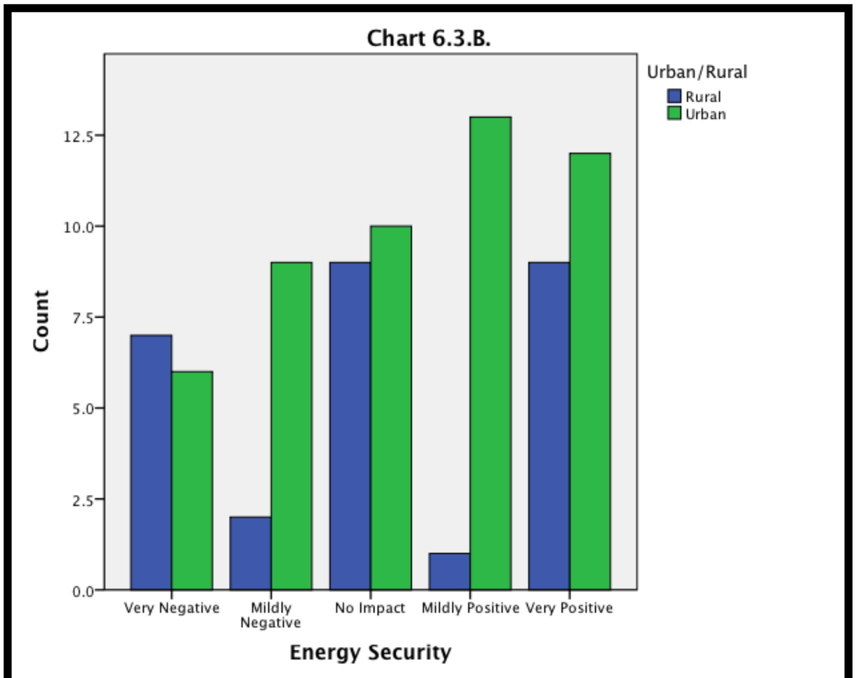


Chart 6.3.B.
Urban/Rural
Rural
Urban
Count
12.5
10.0
7.5
5.0
2.5
0.0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Energy Security

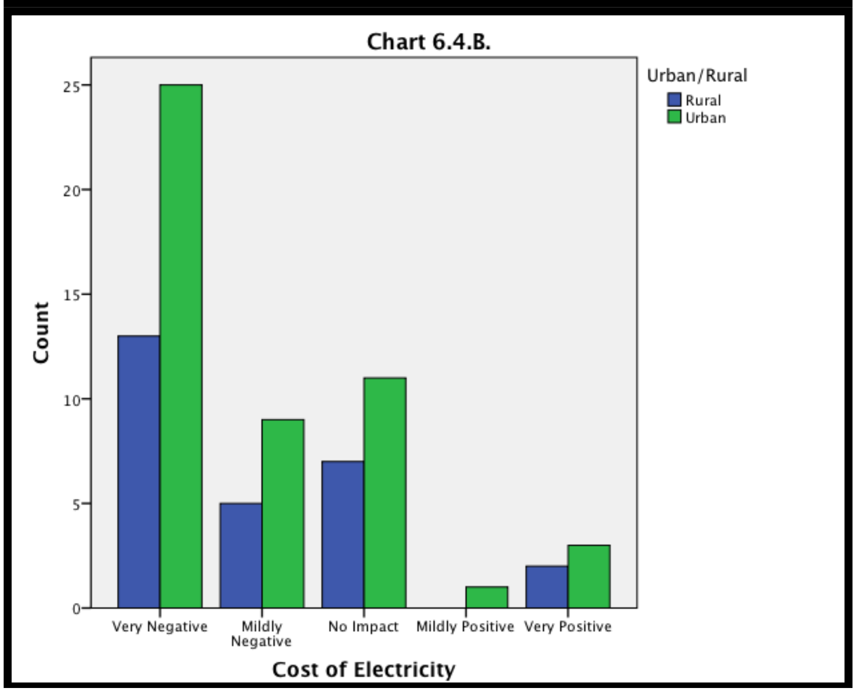


Chart 6.4.B.
Urban/Rural
Rural
Urban
Count
25
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Cost of Electricity

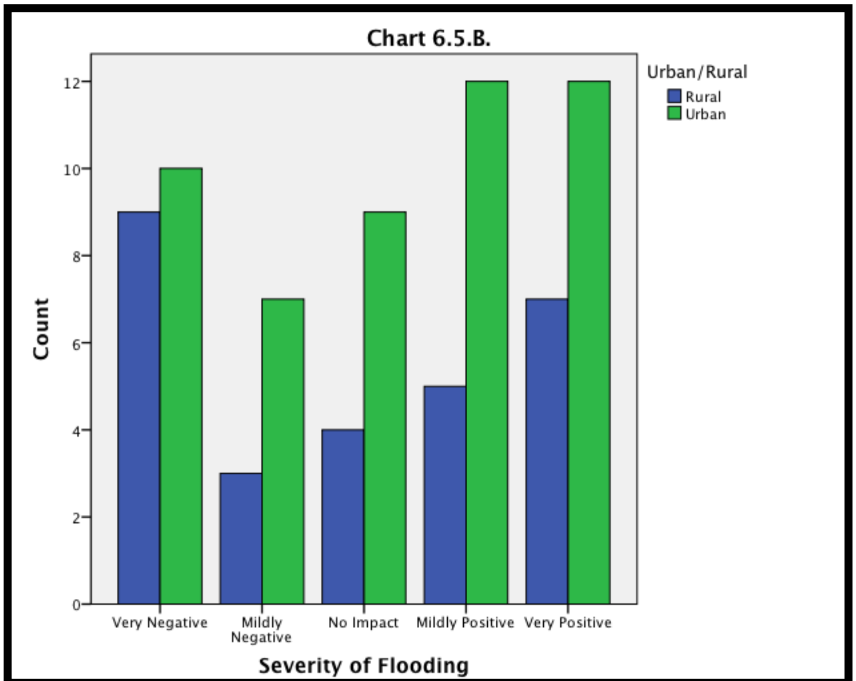


Chart 6.5.B.
Urban/Rural
Rural
Urban
Count
0
2
4
6
8
10
12
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Severity of Flooding

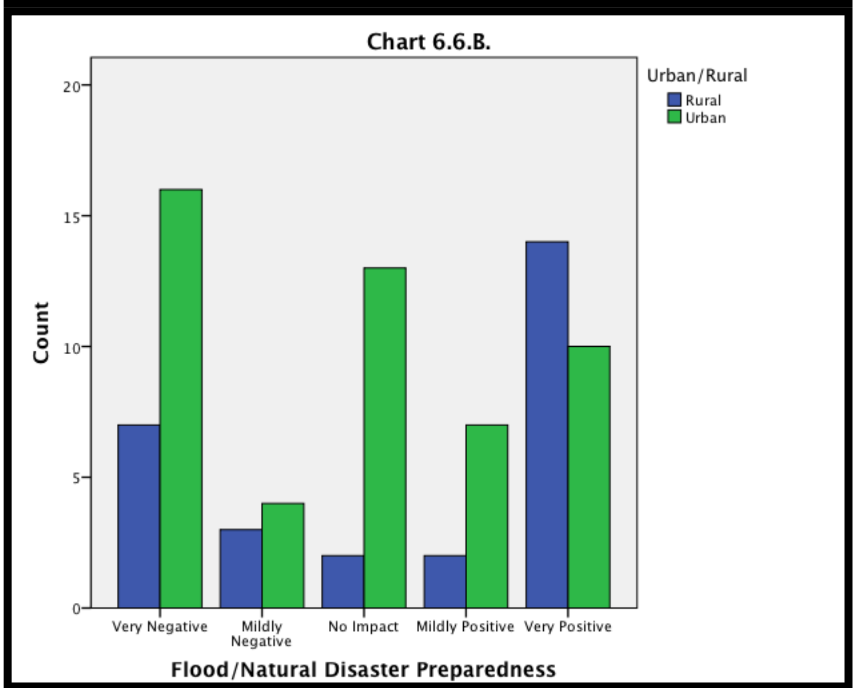


Chart 6.6.B.
Urban/Rural
Rural
Urban
Count
0
5
10
15
20
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood/Natural Disaster Preparedness

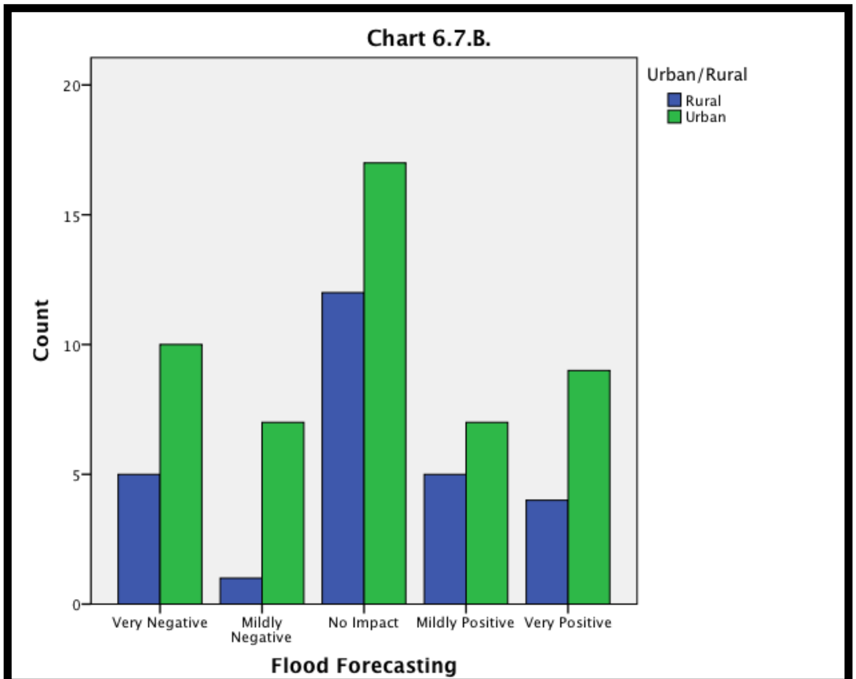


Chart 6.7.B.
Count
20
15
10
5
0
Urban/Rural
Rural
Urban
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood Forecasting

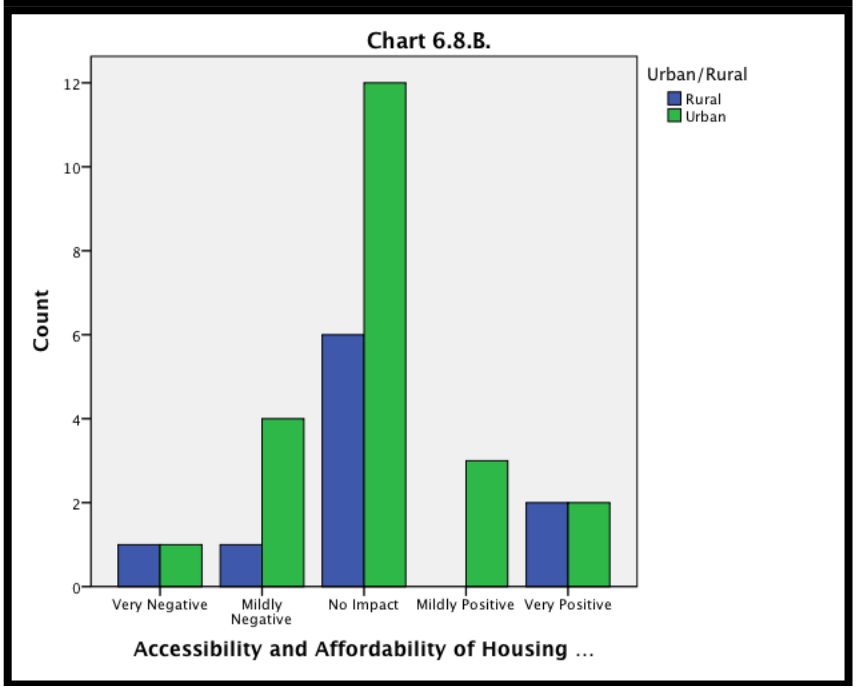


Chart 6.8.B.
Count
12
10
8
6
4
2
0
Urban/Rural
Rural
Urban
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Accessibility and Affordability of Housing ...

