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# We know not the worth of water until the well runs dry: Assessing municipal water use for fifteen incorporated cities in Hidalgo County, Texas for the years 1984-2005

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# WE KNOW NOT THE WORTH OF WATER UNTIL THE WELL RUNS DRY: ASSESSING MUNICIPAL WATER USE FOR FIFTEEN INCORPORATED CITIES IN HIDALGO COUNTY, TEXAS FOR THE YEARS 1984 - 2005

A Thesis

by

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ABSTRACT

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This paper studied municipal water use in fifteen incorporated cities of Hidalgo County, Texas using historical water use data provided by the Texas Water Development Board's *Texas Water Use Survey* for the years 1984 to 2005. The cities studied were Alamo, Alton, Donna, Edcouch, Edinburg, Elsa, Hidalgo, La Joya, La Villa, McAllen, Mission, Mercedes, Pharr, San Juan, and Weslaco. This paper examined five key areas that supported this study: population growth, city sales tax revenue, Gross Domestic Product, water demand, and water use. This research concludes with a set of recommendations to assist municipal leadership as they prepare for the future.

## DEDICATION

*I wish to dedicate this labor of love to the following:*

*To the Great Spirit* who every day showers us all with *His* blessings like tiny stars from heaven.

*To Mother Earth* who has lovingly bestowed upon *her* human children a stunning and miraculous place to inhabit.

*To my beautiful and loyal parents*, who in 2005 took a stroll together in a glorious garden, Edmundo Celso Montemayor and Irma Galvan Montemayor, my eternal gratitude for showing me why it is important to follow my head before I follow my heart, be wiser than smarter, stand tall against adversity, believe in myself, never forget my heritage or where I came from, smile in the rain as in the sunshine, embrace knowledge daily, and seek out life's truths, while defending them always.

*To my husband*, William, who took a chance on a small-town girl from deep South Texas, becoming my love and guiding light, I thank you for teaching me to think critically, question all the answers, assume nothing, and take nothing for granted.

*To my dear son*, whose love and loyalty are unmatched, Alexander, I thank you for being my guardian angel in this wonderful life.

*To my friends*, old and new, I offer my deepest appreciation for your loving *amistad* and generous support.

*To my peers*, my sincere thanks for four memorable years of shared scholastic enlightenment and warm camaraderie.

*To Dean Van Reidhead and Dr. Frederick Ernst*, a special recognition for assisting me through a harrowing time in my academic career to obtain a swift resolution and a well-deserved vindication.

*To my professors in the MPA Program*, I thank you all for the *positive* impact you made on my life: Dr. Cynthia E. Lynch, Dr. Aziza Zemrani, Mr. John R. Milford, Mr. Richard Montesdeoca, and last, but never least, Dr. Jose R. Hinojosa.

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This endeavor could not have been possible without the exceptional training, preparation, and field practice offered with every course taken in the MPA program. My academic journey has culminated into a thesis that adds to the greater body of work involving population growth, water use, water conservation, and water resource management and sustainability. I am very grateful for the opportunity to incorporate my interest in water, as a vital natural resource, into this laudable and scholarly effort.

I would like to close with a very special thanks to my husband, William, for his loving support, patience, and cooperation during the production of this thesis. From the long days and nights of researching, analyzing, and writing to those difficult times we experienced on this path to success I say to him: ¡Gracias, mi amor!

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# CHAPTER I

# INTRODUCTION

## Statement of Purpose

The purpose of this thesis is to examine the relationship between population growth and water use in fifteen incorporated cities of Hidalgo County in the Lower Rio Grande Valley of South Texas for the years 1984-2005. This topic is significant because water is a scarce resource. According to Postel (2000: 941), "a growing scarcity of fresh water relative to human demands is now evident in many parts of the world . . . with the world population projected to increase by an additional two billion people by the year 2030, finding ways to satisfy humanity's water demands . . . now ranks among the most critical and difficult challenges of the 21$^{st}$ century."

The historical water use data needed for this study are drawn from the Texas Water Development Board's *Texas Water Use Survey* for the years 1984 to 2005. These years were chosen because the Texas Water Development Board has conducted an annual water use survey since 1984. The fifteen incorporated cities in this study are: Alamo, Alton, Donna, Edcouch, Edinburg, Elsa, Hidalgo, La Joya, La Villa, McAllen, Mercedes, Mission, Pharr, San Juan, and Weslaco. Each of these cities participated in the water use survey from 1984-2005 and provided complete survey returns for all the years in the study.

The first chapter of this thesis is the Introduction. This section includes the description of the various chapters of this thesis as well as the research question and hypothesis statements examined in this study, the significance of the study, the definition of terms, and the assumptions and limitations of the study.

The second chapter reviews the literature that is relevant to this study. This chapter is divided into five key areas including population growth, city sales tax revenue, Gross Domestic Product, water demand, and water use.

The third chapter in this study is the methodology. This chapter includes a description of the fifteen incorporated cities of Hidalgo County, an explanation of the variables, a description of the techniques of data management and any procedures used. This chapter also discusses the reliability of the data and the data analysis techniques used.

The fourth chapter is the study's analysis of the data using the SPSS 17.0 statistical program (April 18, 2009). The fifth chapter discusses the major findings and offers policy recommendations for city leadership.

Background

The Lower Rio Grande Valley is the American side of the U.S.-Mexico border along the Rio Grande River in South Texas. The area has a uniquely vibrant and rich Mexican American cultural heritage. Due to the proximity of Mexico, both Spanish and English are commonly used in everyday life. Four counties that comprise the Lower Rio Grande Valley of South Texas are Cameron, Hidalgo, Starr, and Willacy. From its easternmost city, Mercedes, Hidalgo County is a little more than 50 miles inland from the Gulf of Mexico along the Texas-Mexico border. Hidalgo County is also approximately

240 miles south of San Antonio; roughly 350 miles south of Houston; around 140 miles northeast of Monterrey, Mexico; about 600 miles north of Mexico City, Mexico; and at its southern-most city, Hidalgo, the county is a little more than 2 miles from Reynosa, Mexico. According to the most recent U.S. Census Bureau data, Hidalgo County's estimated population size in 2008 was 726,604 (U.S. Census Bureau, 2008a, Population Finder – Hidalgo County, Texas).

Research Question and Hypothesis

The guiding research question for this study asks:

> How does population's growth impact water use for fifteen incorporated cities of Hidalgo County, Texas?

The hypothesis statements for this research can be expressed as:

> $H_0$: Population growth has no impact on water use.
>
> $H_1$: Population growth impacts water use.

This research controls for other factors that may impact water use, including regional economics and economic development.

Significance of the Research

This research focuses on how population growth in fifteen incorporated cities in Hidalgo County affects the amount of water used. There is a paucity of investigative studies, on this topic of study, which confirms that municipal water use in South Texas has captured little interest from potential researchers. This study will contribute to the greater body of knowledge on the topic of water resource management and sustainability at the municipal level. The research findings and recommendations offer municipal leadership assistance in dealing with the very real problems of water management by creating a greater awareness of their city's water resource management practices.

Definition of Terms

*Acre-foot (Acft)* is a measure utilized by the Texas Water Development Board in its studies and is defined as one foot of water covering one acre of ground equal to 325,851 gallons (Texas Water Development Board, 2009a, Frequently Asked Questions – Acre-foot).

*City Sales Tax* is a tax levied by a city on the retail price of an item, collected by the retailer (InvestorWords.com, 2009a, Sales Tax Entry).

*Gallons Per Capita Daily* (GPCD) is another measure for water consumption. It is the measurement of the amount of water used on a daily basis by water-consuming individuals. These estimates are intended for the express purpose of projecting the future water needs of each city (Texas Water Development Board, 2009b, Frequently Asked Questions – Gallons per Capita Daily).

*Gross Domestic Product* (GDP) is the total market value of all final goods and services produced . . . in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports (InvestorWords.com, 2009b, Gross Domestic Product Entry).

*Municipal Water Demand* is water to be used for municipal purposes in the future and includes residential, commercial, institutional and public use, but does not include sales to water-intensive manufacturing plants or to other municipal water suppliers (Texas Water Development Board, 2009b, Municipal Water Demand Entry).

*Population* is defined by Merriam-Webster's Dictionary Online (2009) as "the whole number of people or inhabitants in a country or region" (Merriam-Webster Online Dictionary, 2009, Entry 1a).