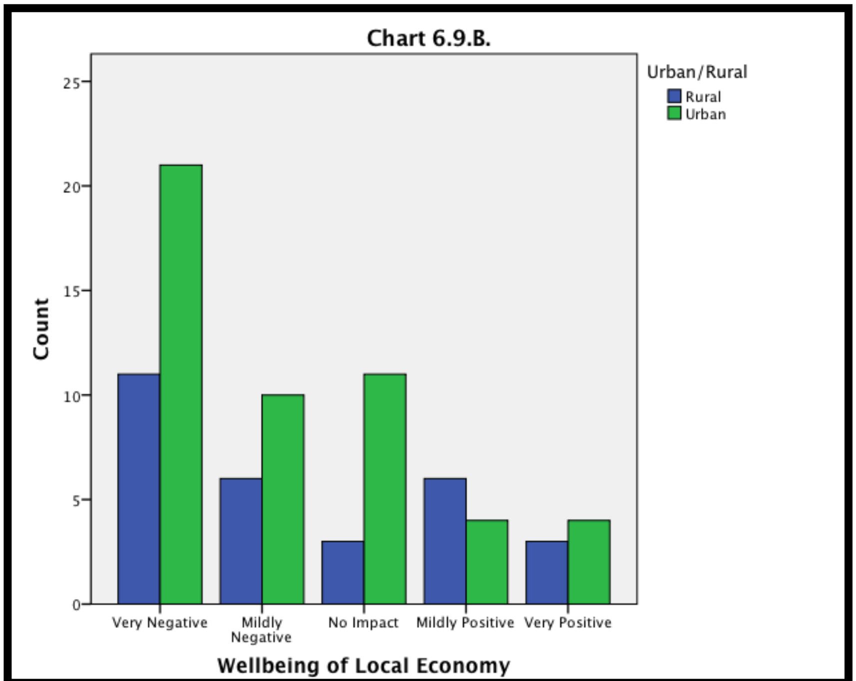


Chart 6.9.B.
Urban/Rural
Rural
Urban
Count
0
5
10
15
20
25
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Wellbeing of Local Economy

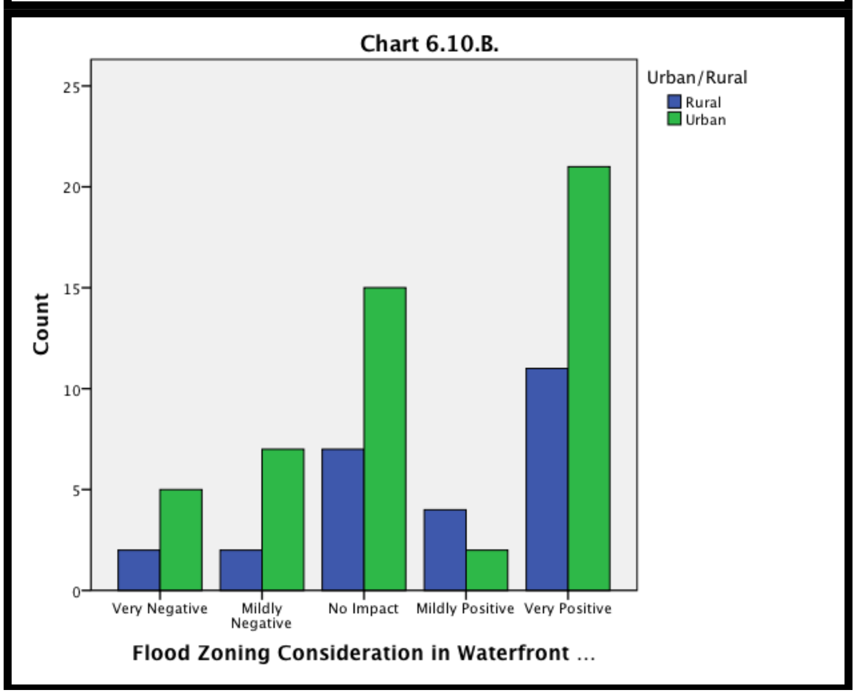


Chart 6.10.B.
Urban/Rural
Rural
Urban
Count
0
5
10
15
20
25
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood Zoning Consideration in Waterfront ...

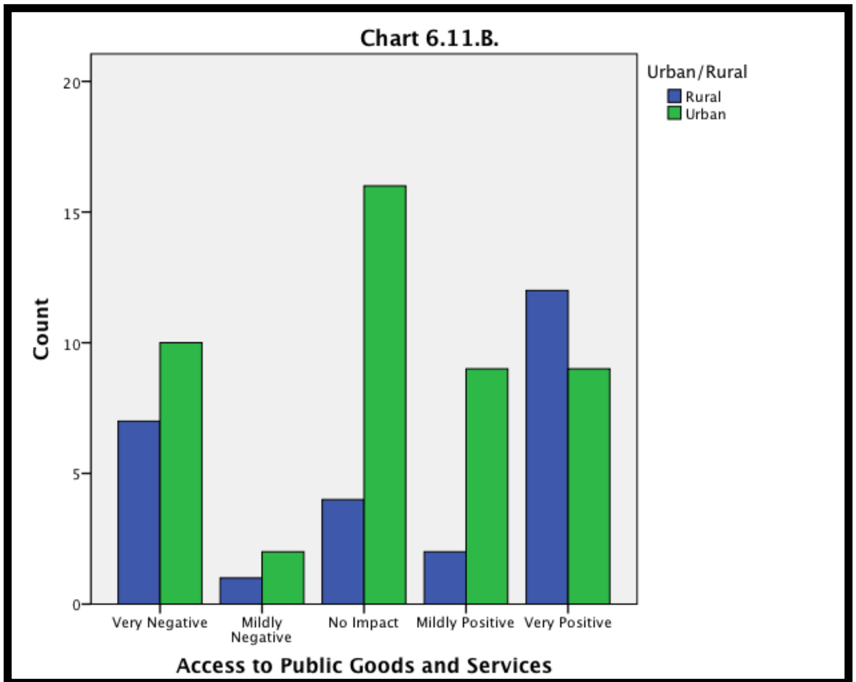


Chart 6.11.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Access to Public Goods and Services

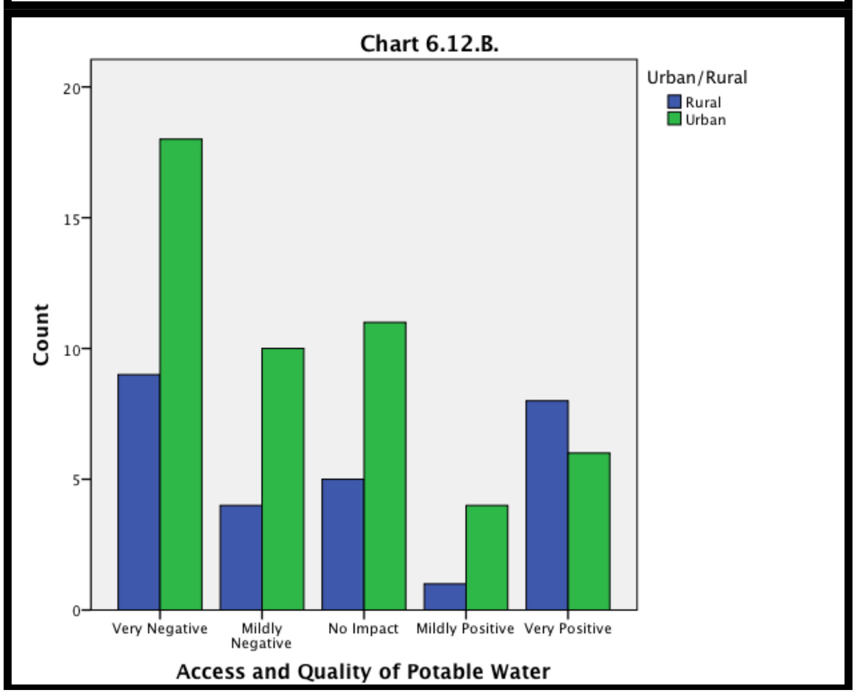


Chart 6.12.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Access and Quality of Potable Water

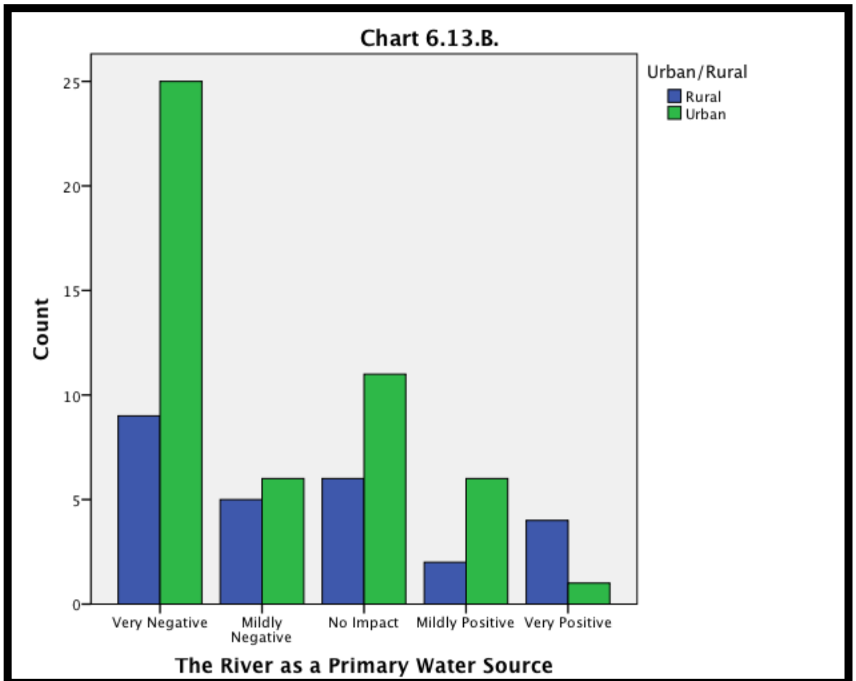


Chart 6.13.B.
Urban/Rural
Rural
Urban
Count
25
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
The River as a Primary Water Source

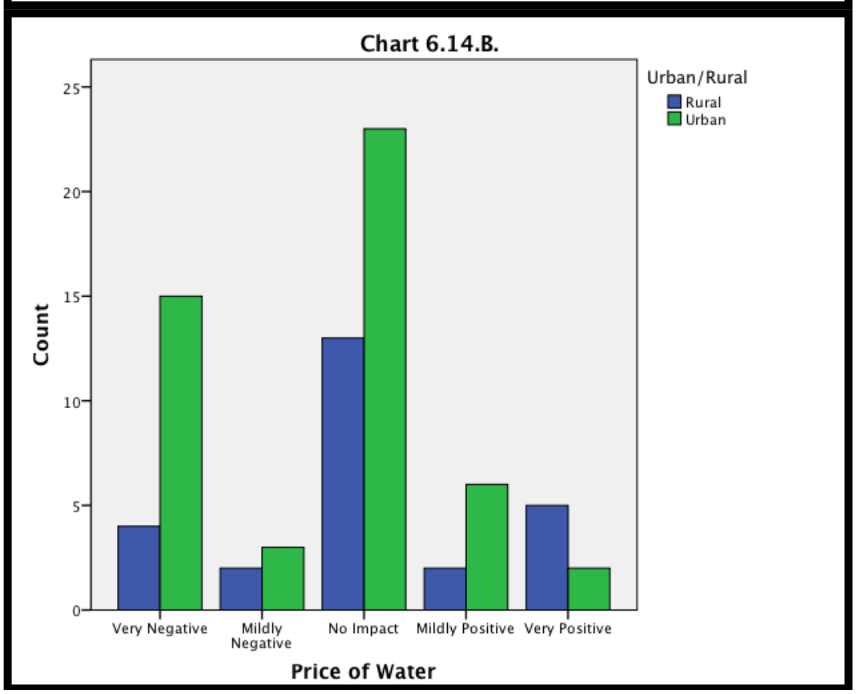


Chart 6.14.B.
Urban/Rural
Rural
Urban
Count
25
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Price of Water

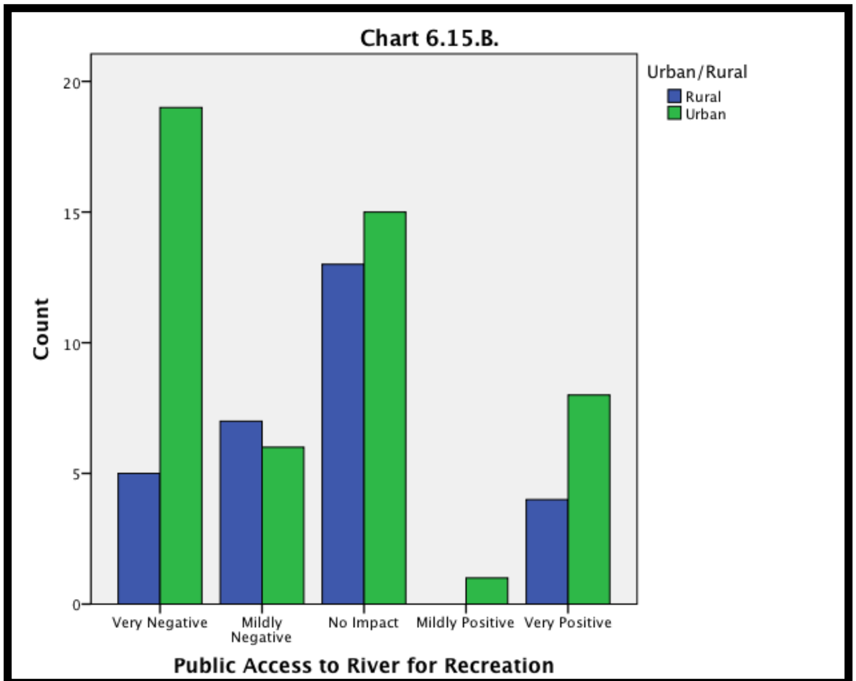


Chart 6.15.B.
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Public Access to River for Recreation
Urban/Rural
Rural
Urban

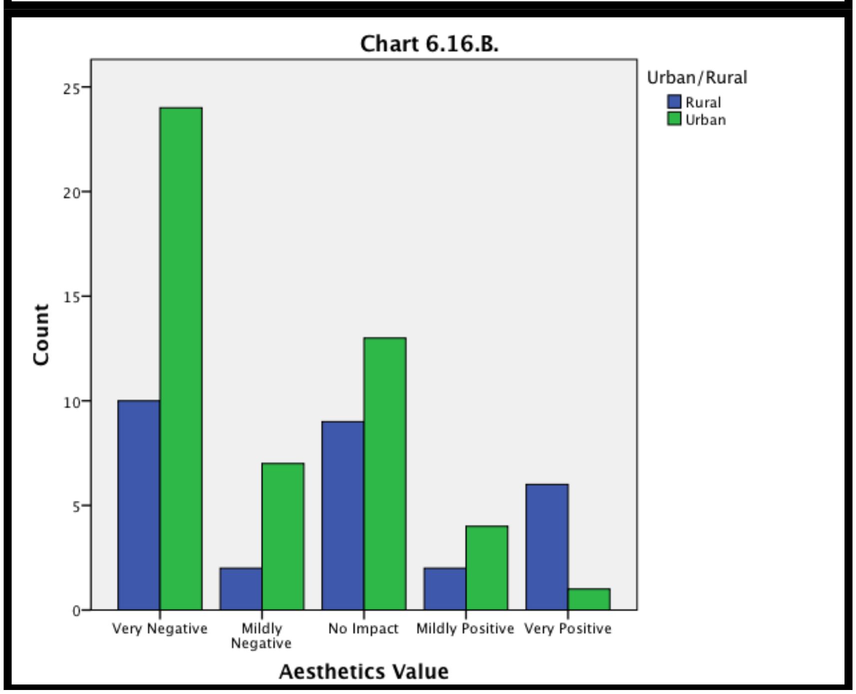


Chart 6.16.B.
Count
25
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Aesthetics Value
Urban/Rural
Rural
Urban

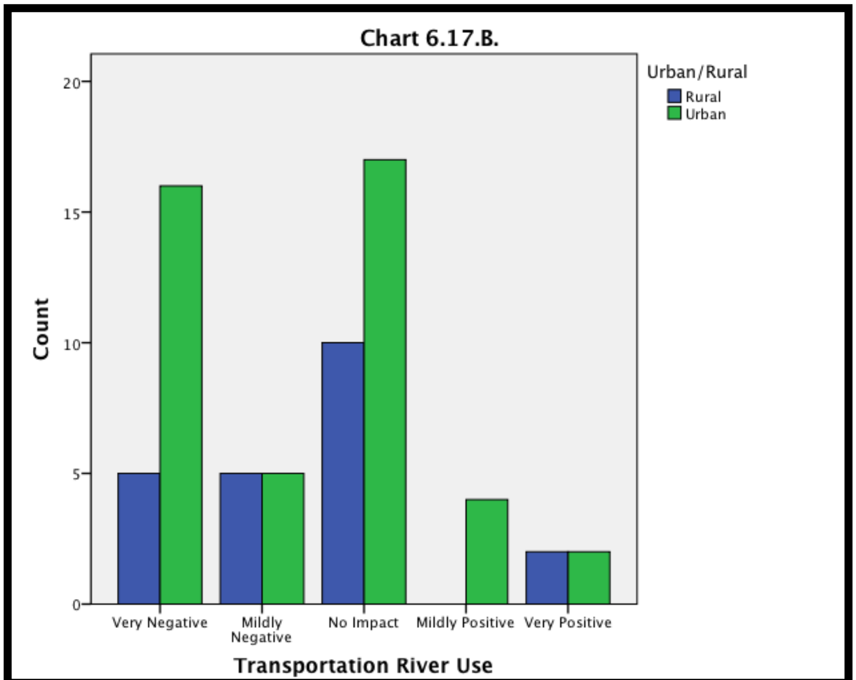


Chart 6.17.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Transportation River Use

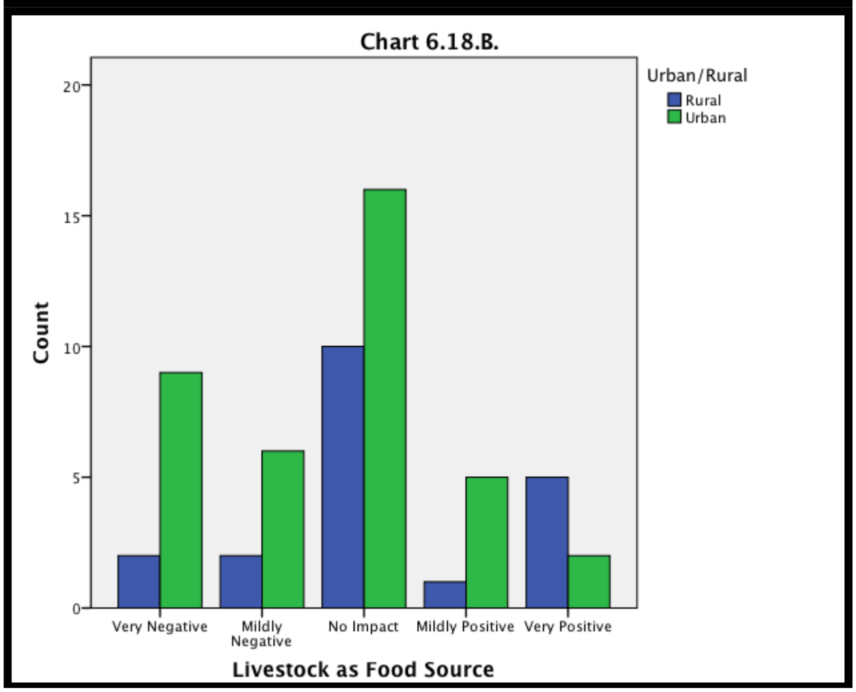


Chart 6.18.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Livestock as Food Source

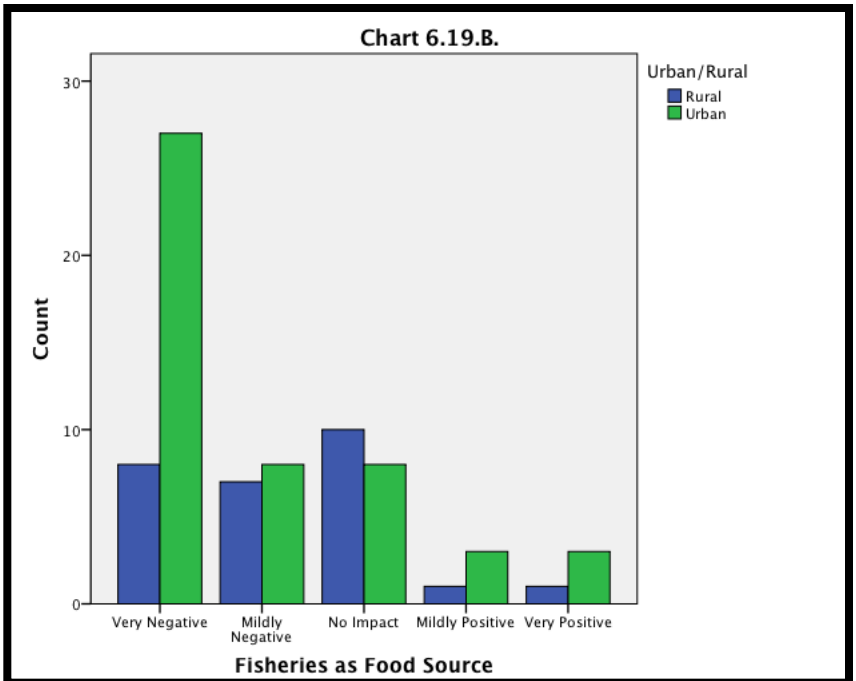


Chart 6.19.B.
Urban/Rural
Rural
Urban
Count
30
20
10
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Fisheries as Food Source

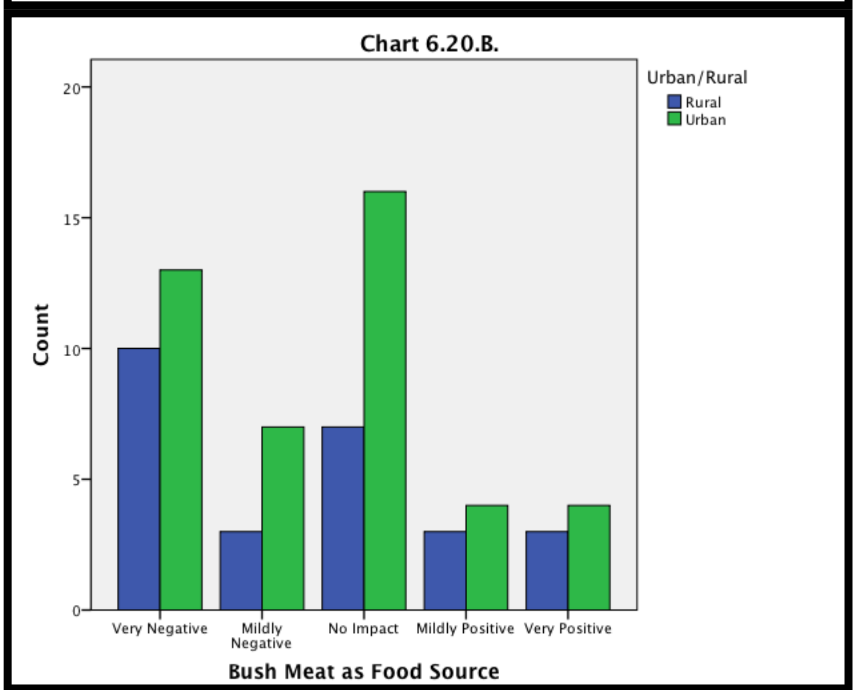


Chart 6.20.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Bush Meat as Food Source