*Population Density* is "the measure of the intensity of land use, expressed as number of people per square kilometer or square mile . . . Also called density of population" (BusinessDictionary.com, 2009a, Population Density Entry).

*Population Growth* is the rate of natural growth, which represents the births and deaths in a country's population and overall growth, which takes migration into account (Rosenberg, 2009, ¶ 1).

*Scarcity* is the ever-present situation in all markets whereby either less goods are available than the demand for them (BusinessDictionary.com, 2009b, Scarcity Entry).

*Texas Water Development Board* (TWDB) was "created to provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas and to accomplish its goals of planning for the state's water resources and for providing affordable water and wastewater services, the TWDB provides water planning, data collection and dissemination, financial assistance and technical assistance services to the citizens of Texas" (Texas Water Development Board, 2008a, ¶ 1 - ¶ 2).

*Texas Water Use Survey* is conducted annually by the Texas Water Development Board Water Use Unit and through this survey acquires data on ground and surface water use by municipal and industrial entities within the state of Texas by collecting the volume of both ground and surface water used, the source of the water, water sales and other pertinent data from the users (Texas Water Development Board, 2008b, ¶ 1).

*Water Demand* is the future amounts of water expected to be needed in dry-year conditions, and the water amounts are listed in acre-feet per year with an acre-foot of water per year being roughly 900 gallons per day (Texas Water Development Board, 2009a, Water Demand Entry).

Assumptions and Limitations

This research is based on the following assumptions: (1) growth will continue at the same pace as recorded; (2) water use will stay constant on a per city basis; (3) the existing water supply system will be used and modernized as needed; and (4) no outside influences will adversely affect the quality of life if municipal leadership continue to maintain and manage their water supplies, while promoting city-wide conservation (Texas Water Development Board, 2006a: 85-90). It is also assumed that the Texas Water Development Board's historical water use data will assist in evaluating the impact of population on water use for fifteen incorporated cities of Hidalgo, County, Texas for the years 1984-2005.

This study is limited to those fifteen incorporated cities of Hidalgo County, Texas in the Lower Rio Grande Valley of South Texas who submitted a water use survey for the years 1984-2005. As previously stated, they are: Alamo, Alton, Donna, Edcouch, Edinburg, Elsa, Hidalgo, La Joya, La Villa, McAllen, Mercedes, Mission, Pharr, San Juan, and Weslaco. This study does not address any unincorporated areas of the county.

# CHAPTER II

## A REVIEW OF THE LITERATURE

The history of humankind and water is an intermingled one. Though water can exist without humans, humanity cannot say the same. Traditionally, human beings throughout the ages have attempted to harness the power of water, forcing it to bend against the innate course set by nature, and for the most part have been successful. Rivers, lakes, and streams have been manipulated to move in directions we deem fit for our wants and needs. Other sources, such as aquifers, have also been tapped into as a fresh water source. Regrettably, the over-development of land, coupled with other forms of anthropogenic influence, such as water pollution, has been detrimental to the natural environment.

As a required component to life, water is forever linked to humans in the great chain of life. The very nature of water denotes a life-giving component that refreshes, gratifies, and sustains all living things on the planet. Earth is known as the *Blue Planet* and with good reason. "About 70 percent of the Earth's surface is water-covered" and of "the vast majority of water on the Earth's surface, over 96 percent, is saline water in the oceans" (Perlman, 2008, ¶ 1 - ¶2). Moreover, water has become very important in the 21st century. Studying water and making use of the knowledge found may assist leaders around the world as they prepare for continued population growth.

The world's demand for water continues to increase making population growth and the value of water or the perception of water's value a heated topic for discourse. Adam Smith's *Water-Diamond Paradox* (also known as the *Classical Value Paradox*) has found a place in today's global discussion over water. Smith claimed that because diamonds are scarce, they have greater value than water, which can be found in abundance and is far more accessible than diamonds (Smith, 1776, Section I.4.13).

Today, Adam Smith's famous paradox will find many naysayers who will quickly take the position that water is becoming a rare commodity in certain parts of the world and is far more precious than any diamond. Water sustains all life and since not all regions of the world have readily accessible or clean water for human consumption and use, life is often threatened. Therefore, in places where water, especially clean water, is scarce, the value increases manifold. Smith's 200-year-old assertion that diamonds have greater value than water no longer applies to this modern world whose water needs and population are increasing every day.

Water Use in Hidalgo County in the Lower Rio Grande Valley of South Texas

For the past 30 years, Hidalgo County in the Lower Rio Grande Valley of South Texas has experienced a steady, but noticeable increase in population. U.S. Census Bureau data reveals that the population in 1990 was at 383,545, by 2000 that figure had augmented to 569,463, and in 2007, that number had reached 726,604, about a 28% rise, making it almost ¾ of a million people residing in the county (U.S. Census Bureau, 2008b, Second Bullet Point - View population trends). Extrapolating from these figures, Hidalgo County's projected population could peak to well over a million by 2020.

Historically, the Lower Rio Grande Valley of South Texas was mostly agrarian, but over time this has shifted. Long-time residents are witnessing an urban population explosion, as well as an increase in land development, both residential and commercial. In addition to the county's population growth, data from the Milken Institute has identified the border area of Hidalgo County, (McAllen-Edinburg-Mission MSA), as one of the fastest growing areas in the nation and ranked this metropolitan area as number seven in the nation for a second year in its *2008 Best Performing Cities – 200 Largest Metros* yearly report (Milken Institute, 2008).

Water supply planning gains momentum when municipal leadership, aware of continued population growth, moves with alacrity to prepare for future water needs. A forum sponsored by the Texas Center for Policy Studies that took place in Brownsville, Texas in 1999 revealed that "cities and counties long term will have to do water supply planning together" (Chapman and Cruz, 1999: 4-5). One study presented at the forum found water shortages and water pollution topped the list of the biggest environmental problems (Chapman and Cruz, 1999). This supports the conclusion that citizens in the Lower Rio Grande Valley of South Texas are concerned about water and its availability and usability.

The Texas Water Development Board refers to the region which contains Hidalgo County as *Region M.* A water survey is conducted regularly to assess the amount of water used within a year for the following sectors: municipal, manufacturing, mining, steam electric, irrigation, and livestock. Figure 1 gives the numbers for the 2006 *Water Use Survey* for all of Region M. As can be seen, Hidalgo County far surpasses all the other counties with a population size of 708,235 and the largest municipal water use amount, 113,387 acre-feet of water used (Texas Water Development Board, 2008a, Survey Summary Estimates).

FIGURE 1 – 2006 Municipal Water Use Survey Summary
Estimates in Acre-Feet
(Region M)

| Region | County | Population Estimates | Municipal |
|---|---|---|---|
| M | CAMERON | 389,571 | 72,973 |
| M | HIDALGO | 708,235 | 113,387 |
| M | JIM HOGG | 5,090 | 833 |
| M | MAVERICK | 52,162 | 8,783 |
| M | STARR | 62,432 | 8,917 |
| M | WEBB | 234,498 | 51,020 |
| M | WILLACY | 20,884 | 2,642 |
| M | ZAPATA | 14,125 | 3,021 |

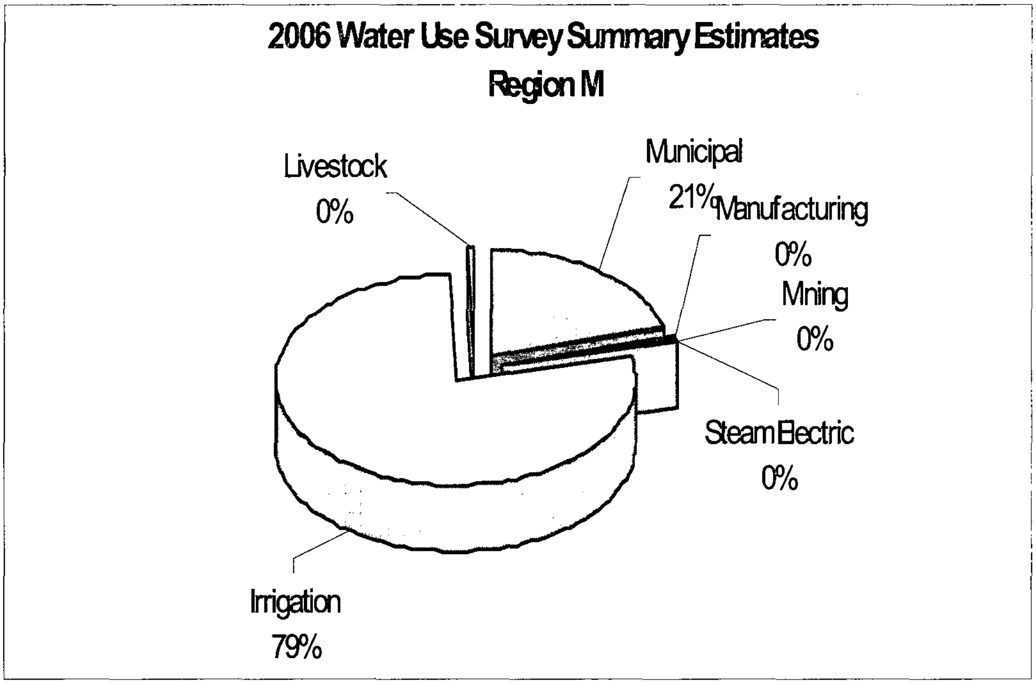
Source: Texas Water Development Board's *2006 Texas Water Use Survey*

(1.) An acre-foot is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.