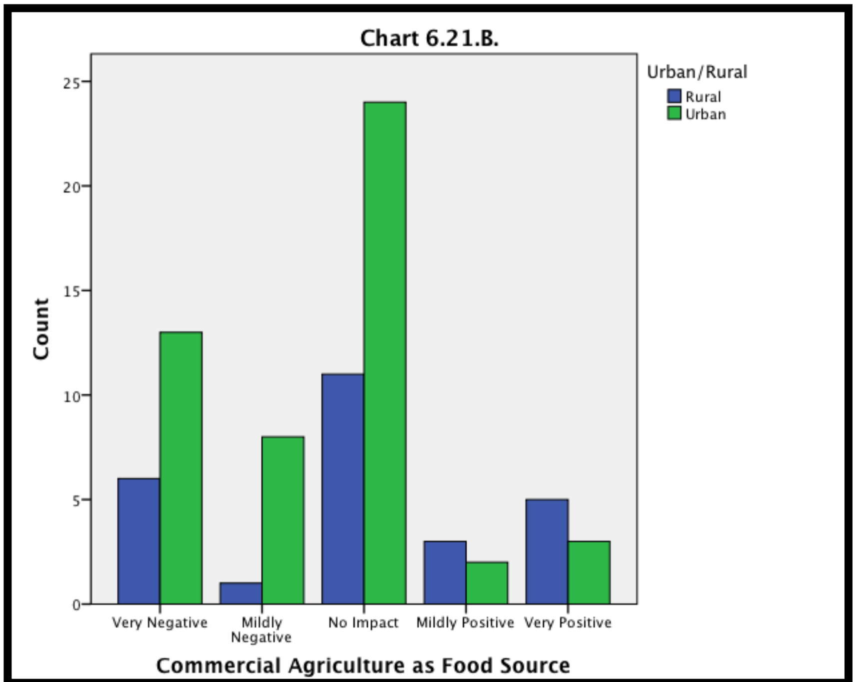


Chart 6.21.B.
Urban/Rural
Rural
Urban
Count
25
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Commercial Agriculture as Food Source

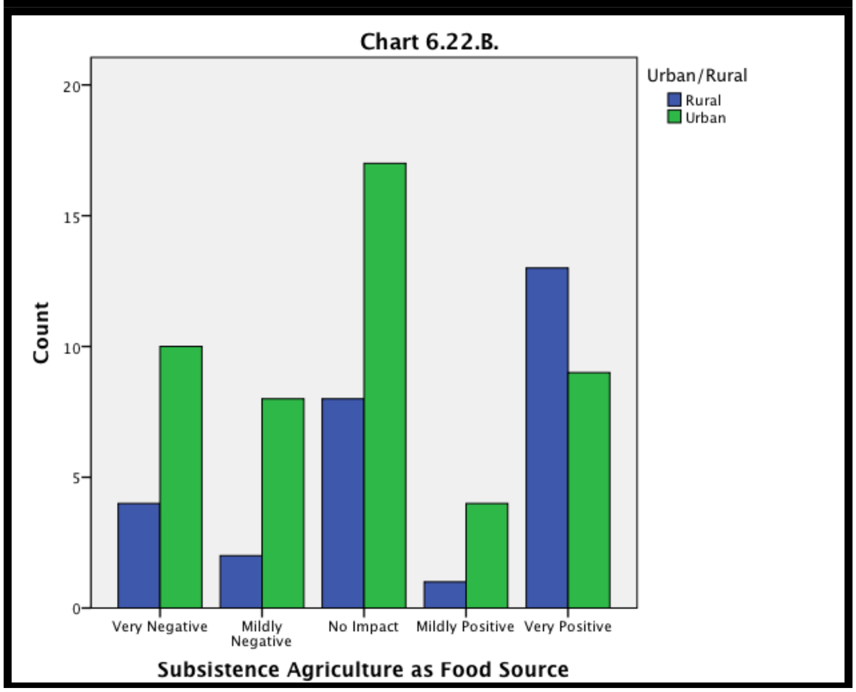


Chart 6.22.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Subsistence Agriculture as Food Source

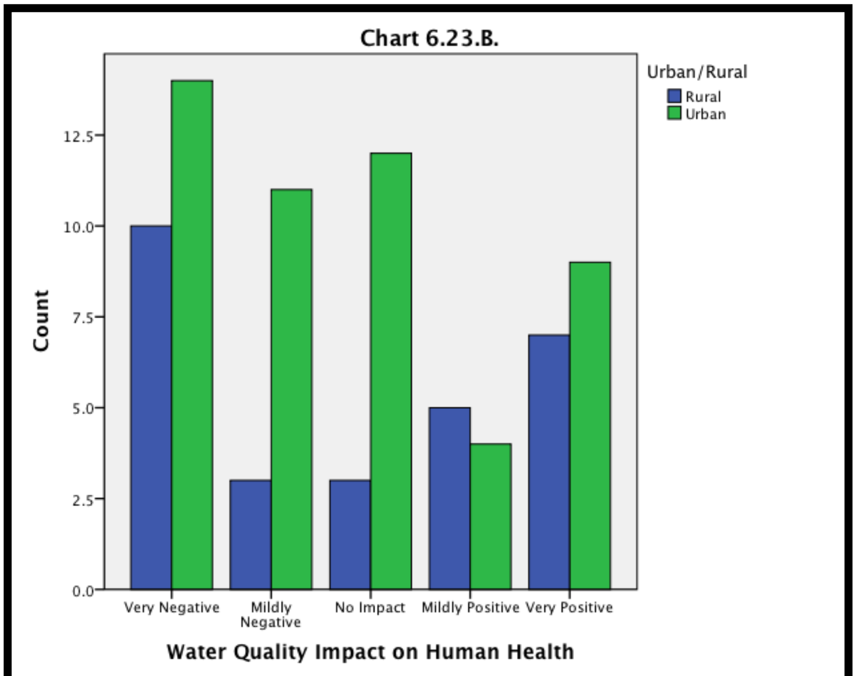


Chart 6.23.B.
Urban/Rural
Rural
Urban
Count
12.5
10.0
7.5
5.0
2.5
0.0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Water Quality Impact on Human Health

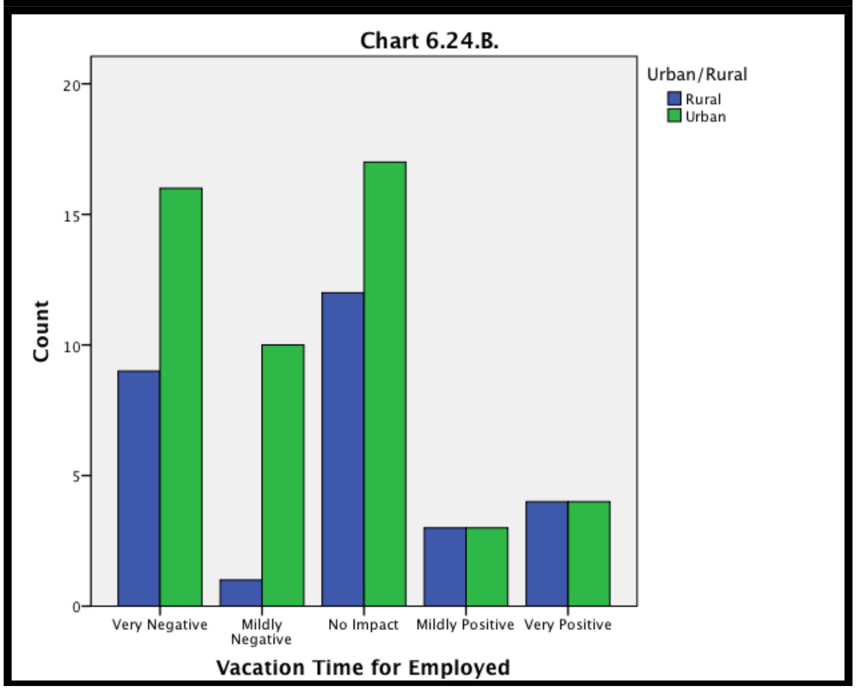
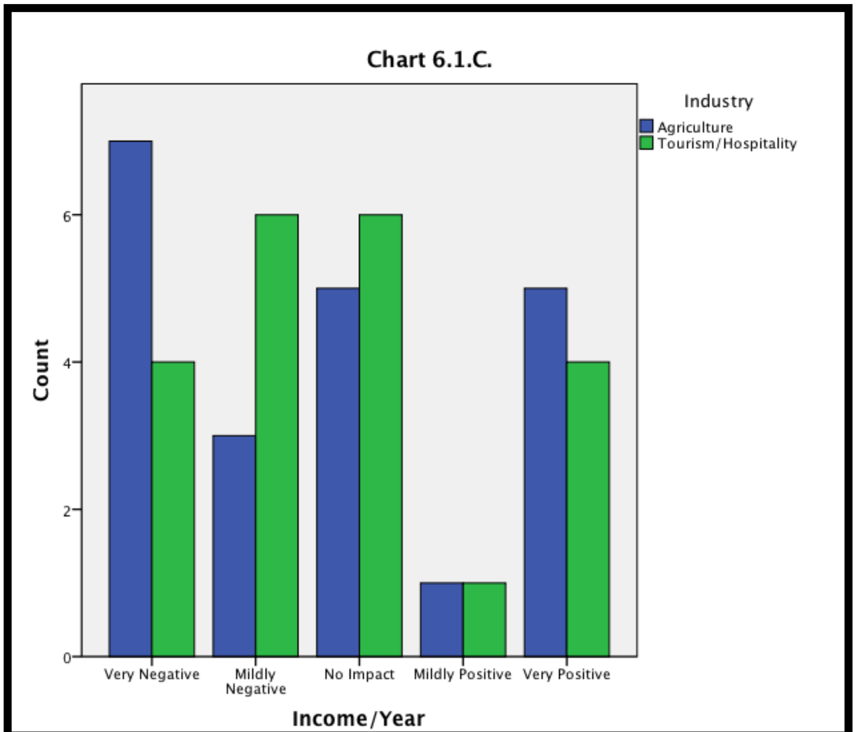
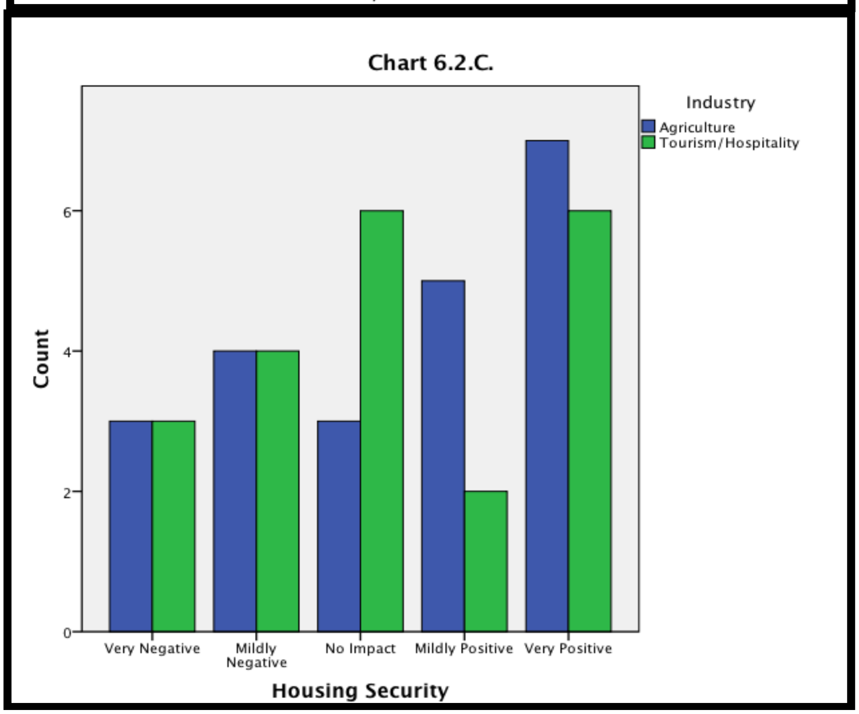


Chart 6.24.B.
Urban/Rural
Rural
Urban
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Vacation Time for Employed

Appendix 6.3 Bar Chart Results for Socioeconomic Indicators Comparing the Agricultural Industry and Tourism Industry Sample Groups (Charts 6.1.C. – 6.24.C)





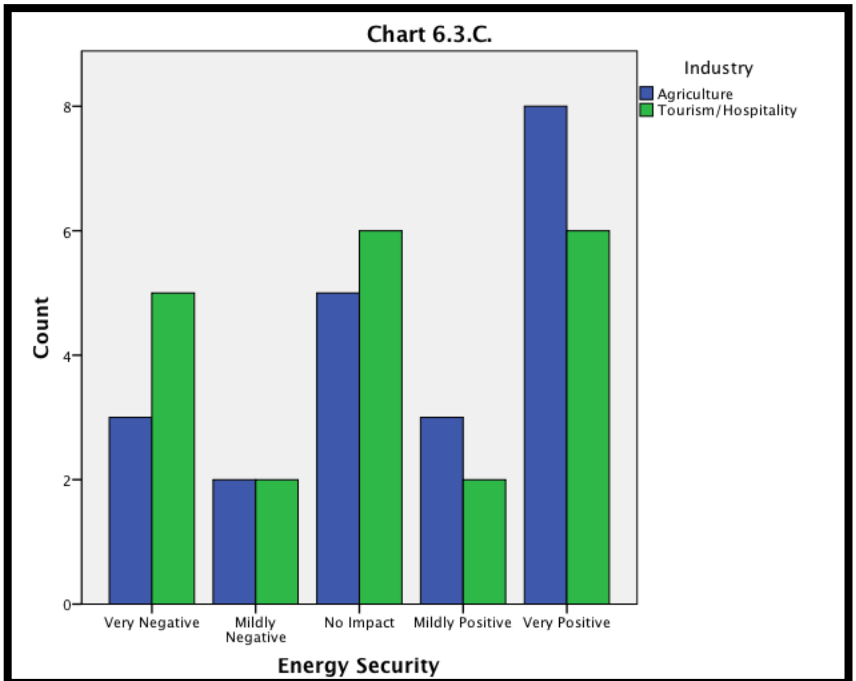


Chart 6.3.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Energy Security

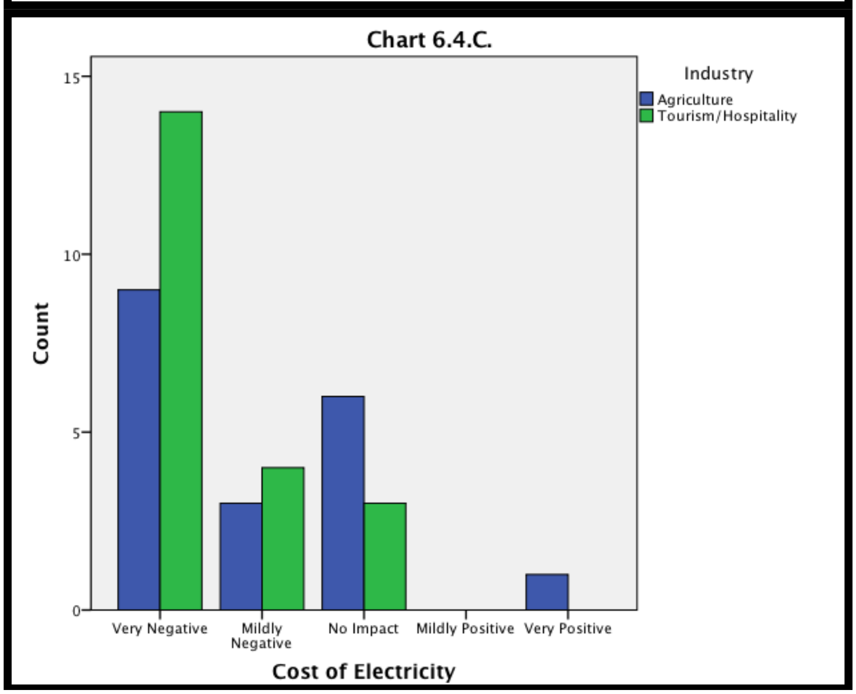


Chart 6.4.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
5
10
15
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Cost of Electricity

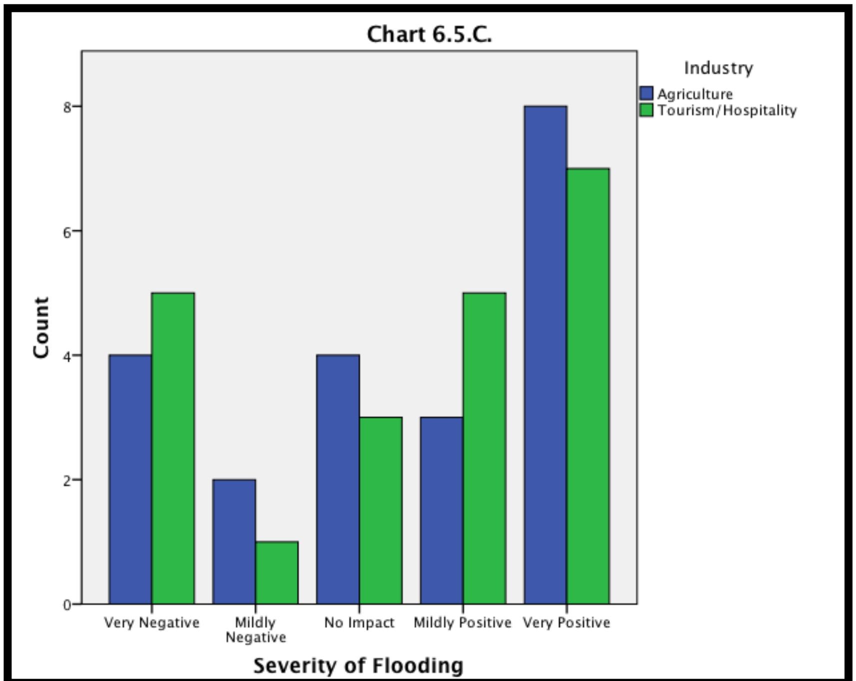


Chart 6.5.C.
Industry
Agriculture
Tourism/Hospitality
Count
8
6
4
2
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Severity of Flooding

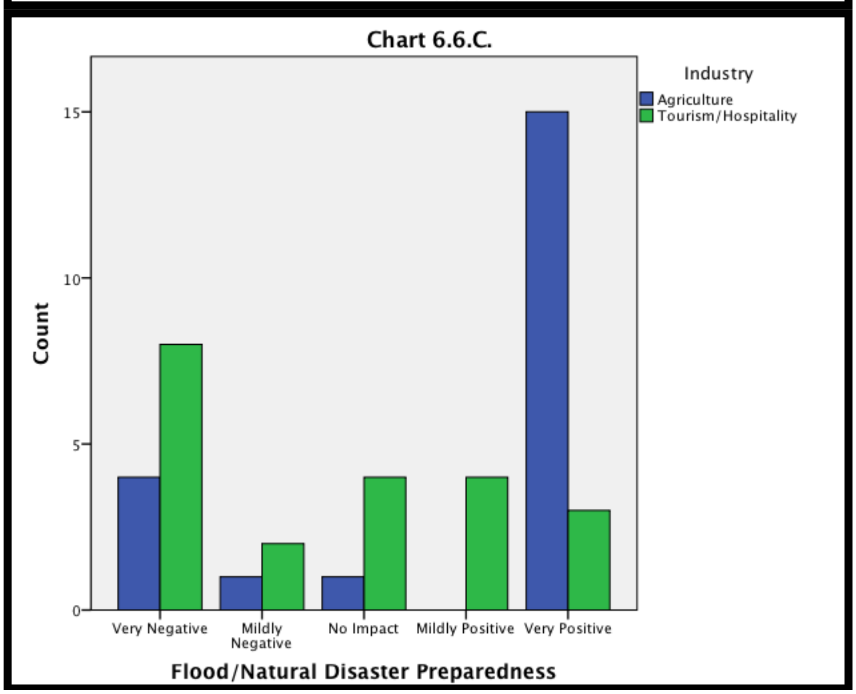


Chart 6.6.C.
Industry
Agriculture
Tourism/Hospitality
Count
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood/Natural Disaster Preparedness

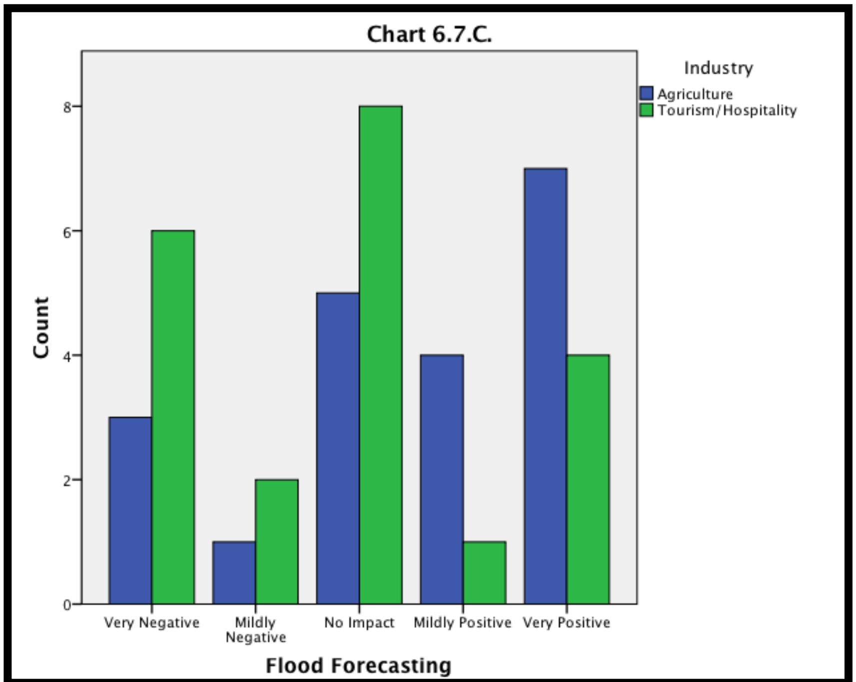


Chart 6.7.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood Forecasting

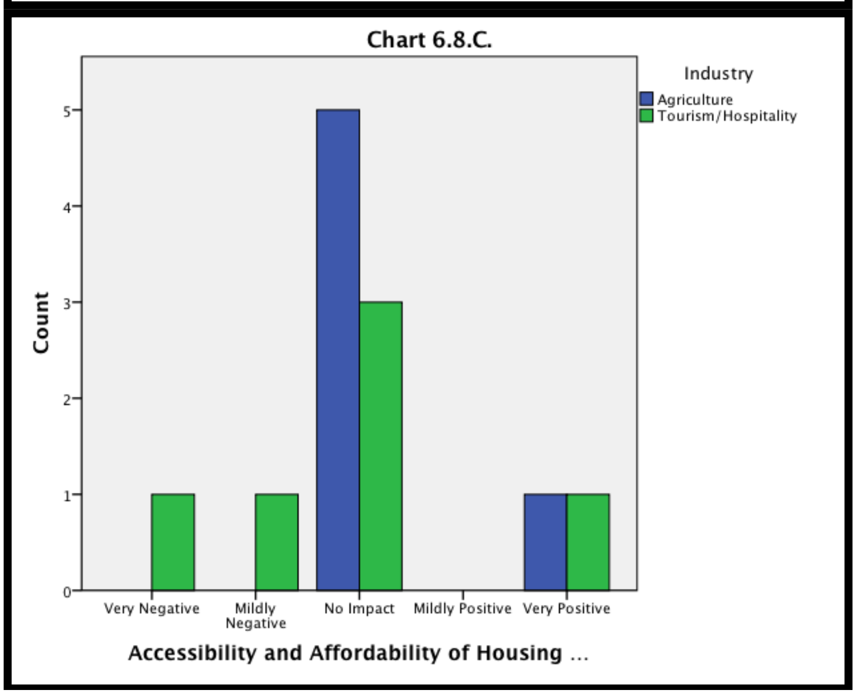


Chart 6.8.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
1
2
3
4
5
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Accessibility and Affordability of Housing ...