(2.) 2006 Total Population Estimates for Texas counties as of July 1, 2006 from the Texas State Data Center.

The most available data taken from the Texas Water Development Board's Web site for Region M is for the year 2006. The *2006 Municipal Water Use Survey Summary Estimates for Region M* have been broken down in percentage numbers as shown in Illustration 1. The pie chart reveals that the irrigation sector used the greatest amount of water, 79% of the total. The second largest area of consumption was municipal water use, 21% of the total. Livestock, manufacturing, mining, and steam electric had a minimal impact on water use amounts. The Texas Water Development Board report states that estimates may be revised as additional or more accurate data becomes available through survey responses (Texas Water Development Board, 2008b, Pie Chart). Illustration 1 shows water use in the six sectors for Region M in the year 2006:

ILLUSTRATION 1 - 2006 Water Use Survey Summary Estimates
(Region M)




Source: Texas Water Development Board's *2006 Water Use Survey Summary Estimates* for Region M

Last updated on 8/30/2008 - Estimates may be revised as additional or more accurate data becomes available through survey responses.

The Texas Water Development Board provides historical ground water use data in acre-feet for water derived from the Gulf Coast aquifer, which lies underneath several counties, including Hidalgo County, Texas. The groundwater pumpage summary for Hidalgo County covers the years 1984 to 2003. Figure 2 shows columns for the year, municipal sector water use with its total, irrigation sector water use with its total, and the total for water use from both sectors for each year. Between the years 2000 and 2003 water use moved away from agriculture, while municipal water use increased with each year. As the data depicts, while water use fluctuates, municipal water use numbers have steadily risen since the year 2000. In contrast, irrigation water use numbers have steadily dropped since the year 2000 demonstrating that recent changes have taken place to transform the area from a rural-agricultural region to a more urbanized one. One possible reason for this shift may be that farmers are finding it more lucrative to sell their land to developers who in turn build housing to meet the needs of the population. Figure 2 displays the historical groundwater pumpage summary for Hidalgo County:

FIGURE 2 – Historical Groundwater Pumpage Summary for Hidalgo County -- Gulf Coast Aquifer

| Year | Municipal | Irrigation | Total |
|---|---|---|---|
| 1984 | 5357 | 8850 | 14,207 |
| 1985 | 4348 | 9957 | 14,305 |
| 1986 | 5355 | 0 | 5355 |
| 1987 | 4782 | 0 | 4782 |
| 1988 | 5055 | 0 | 5055 |
| 1989 | 5122 | 10932 | 16,054 |
| 1990 | 5739 | 20403 | 26,142 |
| 1991 | 6044 | 19795 | 25,839 |
| 1992 | 6119 | 8259 | 14,378 |
| 1993 | 5637 | 12912 | 18,549 |
| 1994 | 8041 | 14895 | 22,936 |
| 1995 | 8641 | 13224 | 21,865 |
| 1996 | 8859 | 8137 | 16,996 |
| 1997 | 7845 | 5783 | 13,628 |
| 1998 | 7814 | 11611 | 19,425 |
| 1999 | 6252 | 12017 | 18,269 |
| 2000 | 5620 | 4458 | 10,078 |
| 2001 | 7805 | 3734 | 11,539 |
| 2002 | 8665 | 3447 | 12,112 |
| 2003 | 8134 | 2000 | 10,134 |
| | Total 131234 | Total 170,414 | |

Source: Texas Water Development Board (2008)

As development increases, access to potable water then becomes the highest priority with local leadership scrambling to provide a safe and adequate water delivery service as they adjust to meet this growth. In the end, the underlying concern falls on water's future use and costs. This data ends with the year 2003. Yet for all intents and purposes, this information is still pertinent because it reveals a pattern of change that is occurring with water use over the course of twenty years (Texas Water Development Board, 2008a, Hidalgo County – Gulf Coast Aquifer Figure).

The state of Texas' *2007 State Water Plan* offers more information regarding water use in the state and breaks this survey down to regions. As a point of knowledge, the plan offers background information to support the state's reason for establishing and maintaining a yearly water plan. Taken from the Texas Water Development Board's second volume of their *Water for Texas 2007* report (2006b: 2), the following was written:

> Water is the lifeblood of Texas. It sustains our cities and rural communities, our farms and ranches, our businesses and industries, and our natural environment. Water is what will support the economic growth of the state. However, its water resources can be unpredictable, especially in droughts, and there is always a threat of prolonged drought in Texas. For example, the statewide drought of record that lasted almost eight years and ended 50 years ago in 1957 resulted in 244 of Texas' 254 counties being declared disaster areas. In addition to diminished water supplies during droughts, Texas must also contend with a rapidly growing population whose water demands could easily outstrip its water supplies. In response to the drought of the 1950s and in recognition of the need to plan for the future, the Legislature created the Texas Water Development Board (TWDB) to develop water supplies and prepare plans to meet the state's future water needs. In 1997, the Legislature established a new water planning process, based on a "bottom-up," consensus-driven approach. Coordinating this water planning process are 16 planning groups, one for each of regional water planning area.

Hidalgo County is subject to these regular state water surveys to assess water amounts and water use with the goal of providing a forecast of future water use, population growth, and demand. An issue that remains constant is how best to equip the state in case of a drought or from some other interference in the safe and adequate delivery of water.

This research used the *2006 Water Use Survey Estimates by City for Hidalgo County* and presents the water use information studied in this paper. The water use numbers are updated yearly with every survey that is conducted. When a city or a city's water supplier takes part in the annual survey, they contribute to the state's data management plan involving population growth and water use. The *2006 Water Use Survey* for Hidalgo County includes the cities of *Alamo*, *Alton*, *Donna*, *Edcouch*, *Edinburg*, *Elsa*, *Hidalgo*, *La Joya*, *La Villa*, *McAllen*, *Mercedes*, *Mission*, *Palmview*, *Pharr*, *Progreso*, *San Juan*, and *Weslaco*.

City water use data for Hidalgo County is divided into four columns: the city name, the city's population estimates, the city's municipal water use measured in acre-feet, and the city's gallons per capita daily (GPCD). Currently there are twenty-three incorporated cities of Hidalgo County, however only seventeen are listed in Figure 3 - *2006 Water Use Survey Summary Estimates by City (Hidalgo County)* because the focus of this study is on those cities that have municipal water use data from 1984 through 2005 (Texas Water Development Board, 2008c, Survey Summary Estimates). Newly incorporated cities do not meet this time frame requirement. This survey summary data is relevant because it shows that many of the listed cities had no municipal water use and GPCD returns for preceding survey years. This data is required by the state in order to identify and analyze the amounts of water used in cities and counties. Accurate and complete municipal water use data are important for determining future water use amounts and the associated costs.