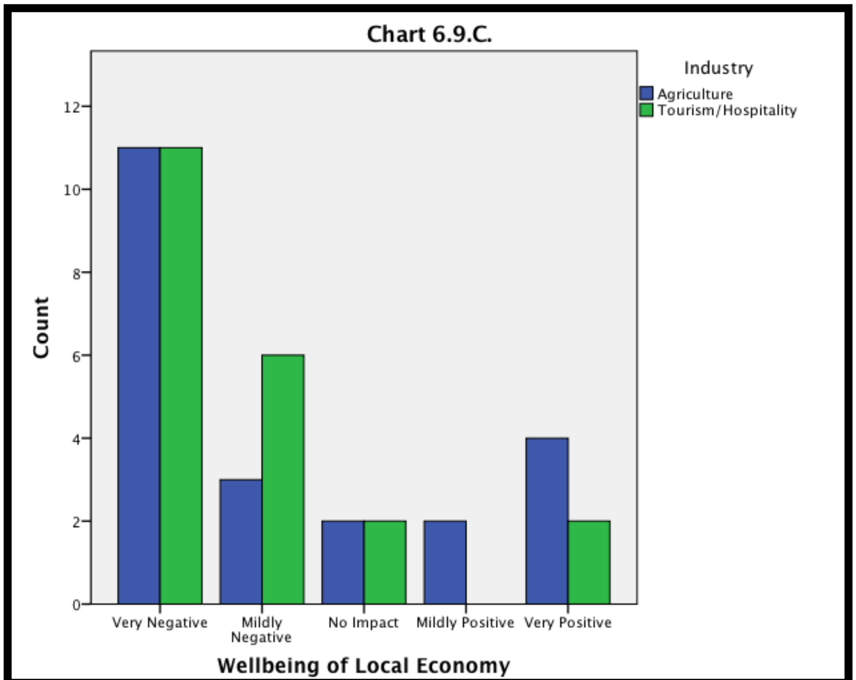


Chart 6.9.C.
Industry
Agriculture
Tourism/Hospitality
Count
12
10
8
6
4
2
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Wellbeing of Local Economy

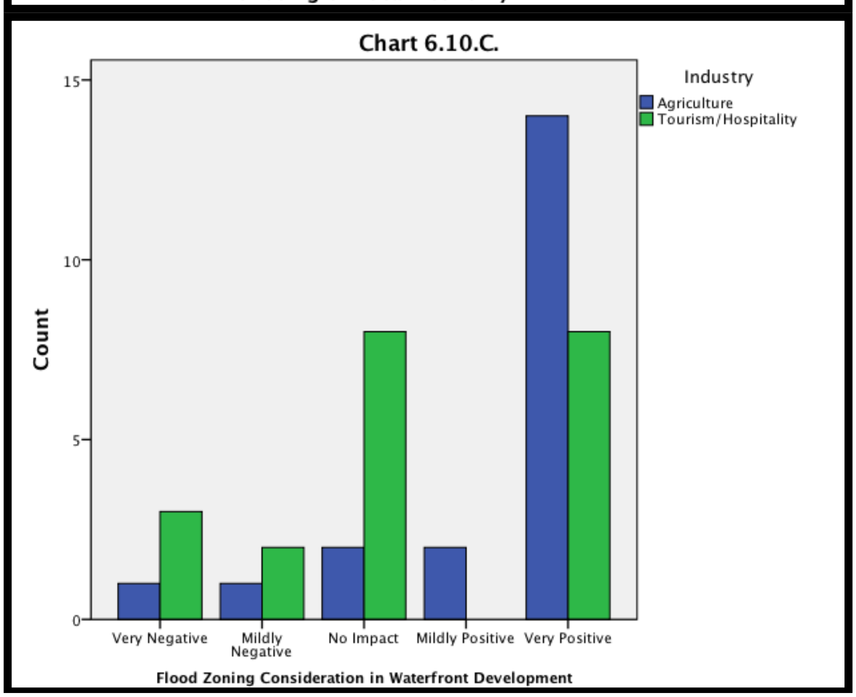


Chart 6.10.C.
Industry
Agriculture
Tourism/Hospitality
Count
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Flood Zoning Consideration in Waterfront Development

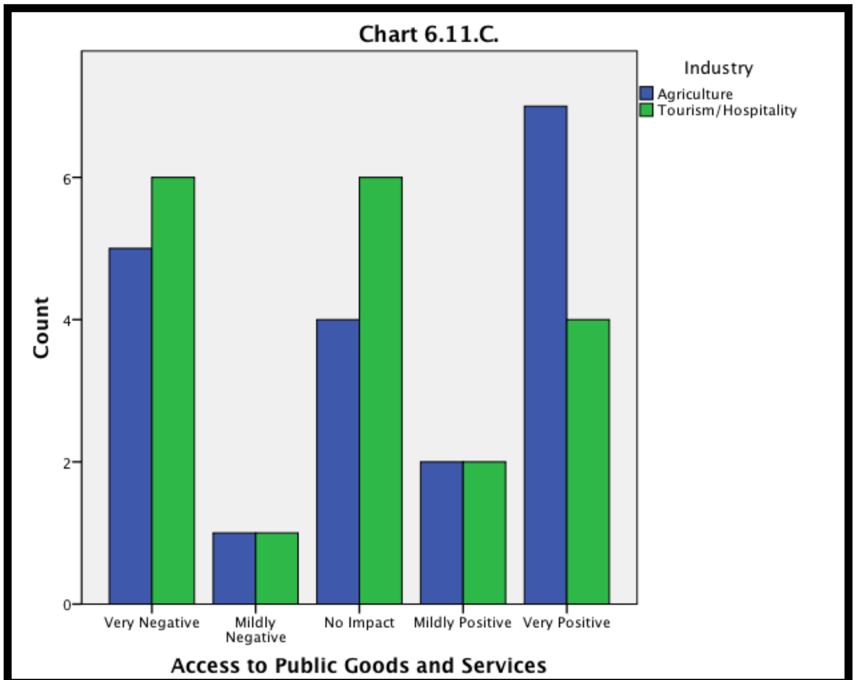


Chart 6.11.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Access to Public Goods and Services

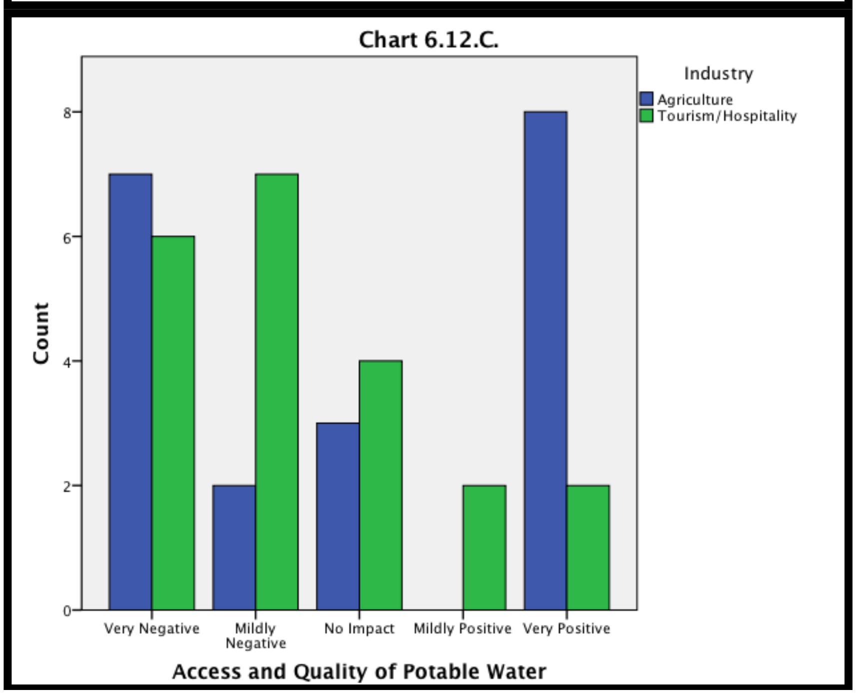


Chart 6.12.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Access and Quality of Potable Water

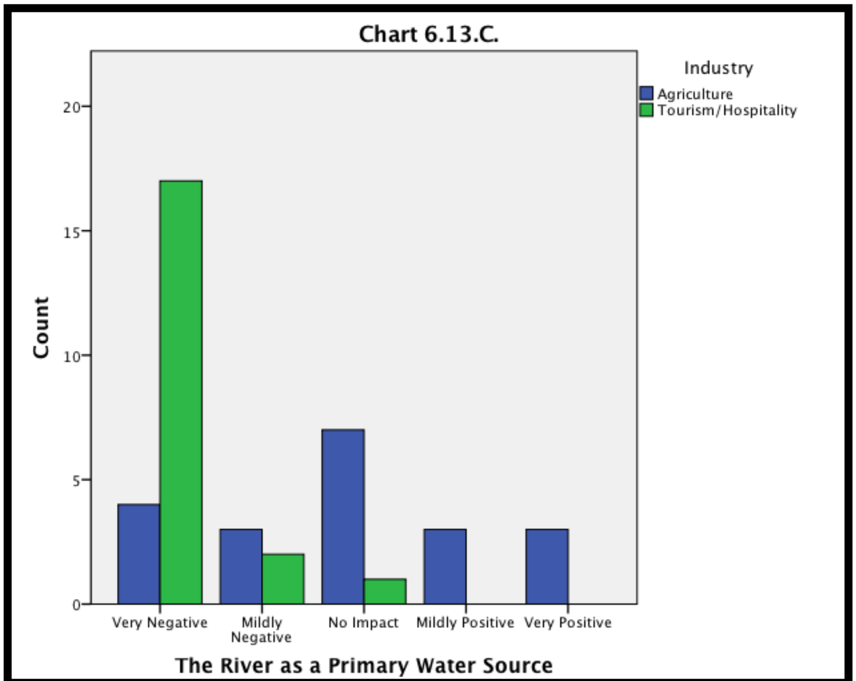


Chart 6.13.C.
Industry
Agriculture
Tourism/Hospitality
Count
20
15
10
5
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
The River as a Primary Water Source