FIGURE 3 – 2006 Water Use Survey Summary Estimates by City
(Hidalgo County)

| City Name | Population Estimates | Municipal Water in Acre-Feet | GPCD |
|---|---|---|---|
| Alamo | 17,876 | 1,574 | 79 |
| Alton | 8,587 | 1,391 | 145 |
| Donna | 17,430 | 2,117 | 108 |
| Edcouch | 4,076 | No Return | No Return |
| Edinburg | 66,138 | 6,992 | 94 |
| Elsa | 6,332 | No Return | No Return |
| Hidalgo | 10,627 | 1,355 | 114 |
| La Joya | 4,236 | 658 | 139 |
| La Villa | 1,386 | No Return | No Return |
| McAllen | 125,930 | No Return | No Return |
| Mercedes | 15,498 | No Return | No Return |
| Mission | 65,138 | No Return | No Return |
| Palmview | 5,056 | 735 | 130 |
| Pharr | 63,034 | 7,067 | 100 |
| Progreso | 5,736 | 413 | 64 |
| San Juan | 33,431 | No Return | No Return |
| Weslaco | 32,030 | No Return | No Return |

Source: Texas Water Development Board and Texas State Data Center

An Acre-Foot is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.

GPCD: Gallon Per Capita Daily.

No Return - The primary water utility for this city failed to return a 2006 water use survey.

Inevitably, population growth can become a deciding factor for how much water will be used. Hidalgo County, Texas is no less susceptible to water issue concerns than any other city around the state of Texas, the country or the world. Combined, it is the unique region, climate, and environment that set South Texas apart from the rest.

Along with water, population as an aggregate becomes a joint issue of concern for municipal leadership. With that said certain issue areas need to be addressed to be able to accurately forecast its use and cost. These key areas are: (1) *population growth*, (2) *city sales tax revenue*, (3) *Gross Domestic Product*, (4) *water demand*, and (5) *water use*.

Population Growth

In his decisive work, *The Tragedy of the Commons*, Hardin offers a scathing argument over the predictable, tragic outcome to the world's commons. Hardin (1968: 1244) defines the *Tragedy of the Commons* (TOC) as the following:

> The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy . . . Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

Hardin claims that "the rational man finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them . . . Since this is true of everyone, we are locked into a system of 'fouling our own nest,' so long as we behave only as independent, rational, free-enterprisers" (Hardin, 1968: 1245). An excess of freedom can only degrade the commons, leaving the collective's resources deficient or in disarray for future generations. Following Hardin's logic, we can expect population growth to continue to rise in this region, unabated, as long as economic growth continues to rise.

City Sales Tax Revenue

A city's sales tax generates needed revenue. This revenue increases as the population grows. The purchasing power of a population is taxed by sales from retailers, and cities benefit from the revenue produced. Pagano and Johnston add, "City and county revenue decisions are constrained not only by legal restrictions, but also by competition forces of other local governments . . . Governments compete to maximize their positions with regard to economic development, and these competitive strategies typically include tax competition" (Pagano, et al., 2000: 160).

Gross Domestic Product

The Gross Domestic Product of a region defines the economic strength of that region. This is especially true when discussing metropolitan areas. Borchert (1972: 358) writes:

> The metropolis is the capital of its nodal region by virtue of two roles. First, it is the dominant center for organizing the economy of the region: production, distribution, finance, and business services . . . Second, it makes the region more cosmopolitan.

As a region grows, so does its metropolitan area and financial district. A metropolitan area greatly influences the Gross Domestic Product and economic well-being of a region.

Water Demand

The demand for water will remain an important concern for municipalities who will be expected to supply water to a growing population. Steven Renzetti (1999: 699) states that "increasing incomes and growing urban populations are putting pressure on municipal water supply and sewage treatment facilities just as provincial and municipal governments struggle to cope with rising deficits and increasingly stringent water quality regulations." This demonstrates how critical the need is for municipal governments to make certain that water supply delivery keep pace with population growth and demand.

Water Use

The U.S. Geological Survey's *National Handbook of Recommended Methods for Water Data Acquisition* discusses the acquisition of water use data and measurements used. More importantly, it discusses the type of measurement used in this study, gallons per capita daily. It states the following:

> Water use can be expressed as an annual total in million gallons or acre-feet. More frequently, it is expressed as a daily rate. This daily rate represents the annual volume divided by 365 days . . ." (U.S. Geological Survey, 2009, Chapter Section 11.B.4).

For a municipality, the measurement of *gallons per capita daily (GPCD)* is useful because local leadership can gauge water use amounts by annual population estimates.

# CHAPTER III

# METHODOLOGY & ANALYSIS

## Introduction

The data for this thesis were taken from the Texas Water Development Board's (TWDB) *Texas Water Use* Survey Web site on March 17, 2008 (http://www.twdb.state.tx.us/wushistorical/) and the Texas Comptroller of Public Accounts Web site on April 6, 2009 (http://www.window.state.tx.us/taxinfo/sales/).

This chapter describes the steps that make up this research design and each is discussed in detail separately. Where appropriate, each section includes definitions of the variables, procedures followed, and the statistical techniques used in the data analysis.

As stated in Chapter 1, the research question for this thesis is: How does population's growth impact water use for fifteen incorporated cities of Hidalgo County, Texas over a period of twenty-two years (1984-2005)? Survey data for the year 2006 had missing data for the cities of Edcouch, Elsa, La Villa, McAllen, Mercedes, Mission, San Juan, and Weslaco and so was not used in this research. Survey data for the years 2007 and 2008 were not made available on the Texas Water Development Board's Web site.

As the literature in Chapter II indicated, there are five key areas for this study on municipal water use: (1) population growth (Hardin, 1968), (2) city sales tax revenue

(Pagano, et al., 2000), (3) Gross Domestic Product (Borchert, 1972), (4) water demand (Renzetti, 1999), and water use in gallons per capita daily (U.S. Geological Survey, 2009, Chapter section 11.B.4). While GDP and water demand are specified in the literature as important, the data were not included because the GDP data for the region only covered six years (2001-2006) and the water demand data were not available.

Unit of Analysis

The unit of analysis for this study are those incorporated areas of fifteen cities in Hidalgo County, Texas. Figure 4 lists the cities in this study with their most current *geographic size* and *population density* (TX HomeTownLocator.com, 2009). They were selected for this study because they provided continuous water use data, from 1984-2005.

FIGURE 4 – City Fact Sheet for Hidalgo County, Texas

| City | Geographic Size | Population Density |
|---|---|---|
| Alamo | 5.72 sq. miles | 2,580.80 people per sq. mile |
| Alton | 2.11 sq. miles | 2,075.49 people per sq. mile |
| Donna | 5.04 sq. miles | 2,929.53 people per sq. mile |
| Edcouch | 0.94 sq. miles | 3,573.86 people per sq. mile |
| Edinburg | 37.37 sq. miles | 1,296.93 people per sq. mile |
| Elsa | 1.48 sq. miles | 3,756.83 people per sq. mile |
| Hidalgo | 4.35 sq. miles | 1,682.24 people per sq. mile |
| La Joya | 2.78 sq. miles | 1,187.59 people per sq. mile |
| La Villa | 0.27 sq. miles | 4,870.42 people per sq. mile |
| McAllen | 45.97 sq. miles | 2,314.66 people per sq. mile |
| Mercedes | 8.58 sq. miles | 1,591.23 people per sq. mile |
| Mission | 24.13 sq. miles | 1,881.91 people per sq. mile |
| Pharr | 20.83 sq. miles | 2,240.25 people per sq. mile |
| San Juan | 11.01 sq. miles | 2,382.98 people per sq. mile |
| Weslaco | 12.69 sq. miles | 2,123.09 people per sq. mile |

Source: Texas Home Town Locator – Hidalgo County, Texas Cities, Towns, & Neighborhoods (2009)

Description of Variables

As previously discussed in Chapter II population growth (Hardin, 1968), gallons per capita daily or water use (U.S. Geological Survey, 2009, Chapter section 11.B.4), and city sales tax revenue (Pagano, et al., 2000) are the variables used in this study. Figure 5 depicts the (1) Dependent variable, (2) Independent variable, and (3) Control variable and their codes.

FIGURE 5 – Variables

| # | Item | Variable Code |
|---|---|---|
| **1** | **gallons per capita daily** | ***gpcd*** |
| **2** | **population of city** | ***population*** |
| **3** | **city sales tax revenue** | ***salestax*** |

Source: Texas Water Development Board – *Items* from Texas Water Use Survey

Dependent Variable - Gallons per Capita Daily (Water Use)

Water use, as operationalized by per capita gallon daily, is the Dependent variable for this research. *Gallons per Capita Daily* or GPCD is the measurement "more frequently used" in order to acquire the daily water use estimates from a municipality (U.S. Geological Survey, 2009, Chapter Section 11.B.4). The state of Texas through the Texas Water Development Board conducts its annual water use survey that requires public water suppliers to enter daily water use amounts in gallons. As previously stated, this research examines the relationship between water use and population growth.

Independent Variable - Population Growth

*Population growth* is the Independent variable for this research. The literature surveyed (Hardin, 1968) showed that there is a relationship between water use and population growth. This research intends to examine this relationship using statistical analysis. As previously stated, the researcher hypothesized that as the population grows or increases, so will water use. In other words, the Dependent variable [water use] will be influenced or impacted by the Independent variable [population growth]. Garrett Hardin expressed that population growth directly affects natural resources, what he calls *the commons*, such as water and therefore, water use should be monitored closely in the face of continued population growth and water scarcity (Hardin, 1968).

Control Variable - City Sales Tax Revenue

This research examines the relationship between per capita daily water use and population growth. However, in statistics or applied research there is no such thing as a perfect relationship. As such, this research appreciates that other variables may interfere with this relationship. To use all the different variables that might impact this relationship is beyond the scope of this thesis. The researcher selected *city sales tax revenue* as the Control variable. Healey (2005) states that in any bivariate relationship the researcher needs to proceed by observing the effects of other variables on the bivariate relationship. That is, this research will observe the relationship between the Independent variable [population growth] and the Dependent variable [water use] after a third variable [city sales tax revenue] is controlled for.

City sales tax revenue data (1986-2006) was used as a proxy for the GDP data for the McAllen-Edinburg-Mission MSA (2001-2006) because not enough GDP data are available to make an impact on the study (Bureau of Economic Analysis, 2008). The term *proxy* is used to show that city sales tax revenue is a good substitute for GDP. Twenty years of city sales tax revenue data used for this study were taken from the Texas Comptroller of Public Accounts Web site (http://www.window.state.tx.us/taxinfo/sales/).

Data Management

The primary data for this study were acquired from the TWDB's *Texas Water Use Survey*, and it involved fifteen incorporated cities of Hidalgo County in the Lower Rio Grande Valley of South Texas for the years 1984-2005. The survey data were entered into the SPSS version 17.0 statistical program and then analyzed. The *Texas Water Use Survey* data are assumed to be accurate and are publicly available via the Texas Water Development Board Web site (http://www.twdb.state.tx.us/wushistorical/).

Procedure

The Texas Water Development Board's *Texas Water Use Survey* is conducted annually since 1984. The water use survey data are divided into three categories: (1) population of city, (2) acre-feet of water used, and (3) gallons per capita daily.

The variables for this research are measured at the continuous level. Continuous scales were used for population growth and water use for the years 1984-2005 and city sales tax revenue for the years 1986-2005. The cities of Edcouch, Elsa, La Villa, McAllen, Mercedes, Mission, San Juan, and Weslaco did not provide data for daily gallons per capita water use after the 2005 water use survey. As previously mentioned, the 2006 data were left out of this study because of this missing data. City sales tax revenue data for the years 1984 and 1985 were not available.

Reliability of the Data

The water use data collected by the Texas Water Development Board are assumed to be reliable. "The TWDB Water Uses Section conducts the annual survey of ground and surface water use to collect current, accurate information on quantities, sources, and related water use data for municipal . . . water users" (Texas Water Development Board, 2009b, ¶ 1). Analysis of this data will be discussed in the Descriptive Statistics section of this chapter.

Descriptive Statistics

This section presents the Descriptive Statistics for each of the fifteen incorporated cities in this study. They include the *Texas Water Use Survey* data for *population growth* and *gallons per capita daily (water use)* and the Texas Comptroller of Public Accounts' Allocation Payment Historical data for *city sales tax revenue.*

Alamo

Table 1 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Alamo. As can be seen in this table, for 22 years Alamo had an average population of 11,671 and an average per capita daily water use of 101.73 gallons. For 20 years, the city has an average annual city sales tax revenue of $643,745.34.

Table 1 - Alamo

| | N | Mean |
|---|---|---|
| population of city | 22 | 11671.00 |
| gallons per capita daily | 22 | 101.73 |
| city sales tax revenue | 20 | 643745.3400 |
| Valid N | 20 | |

Alton

Table 2 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Alton. As can be seen in this table, for 22 years Alton had an average population of 4,280 and an average per capita daily water use of 157.77 gallons. For 20 years, the city has an average annual city sales tax revenue of $95,033.65.

Table 2 - Alton

| | N | Mean |
|---|---|---|
| population of city | 22 | 4279.59 |
| gallons per capita daily | 22 | 157.77 |
| city sales tax revenue | 20 | 95033.6515 |
| Valid N | 20 | |

Donna

Table 3 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Donna. As can be seen in this table, for 22 years Donna had an average population of 14,019 and an average per capita daily water use of 130.45 gallons. For 20 years, the city has an average annual city sales tax revenue of $566,097.08.

Table 3 - Donna

| | N | Mean |
|---|---|---|
| population of city | 22 | 14019.36 |
| gallons per capita daily | 22 | 130.45 |
| city sales tax revenue | 20 | 566097.0805 |
| Valid N | 20 | |

Edcouch

Table 4 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Edcouch. As can be seen in this table, for 22 years Edcouch had an average population of 3,600 and an average per capita daily water use of 107.73 gallons. For 20 years, the city has an average annual city sales tax revenue of $56,658.88.

Table 4 - Edcouch

| | N | Mean |
|---|---|---|
| population of city | 22 | 3600.00 |
| gallons per capita daily | 22 | 107.73 |
| city sales tax revenue | 20 | 56658.8790 |
| Valid N | 20 | |

Edinburg

Table 5 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Edinburg. As can be seen in this table, for 22 years Edinburg had an average population of 40,133 and an average per capita daily water use of 130.05 gallons. For 20 years, the city has an average annual city sales tax revenue of $4,883,506.

Table 5 - Edinburg

| | N | Mean |
|---|---|---|
| population of city | 22 | 40133.32 |
| gallons per capita daily | 22 | 130.05 |
| city sales tax revenue | 20 | 4.8835E6 |
| Valid N | 20 | |

Elsa

Table 6 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Elsa. As can be seen in this table, for 22 years Elsa had an average population of 5,787 and an average per capita daily water use of 148.32 gallons. For 20 years, the city has an average annual city sales tax revenue of $286,542.16.

Table 6 - Elsa

| | N | Mean |
|---|---|---|
| population of city | 22 | 5787.23 |
| gallons per capita daily | 22 | 148.32 |
| city sales tax revenue | 20 | 286542.1610 |
| Valid N | 20 | |

Hidalgo

Table 7 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Hidalgo. As can be seen in this table, for 22 years Hidalgo had an average population of 5,339 and an average per capita daily water use of 117.86 gallons. For 20 years, the city has an average annual city sales tax revenue of $532,219.22.

Table 7 - Hidalgo

| | N | Mean |
|---|---|---|
| population of city | 22 | 5338.68 |
| gallons per capita daily | 22 | 117.86 |
| city sales tax revenue | 20 | 532219.2240 |
| Valid N | 20 | |

La Joya

Table 8 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of La Joya. As can be seen in this table, for 22 years La Joya had an average population of 3,502 and an average per capita daily water use of 111.73 gallons. For 20 years, the city has an average annual city sales tax revenue of $108,123.19.

Table 8 – La Joya

| | N | Mean |
|---|---|---|
| population | 22 | 3501.86 |
| gallons per capita daily | 22 | 111.73 |
| city sales tax revenue | 20 | 108123.1890 |
| Valid N | 20 | |

La Villa

Table 9 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of La Villa. As can be seen in this table, for 22 years La Villa had an average population of 1,586 and an average per capita daily water use of 100.05 gallons. For 20 years, the city has an average annual city sales tax revenue of $11,197.45.

Table 9 – La Villa

| | N | Mean |
|---|---|---|
| population of city | 22 | 1585.77 |
| gallons per capita daily | 22 | 100.05 |
| city sales tax revenue | 20 | 11197.4545 |
| Valid N | 20 | |

McAllen

Table 10 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of McAllen. As can be seen in this table, for 22 years McAllen had an average population of 97,679 and an average per capita daily water use of 187.50 gallons. For 20 years, the city has an average annual city sales tax revenue of $24,262,000.