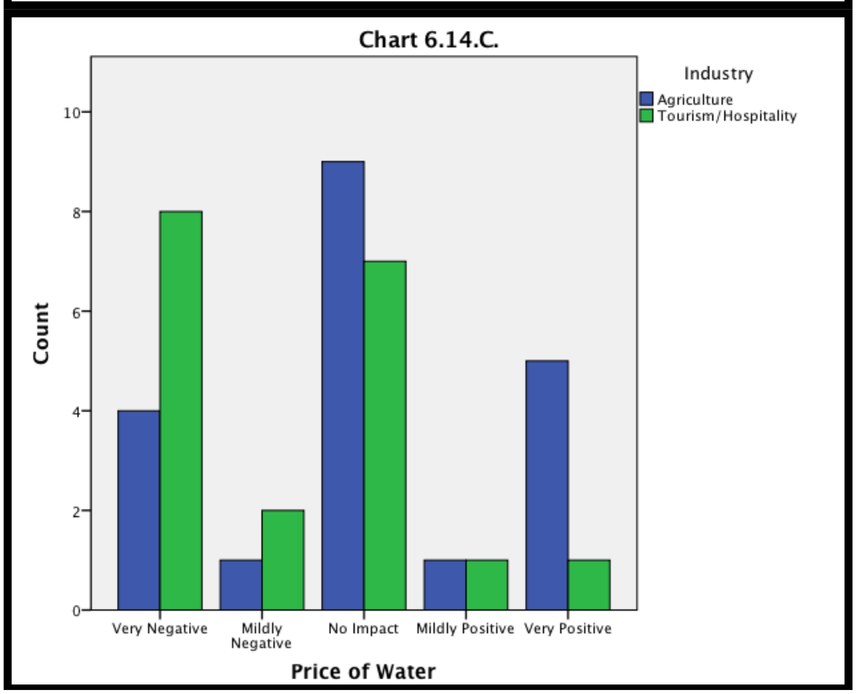


Chart 6.14.C.
Industry
Agriculture
Tourism/Hospitality
Count
10
8
6
4
2
0
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Price of Water

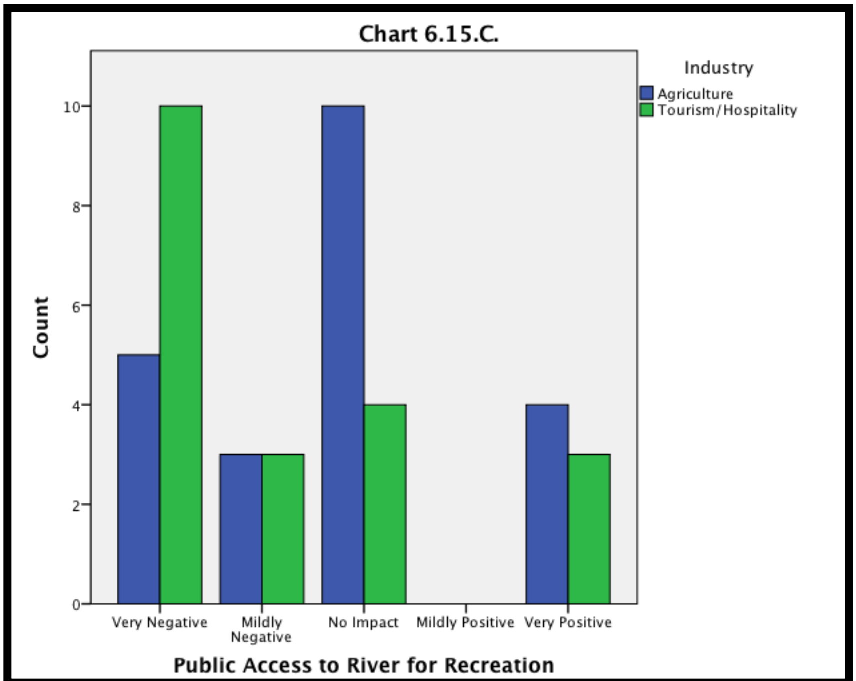


Chart 6.15.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
10
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Public Access to River for Recreation

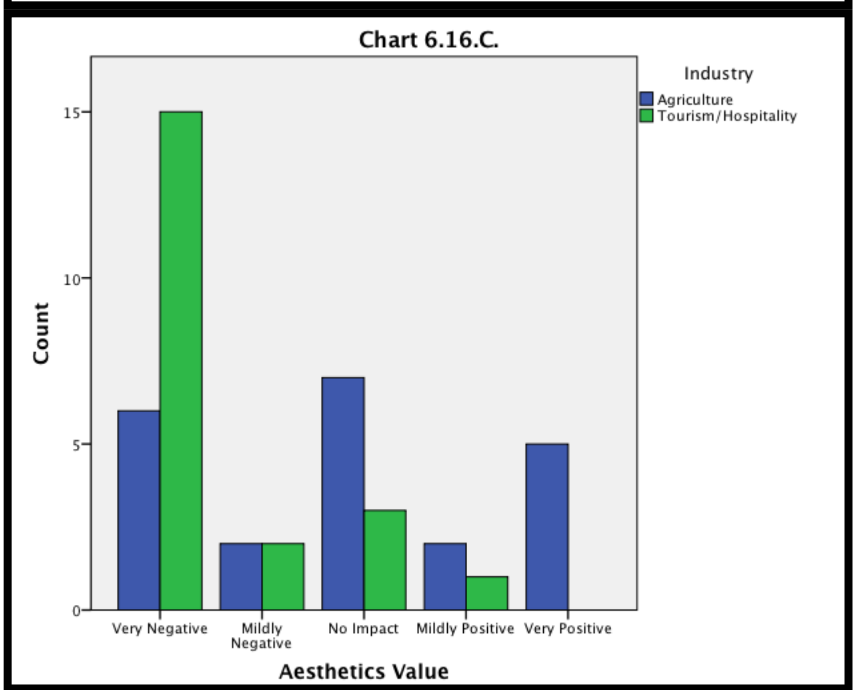


Chart 6.16.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
5
10
15
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Aesthetics Value

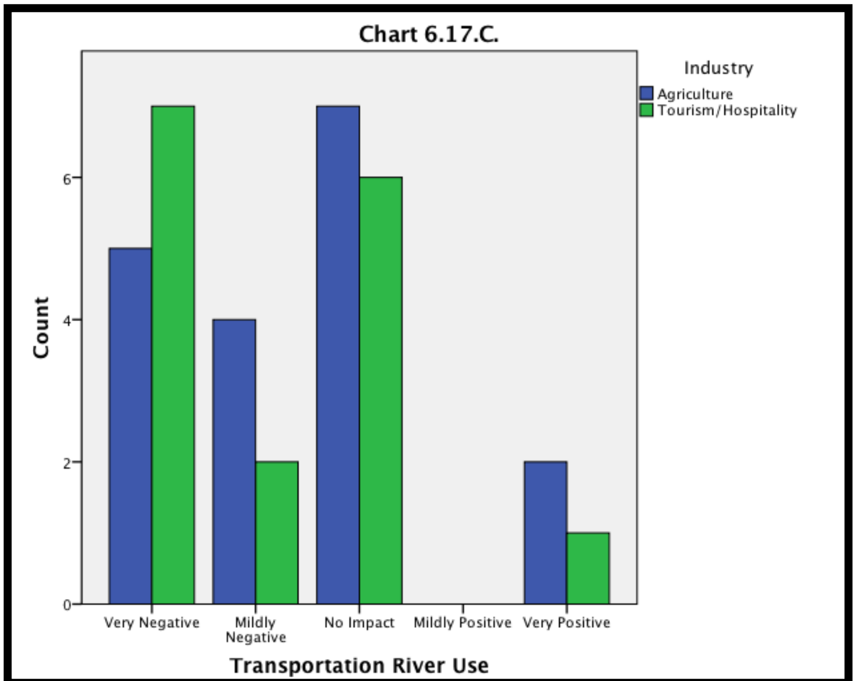


Chart 6.17.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Transportation River Use

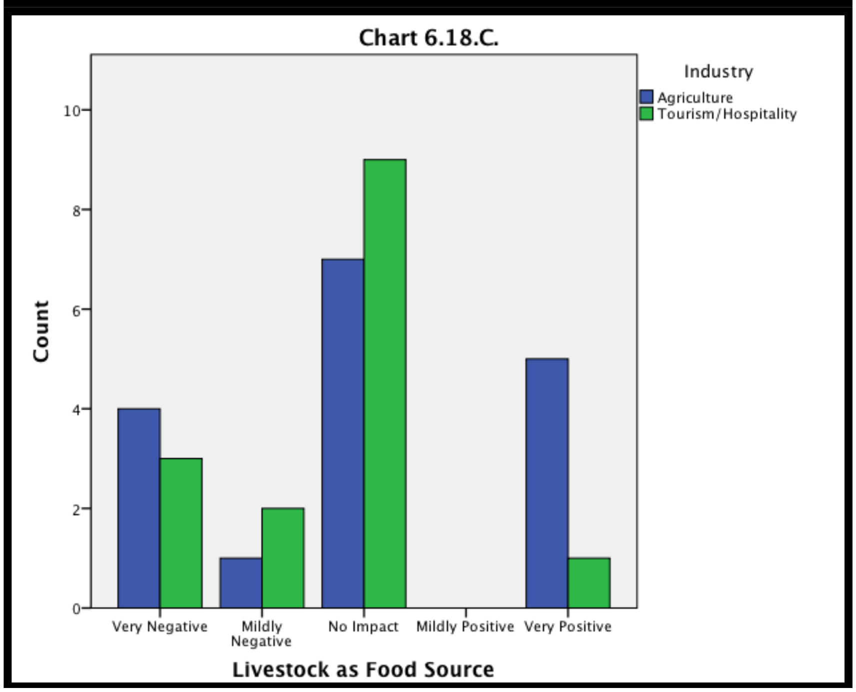


Chart 6.18.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
10
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Livestock as Food Source

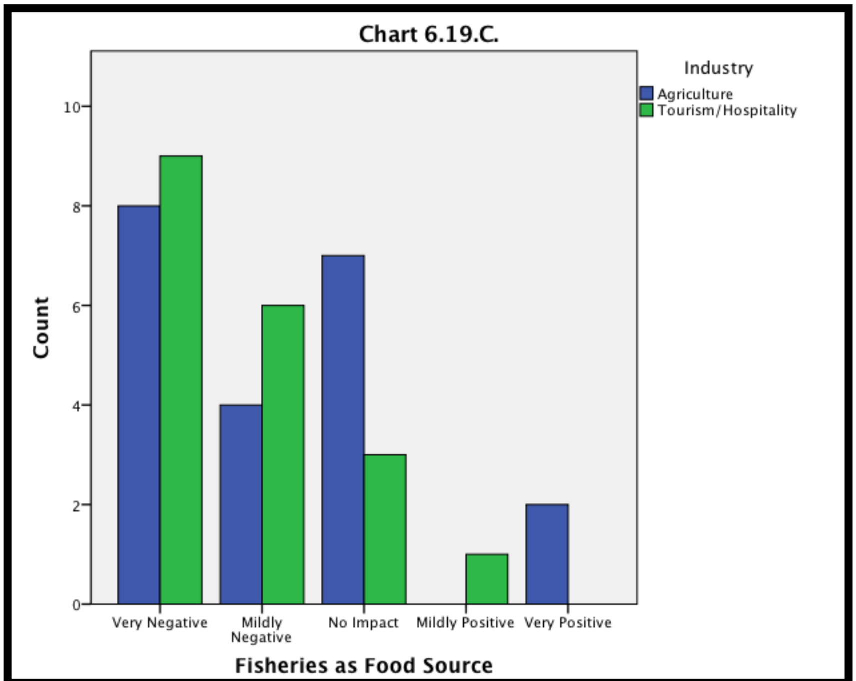


Chart 6.19.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
10
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Fisheries as Food Source