Table 10 - McAllen

| | N | Mean |
|---|---|---|
| population of city | 22 | 97678.59 |
| gallons per capita daily | 22 | 187.50 |
| city sales tax revenue | 20 | 2.4262E7 |
| Valid N | 20 | |

Mercedes

Table 11 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Mercedes. As can be seen in this table, for 22 years Mercedes had an average population of 14,039 and an average per capita daily water use of 127.32 gallons. For 20 years, the city has an average annual city sales tax revenue of $671,272.93.

Table 11 - Mercedes

| | N | Mean |
|---|---|---|
| population of city | 22 | 14039.00 |
| gallons per capita daily | 22 | 127.32 |
| city sales tax revenue | 20 | 671272.9330 |
| Valid N | 20 | |

Mission

Table 12 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Mission. As can be seen in this table, for 22 years Mission had an average population of 39,688 and an average per capita daily water use of 151.50 gallons. For 20 years, the city has an average annual city sales tax revenue of $4,393,300.

Table 12 - Mission

| | N | Mean |
|---|---|---|
| population of city | 22 | 39687.55 |
| gallons per capita daily | 22 | 151.50 |
| city sales tax revenue | 20 | 4.3933E6 |
| Valid N | 20 | |

Pharr

Table 13 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Pharr. As can be seen in this table, for 22 years Pharr had an average population of 39,471 and an average per capita daily water use of 123.91 gallons. For 20 years, the city has an average annual city sales tax revenue of $4,898,900.

Table 13 - Pharr

| | N | Mean |
|---|---|---|
| population of city | 22 | 39471.14 |
| gallons per capita daily | 22 | 123.91 |
| city sales tax revenue | 20 | 4.8989E6 |
| Valid N | 20 | |

San Juan

Table 14 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of San Juan. As can be seen in this table, for 22 years San Juan had an average population of 24,377 and an average per capita daily water use of 118.50 gallons. For 20 years, the city has an average annual city sales tax revenue of $751,617.25.

Table 14 – San Juan

| | N | Mean |
|---|---|---|
| population of city | 22 | 24376.59 |
| gallons per capita daily | 22 | 118.50 |
| city sales tax revenue | 20 | 751617.2470 |
| Valid N | 20 | |

Weslaco

Table 15 depicts the growth of population, the gallons of water used per day, and the city sales tax revenue for the city of Weslaco. As can be seen in this table, for 22 years Weslaco had an average population of 26,148 and an average per capita daily water use of 143.36 gallons. For 20 years, the city has an average annual city sales tax revenue of $4,035,600.

Table 15 - Weslaco

| | N | Mean |
|---|---|---|
| population of city | 22 | 26148.36 |
| gallons per capita daily | 22 | 143.36 |
| city sales tax revenue | 20 | 4.0356E6 |
| Valid N | 20 | |

Summary of Cities – Mean

A summary of the fifteen cities and their means was created as an information tool. Table 16 titled *Summary of Cities-Mean* lists the study's fifteen incorporated cities of Hidalgo County. The three categories listed along with their means are: (1) Population, (2) GPCD, (3) and City Sales Tax Revenue. This summary lists the cities of Alamo, Alton, Donna, Edcouch, Edinburg, Elsa, Hidalgo, La Joya, La Villa, McAllen, Mercedes, Mission, Pharr, San Juan, and Weslaco and shows the largest city relative to the other cities.

Table 16 – Summary of Cities-Mean

| City | Population | GPCD | City Sales Tax Revenue |
|---|---|---|---|
| Alamo | 11,671 | 101.73 | $643,745.34 |
| Alton | 4,280 | 157.77 | $95,033.65 |
| Donna | 14,019 | 130.45 | $566.097.08 |
| Edcouch | 3,600 | 107.73 | $56,658.88 |
| Edinburg | 40,133 | 130.05 | $4,883,506.00 |
| Elsa | 5,787 | 148.32 | $286,542.16 |
| Hidalgo | 5,339 | 117.86 | $532,219.22 |
| La Joya | 3,502 | 111.73 | $108,123.19 |
| La Villa | 1,586 | 100.05 | $11,197.45 |
| McAllen | 97,679 | 187.50 | $24,262,000.00 |
| Mercedes | 14,039 | 127.32 | $671,272.93 |
| Mission | 39,688 | 151.50 | $4,393,300.00 |
| Pharr | 39,471 | 123.91 | $4,898,900.00 |
| San Juan | 24,377 | 118.50 | $751,617.25 |
| Weslaco | 26,148 | 143.36 | $4,035,600.00 |

Conclusion

In all fifteen Descriptive Statistics that were analyzed, the means of the three variables (1) population of city, (2) gallons per capita daily, and (3) city sales tax revenue were the focus because an average of the data for each variable was needed in order to assess any changes over the course of the years studied. The total number of years was calculated, twenty-two years of population growth and water use data and twenty years of city sales tax revenue data. Then the average was calculated for each of the fifteen cities.

These means were listed together, as shown in Table 16, giving the average for each city and each category. With the knowledge of these average amounts, an assessment of past water use may show whether population growth is the cause. Knowing what the average is for the three variables, may also allow for a better understanding of what the typical or normal amount of water use is in a city in this study.

The mean for city sales tax revenue was analyzed to see if it made an impact on water use. In this case and as seen in Table 16, city sales tax revenue does not impact water use because the mean numbers show that between the cities, water use amounts do not increase with an increase in city sales tax revenue. This is a preliminary analysis using raw data. Further statistical analysis using correlations, regression, analysis of variance (ANOVA), and the coefficients will be discussed in Chapter IV.

# CHAPTER IV

## FINDINGS & RECOMMENDATIONS

This chapter discusses the regression models, correlations, analysis of variance (ANOVA), and the coefficients for the data used in this study: (1) population growth, (2) gallons per capita daily, and (3) city sales tax revenue. The correlation test will show if a relationship exists between population growth and water use. In addition, a correlation matrix will be generated using the three main variables for this research. The analysis of variance (ANOVA) will show if there is a statistical significance between the group means or averages. The coefficients test will show the strength of the variables being measured to see which has a greater impact on the Dependent variable. This chapter also includes a discussion of the findings, policy recommendations, closing comments, and the conclusion.

### Correlations

A correlation was performed in order to help identify a relationship between population growth and water use. Since this study looks to see if population's growth impacts water use for fifteen incorporated cities of Hidalgo County, Texas, it was necessary to use a correlation analysis to identify any relationship between the two variables.

As seen in Table 17, the Independent Variable [population growth] and the Dependent Variable [water use] measured by gallons per capita daily (GPCD), shows a strong correlation or relationship. The Pearson Correlation Coefficient (.685) conveys that there is almost a 69 percent variation in the Dependent variable explained by the Independent variable. Furthermore, the coefficient shows that this relationship is a strong, positive relationship: as population grows so does water use. The p-value for this coefficient is .005, which means that this relationship is significant and that there is only a 5 percent chance that this relationship might be due to chance. In other words, this researcher states that the results are 95 percent significant.

Table 17 – Correlations

| | | population | gpcd | salestax |
|---|---|---|---|---|
| population | Pearson Correlation | 1.000 | .685** | .951** |
| | Sig. (2-tailed) | | .005 | .000 |
| | N | 15.000 | 15 | 15 |
| gpcd | Pearson Correlation | .685** | 1.000 | .712** |
| | Sig. (2-tailed) | .005 | | .003 |
| | N | 15 | 15.000 | 15 |
| salestax | Pearson Correlation | .951** | .712** | 1.000 |
| | Sig. (2-tailed) | .000 | .003 | |
| | N | 15 | 15 | 15.000 |

**. Correlation is significant at the 0.01 level (2-tailed).

The table indicates that there is a strong, positive relationship between city sales tax revenue and population, which means that as one increases, so does the other. The correlation coefficient (.95) shows that 95 percent variation in the city sales tax revenue was explained by population growth. On the other hand, there is also a strong, positive relationship between water use and city sales tax revenue with a coefficient of .71, meaning that 71 percent variation in water use by city sales tax revenue. The p-value for this coefficient is .003, highly significant, which shows that there is only .03 percent that these results might be due to chance.

After this analysis of correlation between the Independent, Dependent, and Control variables, the next section will discuss further analysis using statistical tools for inferential studies.

Regression Analysis Summary

As seen in Table 18, the coefficient of determination or $R^2$ is .507. This coefficient explains a 51 percent variation in the Dependent variable by the Independent variable controlling for the third variable, city sales tax revenue.

Table 18 – Regression Analysis Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .712[a] | .507 | .425 | 18.00781 |

a. Predictors: (Constant), salestax, population

Analysis of Variance (ANOVA)

Using the analysis of variance (ANOVA), Table 19 displays the results of the F-test. The F-test (6.180) shows that the regression summary for Model 1 is significant with a p-value of .014. This explains that the regression model using the Independent variable to explain the variation in the Dependent variable is statistically significant at the .05 level of significance.

Table 19 – Analysis of Variance (ANOVA)

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 4008.423 | 2 | 2004.212 | 6.180 | .014[a] |

Regression Coefficients

Table 20 displays the detailed results for the regression analysis. The regression equation for Model 1 is below:

*Y (water use) = 121.307 (Constant) + 0.750 (population growth) + 0. 245 (city sales tax revenue)*

As already hypothesized, there is a positive relationship between water use and population growth. The regression coefficient for population growth (.075) shows that as population grows, there will be a .075 change in the Dependent variable, water use. Even though the t-test (.122) is not significant, it still shows that there is a relationship. Further analysis can be done by increasing the sample size. As already stated in Chapter I, there are limitations to this research, but despite these limitations the results shed light on this relationship.

The second regression coefficient for the city sales tax revenue is 0.245 and shows a positive relationship between the Dependent and Control variables. The regression coefficient for the city sales tax revenue (0.245) shows that as the city sales tax revenue increases, there will be a 0.245 change in the Dependent variable, water use. Even though the t-test (.969) is not significant, it still shows that there is a relationship. Further analysis can be done by increasing the sample size. As already stated in Chapter I, there are limitations to this research, but despite these limitations the results shed light on this relationship.

Table 20 – Regression Coefficients

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 121.307 | 8.160 | | 14.866 | .000 |
| | population | 7.540E-5 | .001 | .080 | .122 | .905 |
| | salestax | 2.450E-6 | .000 | .636 | .969 | .352 |

Given the above results, this research used the transformation variable to run a different regression model to see whether we can get better, significant statistical results. The transformation used is explained below along with the results.

Population Regression Model – Logarithm of Population Growth

Only one variable was transformed and that was the variable of *population growth*. Natural logarithms "make it easier to figure out impacts in percentage terms" (Studenmund, 1997: 219).

Population Regression Model Summary

The coefficient of determination or $R^2$ is .517. This explains a 52 percent variation in the Dependent variable. This shows that there was an increase in the $R^2$ by 0.010 percent meaning that the model improved by doing the transformation of the population. Table 21 displays the results:

Table 21 – Population Regression Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 2 | .719[a] | .517 | .437 | 17.82674 |

a. Predictors: (Constant), population2, salestax

Population Regression Model – Analysis of Variance (ANOVA)

Using the analysis of variance (ANOVA), Table 22 displays the results of the F-test. The F-test is 6.429 and shows that the regression summary for Model 2 is significant with the p-value of .013. This explains the regression model using the Independent variable to explain the variation in the Dependent variable is statistically significant at .05 level of significance or alpha test. It is important to mention here that the results improved given the transformation of the variable. The F-test in Model 1 was only 6.180 versus 6.429.

Table 22 – Population Regression Model-Analysis of Variance (ANOVA)

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 2 | Regression | 4086.284 | 2 | 2043.142 | 6.429 | .013[a] |

Given the above results, this research used the transformation variable to run a different regression model to see whether we can get better, significant statistical results. The transformation used is explained below along with the results.

Population Regression Model – Coefficients

Table 23 displays the detailed results for the regression analysis. The regression equation for Model 2 is below:

*Y (water use) = 96.2 (constant) + 6.587 (log of population) + 0.237 (city sales tax revenue)*

As already hypothesized, there is a positive relationship between water use and population growth. Given the transformation of the variables, the regression coefficients both for major Independent variable [population growth] and the Control variable [city sales tax revenue] did change as seen in Table 23. The city sales tax revenue regression coefficient 0.237 is significant with a t-test value of 2.227 and a p-value of .046 showing a statistical significance. Even though population growth, as the Independent variable, is still not significant, it shows a positive relationship with an improvement in the value of the coefficient. For both coefficients, there will be a change in the Dependent variable as the Independent variable increases. This confirms the results for Model 1.

Table 23 – Population Regression Model-Coefficients

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 2 | (Constant) | 96.269 | 50.849 | | 1.893 | .083 |
| | salestax | 2.370E-6 | .000 | .615 | 2.227 | .046 |
| | population2 | 6.587 | 12.913 | .141 | .510 | .619 |

Research Question and Hypothesis Statements

The guiding research question for this study asks:

> How does population's growth impact water use for fifteen incorporated cities of Hidalgo County, Texas?

The hypothesis statements for this research can be expressed as:

> $H_0$: Population growth has no impact on water use.
>
> $H_1$: Population growth impacts water use.

The Findings

This research addressed the question: How does population's growth impact water use for fifteen incorporated cities of Hidalgo County, Texas? This section reports the major findings, highlighting the steps involved with the statistical analysis, followed by policy recommendations and further research questions.

As already discussed, the correlation analysis shows that the Independent variable [population growth] and the Dependent variable [water use] measured by gallons per capita daily (gpcd), have a strong correlation or relationship. The Pearson Correlation Coefficient (.685) conveys that there is almost a 69 percent variation in the Dependent variable explained by the Independent variable. Furthermore, the coefficient shows that this relationship is a strong, positive relationship: as population grows so does water use.

The p-value for this coefficient is .005, which means that this relationship is significant and that there is only a 5 percent chance that this relationship might be due to chance. In other words, this researcher states that the results are 95 percent significant.

The correlation coefficient (.95) shows that 95 percent variation in the city sales tax revenue was explained by population growth. Furthermore, inferential statistics using regression with all its components (ANOVA, $R^2$ regression coefficients) highlighted some interesting and valuable findings. The $R^2$ for both Model 1 and Model 2 explained not only a 51 percent variation in the Dependent variable by the Independent variable controlling for the third variable, city sales tax revenue, for Model 1, but it also shows that there was an increase in the $R^2$ by 0.010 percent for Model 2, meaning that the model improved by doing the transformation of the population. Using the analysis of variance (ANOVA), the results of the F-test (6.180) shows that the regression summary for Model 1 is significant with a p-value of .014. Furthermore, this shows that the test did improve the variable transformation. As already discussed, the results of the F-test (6.429) showed that the regression summary for Model 2 is significant with a p-value of .013.

Given the transformation of the variables, the regression coefficients both for major Independent variable [population growth] and the Control variable [city sales tax revenue] did change, which did add value to the research, confirming the assumption that the measurement of the population had to be transformed to run a different model. The city sales tax revenue regression coefficient 0.237 is significant with a t-test value of 2.227 and a p-value of .046 showing a statistical significance. Even though population growth, as the Independent variable, is still not significant, it shows a positive relationship with an improvement in the value of the coefficient. Despite the fact that the researcher failed to reject the null hypothesis, the research is still significant, knowing the limitations of a small sample size.

Discussion

The largest city in Hidalgo County, McAllen, experienced a regular yearly increase in its population over the course of twenty-two years, but water use was not shown to increase with this growth. Smaller cities, whose population numbers fluctuated, growing and decreasing over the twenty-two years, did not experience noticeable changes in water use, either. In addition, those cities located closer to the U.S.-Mexico Border experienced greater growth than those cities located in more rural areas. A direct link may exist between a city's economic advancement and the increase in business investments and opportunities.

As discussed in Chapter III, city sales tax revenue was used as the Control variable, holding it constant so that it did not impact either the Independent or Dependent variables. As economic growth continues, less irrigation water will be needed as agricultural land converts to municipal land. The Texas Water Development Board's *Water for Texas – 2007 Report* states that in Region M where Hidalgo County is located, "Agricultural irrigation water demands makes up the largest share of these demands in all decades but is projected to decrease 16 percent over the planning period due to urbanization, from 1,163,634 acre-feet to 981,748 acre-feet . . . Municipal water demand, however, is projected to more than double (124 percent), increasing from 250,834 acre-feet to 560,780 acre-feet per year by 2060" (Texas Water Development Board, 2006c: 85-86).

As discussed in Chapter I, this study is limited to the fifteen incorporated cities of Hidalgo County, Texas in the Lower Rio Grande Valley of South Texas who submitted a water use survey for the years 1984-2005. As previously stated, they are: Alamo, Alton, Donna, Edcouch, Edinburg, Elsa, Hidalgo, La Joya, La Villa, McAllen, Mercedes, Mission, Pharr, San Juan, and Weslaco. This study does not address any unincorporated areas of the county.