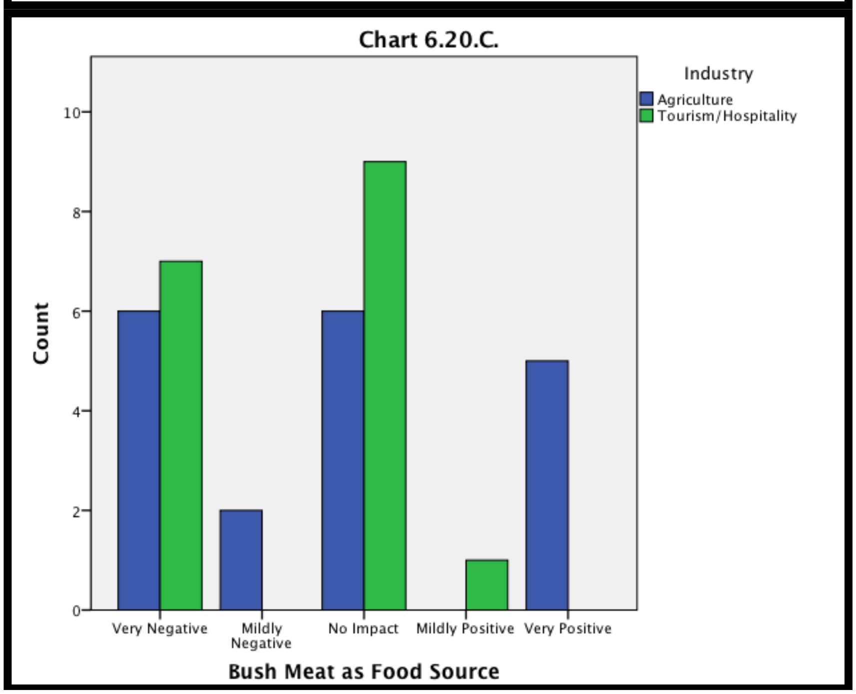


Chart 6.20.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
10
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Bush Meat as Food Source

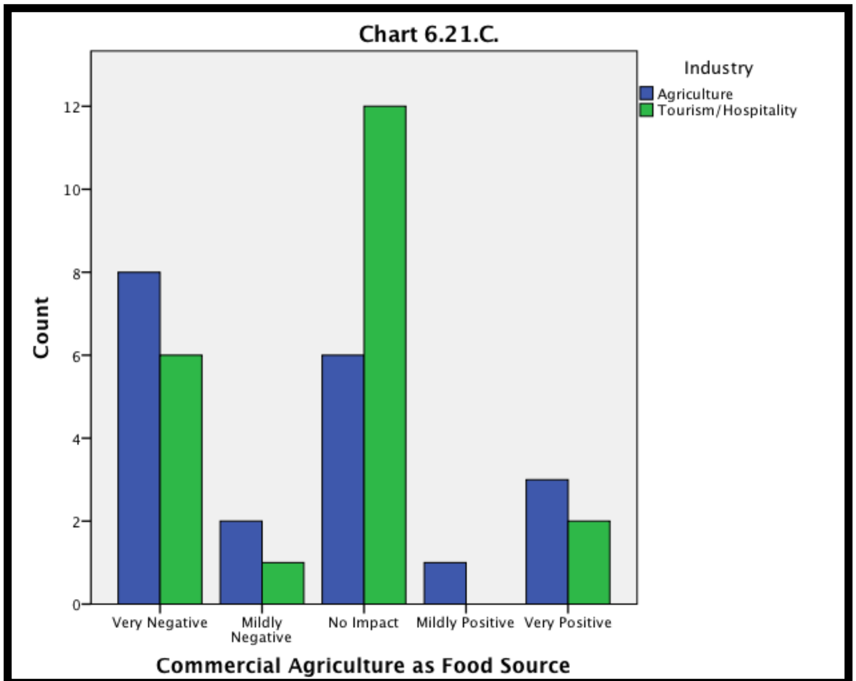


Chart 6.21.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
10
12
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Commercial Agriculture as Food Source

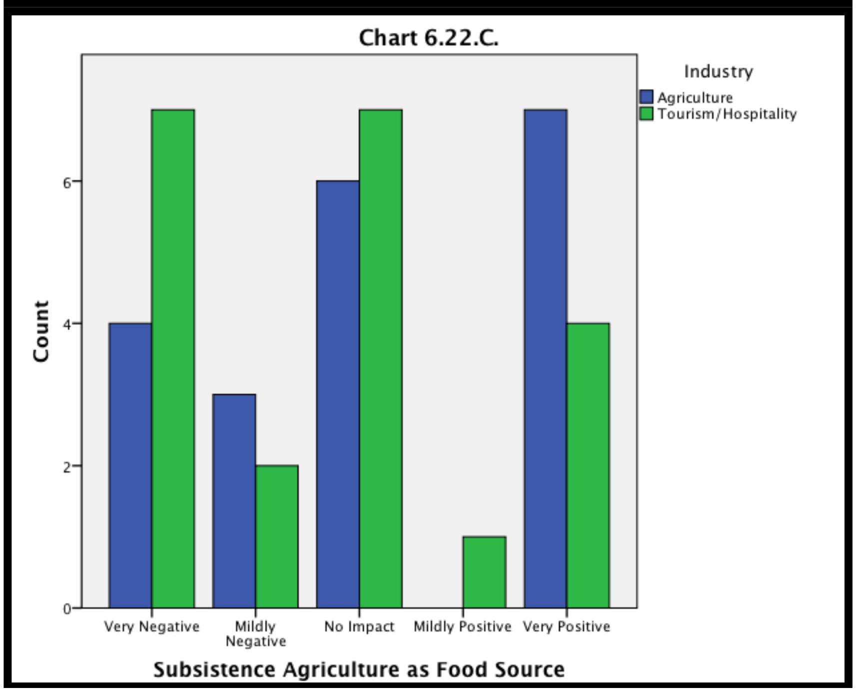


Chart 6.22.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Subsistence Agriculture as Food Source

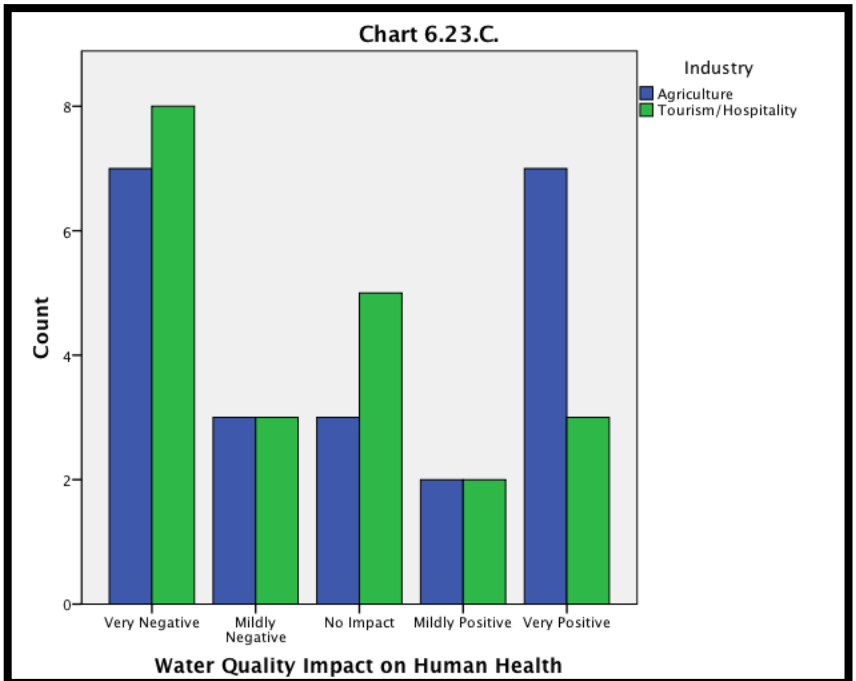


Chart 6.23.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Water Quality Impact on Human Health

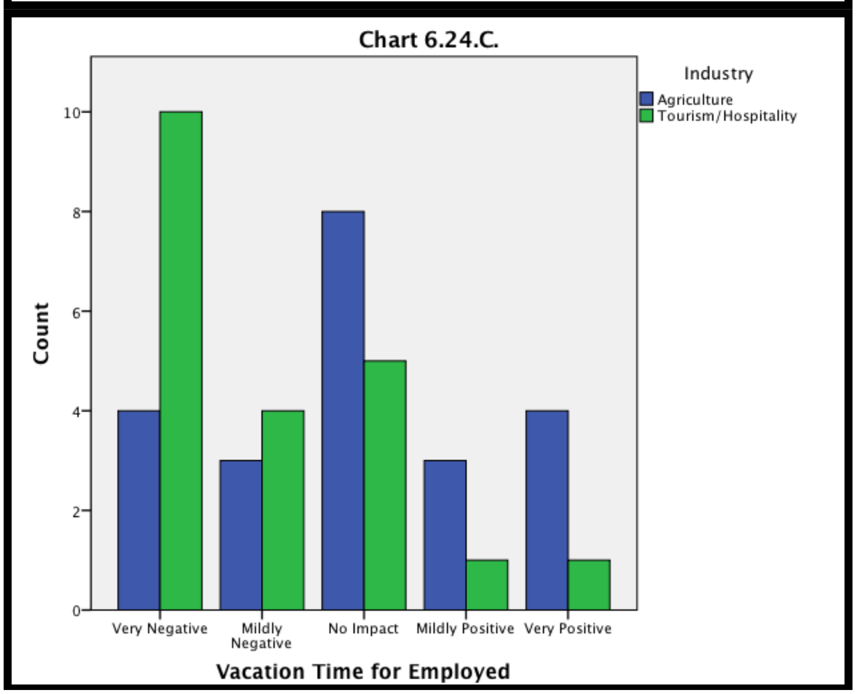


Chart 6.24.C.
Industry
Agriculture
Tourism/Hospitality
Count
0
2
4
6
8
10
Very Negative
Mildly Negative
No Impact
Mildly Positive
Very Positive
Vacation Time for Employed

Appendix 7.1 The Comparison of Sample Groups by Experienced Impact

		Sample Groups			
Socioeconomic Impact Indicators	**Total Sample**	**Rural**	**Urban**	**Agriculture**	**Tourism**
Income/year	mildly negative	no impact	no impact	mildly negative	mildly negative
Housing Security	no impact	mildly positive	no impact	mildly positive	no impact
Energy Security	mildly positive	no impact	mildly positive	mildly positive	no impact
Cost of Electricity	very negative	very negative	very negative	very negative	very negative
Severity of Flooding	mildly positive	mildly positive	mildly positive	mildly positive	mildly positive
Flood / Natural Disaster Preparedness	no impact	mildly positive	no impact	very positive	no impact
Flood Forecasting	no impact	no impact	no impact	mildly positive	no impact
Accessibility and Affordability of Housing Insurance	no impact	no impact	no impact	no impact	no impact
Wellbeing of Local Economy	very negative	mildly negative	very negative	very negative	very negative
Flood Zoning Consideration in Waterfront Development	very positive	mildly positive	very positive	very positive	no impact
Access to public goods and services	mildly positive	mildly positive	no impact	no impact	no impact
Potable Water Access and Quality	very negative	no impact	very negative	no impact	mildly negative
River Use as a Primary Water Resource	very negative	no impact	very negative	no impact	very negative
Price of water	no impact	no impact	no impact	no impact	mildly negative
Public Access for Recreational Use	mildly negative	mildly negative	very negative	no impact	very negative
Aesthetics Value of River	very negative	no impact	very negative	no impact	very negative
Transportation by River	no impact	no impact	no impact	mildly negative	very negative
Livestock as Food Source	no impact	no impact	no impact	no impact	no impact
Fisheries as Food Source	very negative	mildly negative	very negative	very negative	very negative
Bush meat as Food Source	mildly negative	mildly negative	no impact	no impact	no impact
Commercial agriculture as Food Source	no impact	no impact	no impact	mildly negative	no impact
Subsistence agriculture as Food Source	no impact	mildly positive	no impact	no impact	no impact
Water Quality Impact on Human Health	mildly negative	no impact	very negative	no impact	very negative
Vacation Time for Employed	no impact	no impact	mildly negative	no impact	very negative