This research is critical for Hidalgo County and further exploration of the topic is needed given that water is a scarce resource. Other variables need to be included to strengthen the research.

Five Policy Recommendations for City Leadership

Implementing any or all of these recommendations is left solely to the leadership of the fifteen incorporated cities of Hidalgo County studied in this research. These recommendations can be utilized by any city interested in water resource management and water conservation. The following recommendations are extended to municipal leadership:

1. Create and/or continue with conservation techniques and measures regarding water use within the various sectors of a municipality.
2. Enhance municipal beautification projects with more tree-planting and xeriscaping, which is the planting of native flora, as part of a city's water conservation plan.
3. Implement a sound plan for upgrading unsafe and/or inadequate infrastructure, along with a plan for scheduling regular maintenance, in order to continue the safe and regular delivery of water to the population.

4. Prepare water workshops and administer them regularly in order to educate and train citizens and businesses regarding water use and pertinent water issues, such as proper drainage during a severe storm (i.e., a hurricane) or a severe drought.
5. As one more conservation effort, future residential growth should be monitored and kept as horizontal growth (single family dwellings of one or two stories) and encouraged over vertical growth (multi-family dwellings of three or more stories).

The recommendations offered here may already be in effect for a few of these fifteen incorporated cities of Hidalgo County, Texas. Yet the recommendations offered may still be utilized or refined to meet individual plans or agendas. This, of course, is left to the discretion of a municipality.

In regards to water availability in Hidalgo County, water levels at this time are well over capacity. Even though the Lower Rio Grande Valley of South Texas has been hit by a "lingering drought that has been upgraded from moderate to severe," says Nezette Rydell, a meteorologist with the National Weather Service in Brownsville, Texas, Erasmo Yarrito, Jr., the Texas Commission on Environmental Quality's Rio Grande watermaster, stated that "the area's reservoirs are filled to the brim and that water levels at the reservoirs behind Falcon and Amistad dams are so high that farmers were able to irrigate between October and March at no charge, meaning that the water they used was not charged against their yearly allocations" (Santa Ana, 2009: 8D). Therefore, copious amounts of municipal water may currently be available, but conservation methods should continue and are still required to maintain future availability if drought conditions continue.

Updating the Current Infrastructure for Future Population Growth

Water has become more than a popular issue du jour. Interest in conserving and protecting it has gained impetus with the start of the new millennium, evolving into a revitalized *green* movement that seeks to promote environmental awareness and the protection of our world's natural resources. The initiative for protecting water has found a place under the greater umbrella-issue of global warming. Changes in the climate, the unpredictability of rainstorms, depleting water sources, and an inequitable water distribution have caused policymakers around the world to ask how an area can best manage its water use, while preparing for water shortages or other water-related issues. World governments who seek to promote the common good are in a race against time. As discussed earlier, water has not only become an expensive commodity, but also a precious one. Humanity will require and demand greater amounts of water as time passes and leaders around the world will need to find new and innovative ways of providing this life requisite to an ever-growing population.

Besides water conservation methods, a more adequate infrastructure must be in place to support a continuous water delivery system. Without a safe and secure infrastructure, water delivery may be comprised, restricting a population from receiving its share of this valuable resource. Access to water and managing the cost of water are arguably two of the most significant topics on the subjects of water resource availability, water resource management, and water resource sustainability. Yet local leadership should include infrastructure as one of the primary components to an effective water resource delivery system.

The global need for water, while urgent twenty years ago, has today become critical. Antiquated methods of procuring and utilizing water continue to claim precious water resources around the world, leaving regions suffering from thirst, sickness, and other water-related issues that have negatively impacted an area. Population growth is a recurring theme that concerns global leadership and that includes, at the local level, municipal leadership. City leaders in Hidalgo County must continue to provide and employ a stable and reliable local water resource management plan for their communities. Information on water use will continue to be the focal point for many municipal agendas. Water management and conservation are without a question necessary for global water resource sustainability.

Understanding regional climate, sector water use, and population growth may encourage municipal leadership in the cities of Hidalgo County to strengthen their resolve as they work to implement and/or preserve a healthy and feasible water resource management plan with a focus on cost effectiveness and sustainability. This will be necessary, especially in light of the recent droughts that have plagued the state of Texas. Therefore, promoting the conservation and protection of local water resources ensures water availability for years and generations to come.

## Tragedy of the Water Commons

The literature review in Chapter II discussed Garrett Hardin's seminal work, *The Tragedy of the Commons*, which detailed the tragic outcome of the commons due to the overuse and misuse of the world's natural resources as a consequence of overpopulation and independent decisions. The author finds culpability with those who do not work on behalf of the commons. Every day, people around the world take from the commons. He adds that many do not practice restraint in the utilization of the commons. Without a doubt, water is our greatest good held in the common. Neglecting its protection and conservation will impact our future survival.

Developing a realistic and reasonable *water commons declaration* that will serve to protect the world's water resources will eventually become the requisite. No longer will individual persons or countries make independent decisions on the use and distribution of water. Adhering to the *regulations of restraint* will be the highest priority. For too long humanity has taken from the *water commons* with incredible disregard for each other, the wilderness that must share from these same resources, and the future of water as a life-giving component to all living things on this planet.

Municipal water use in the cities of Hidalgo County must also follow a *regulation of restraint* in order to combat overuse or misuse of the communal water source. As long as population numbers in Hidalgo County continue to rise, municipal leadership will have to provide a regular, safe, and steady water delivery system, while maintaining this growing populace. The five key areas raised in the literature review of Chapter II created the necessary backdrop for study on municipal water use in Hidalgo County: (1) *population growth*, (2) *city sales tax revenue*, (3) *Gross Domestic Product*, (4) *water demand*, and (5) *water use*.

Hidalgo County in the Lower Rio Grande Valley of South Texas is challenged because its water must be shared between the various sectors with municipal water use taking a greater emphasis as regional population growth continues to rise with every year and decade that passes. Water use, water safety, and water availability can be monitored in order to better understand water in the Lower Rio Grande Valley of South Texas. Growth in the Rio Grande Valley does not appear to be slowing down and every municipal government must be prepared.

Conclusion

While this paper did not seek to argue for the creation of some *global ecotopia*, it does seek to create awareness by studying the relationship between population growth and water use among fifteen incorporated cities of Hidalgo County, Texas. This scholarly work has produced a valid outcome, which will only add to the greater body of work involving population growth, water use, water conservation, and water resource management and sustainability. This paper has attempted to address the issues of population growth and water use, but has done so with limitations. Even though this data has gone beyond the scope of this research, it can still be easily replicated for future studies.

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# BIOGRAPHICAL SKETCH

Rosario Adriana Wilson was born in the city of McAllen in the Lower Rio Grande Valley of South Texas to Edmundo and Irma Montemayor. She is a direct descendent of Don Diego de Montemayor, founder of Monterrey, Mexico. Her ancestral roots reside in Old World Spain and Sephardim and in the New World's blending of Spanish, French, and Amerindian. After earning her diploma in 1988 from the Lower Rio Grande Valley's first magnate high school, South Texas High School for Health Professions, in Mercedes, Texas, she went on to attend the University of Texas-Pan American and earned a Bachelor's Degree in Government and Sociology and full alumna status in the Delta Zeta Sorority in 1995. She returned to her alma mater to earn a Bachelor's degree in History with a double minor in English and Anthropology in 2003. Returning to her alma mater once more, she went on to pursue and earn a Masters of Public Administration (MPA) degree in 2009.

In 2006, she was honored by becoming the first student chosen that year from the MPA program to intern for the Government Accountability Office in Washington, D.C. Due to her exceptional work and dedication, she was made a co-author on her team's official congressional report, GAO-07-714. Upon her return from Washington, D.C., she authored two internship guides, which she donated to the MPA program to be used by her colleagues. In 2008, she was inducted into the prestigious Golden Key International Honour Society. In 2009, Texas State Representative Aaron Peña introduced a resolution [81(R) HR 2825] that honored her, along with two of her colleagues, for exceptional achievements with a commendation for successfully graduating with an MPA degree from UTPA. Rosario Adriana Wilson will continue her work in service to the public, while promoting, preserving, and protecting the common good.

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