Sustainable Development and Humanitarian Affairs

Analyzing Spatiotemporal Patterns and Marketing a Changing Community

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Abstract

As there has been a lack of proper planning and spatial data infrastructure in a rural Texas county, a countywide GIS has been developed for use in determining patterns pertaining to development and economic growth and their relationships to a severely fluctuating lake. Asset mapping and spatiotemporal analysis results showing the effects on eco-tourism and economic stability are shared using ArcGIS Online and outlines a framework for planning and better decision making for a sustainable economy.

Introduction

Not unlike many rural counties, a framework for planning and better decision making for a sustainable economy has not been fully established for the county of Zapata, Texas. County agencies have not had the funding or the capacity to implement ongoing recordation of existing and new infrastructure as it becomes available. Many record as-builts for new infrastructure as a result of Public works projects funded by the county or other agencies are only kept for a limited time period. These records then somehow become lost in the archives where access becomes nearly impossible. Certain individuals within county departments cognitively retain most knowledge of where existing infrastructure is located and are called upon when inquiries are made. To remedy this situation of mere cognitive spatial knowledge of existing infrastructure, a countywide Geographic Information System (GIS) has been developed by the local economic development organization, the Zapata Economic Development Corporation (ZEDC). The ZEDC is a non-profit organization whose mission is to see to local and regional economic development initiatives. The establishment of the GIS begins with a countywide asset mapping process which plays an important role in sustainable development for the county.

The ZEDC implements programs for attracting new industry and assisting existing businesses with retention and expansion efforts. The ZEDC also conducts research and reports data pertaining to quality of life and the local economic state. A portion of the local economy of this rural community in South Texas is affected by Falcon Lake, and to gain some insight on the more recent effects of its existence, data sets have been added to the developing GIS to model past and present conditions with regard to the local economy and the severely fluctuating lake.

In addition to the modeling and analysis phases of the GIS implementation, some spatial data is made available publicly through the ArcGIS online platform. Utilizing ArcGIS online for organizations allows the ZEDC to collaborate with other local organizations for sharing and collecting pertinent data that is associated with this project as well as to provide an online portal for publishing dynamic user

friendly maps for sharing information regarding community assets including local features, available properties, and available services.

The efforts of the ZEDC in carrying out these objectives are to promote sustainable development locally and regionally with respect to economic stability and improved quality of life. "Sustainable development is the balance of meeting humankind's present needs while protecting the environment to ensure the fulfillment of future generations' needs." (ESRI, 2014). Locally, regulations have been adopted in accordance with Texas Local Government Code, Section 231.251 to promote eco-tourism, cultural awareness, use of recreational areas, and to preserve areas of significance for residents and those of historical, cultural, or architectural importance through compatible economic development. The regulations are to also enforce zoning districts to reduce sprawl and thereby follow national efforts to reduce the use of hydrocarbons and carbon emissions to aid in the reduction of global warming. These regulations are enforceable within a 25,000 foot buffer from the defined Falcon Lake project area, and its tributaries. The land within the T1 Rural Preserve district included in this regulation is legally protected from development as it is designated and intended for open space. The T2 Rural Reserve district includes "land that should be protected from development through public acquisition or control." These are areas that are within flood plains or other hazardous or delicate areas (Zapata County Falcon Lake Zoning Regulations, 2011). Lands which have already been developed and are mostly privately owned fall within this district.

Many other local governments are adopting these types of regulations in conformity with national and international goals. ICLEI (International Council for Local Environmental Initiatives) also known as Local Governments for Sustainability currently has over 1,000 members around the world ranging from mega-cities to small and medium sized cities and counties in 84 countries (ICLEI, 2014). ICLEI was formed after the United Nations (UN) Rio Earth Summit in 1992 which was attended by U.S. President George Bush, Sr. and leaders from 178 other nations where an agreement was made to use certain principles as guidelines for Sustainable Development called Agenda 21. In addition to local governments subscribing to this global agenda, the U.S has established plans that adhere to the goals of Agenda 21 as well, which include the establishment of the President's Council on Sustainable Development by President Clinton's executive order in 1993 (PCSD, 1993) and President Obama's Federal Leadership in Environmental, Energy, and Economic Performance through executive order in 2009 (Obama, 2009).

With regard to Sustainable Development, the UN does not cite a term definition, but asserts specific agenda items that delineate its plan for "Sustainable Development – Agenda 21". This plan states: "One of the major challenges facing the world community as it seeks to replace unsustainable development patterns with environmentally sound and sustainable development is the need to activate a sense of common purpose on behalf of all sectors of society." (UN Agenda 21, 1992, Sec. 27.2). Agenda 21 discusses Social and Economic Dimensions in Section I which deals with the conservation and expansion of forest areas and biological diversity (UN Agenda 21, 1992). This section also explains the need to formulate strategies to mitigate the damaging impact of human populations on the environment and therefore the need to develop programs to increase public awareness on population concerns and to address the consequences of population growth through the design of public policies (UN Agenda 21, 1992). The Federal Government participates in the preservation of forest areas through

its ownership of approximately one third of the lands in the United States which amounts to about 650 million acres (Nationalatlas.gov). Recent land takings by the Federal Government for purposes of environmental conservation and expansion efforts continue to come about with efforts to increase the amount of takings underway (National Geographic, 2014).

Study Area

The study site, Zapata County, home to Falcon Lake is located in South Texas along the Rio Grande and the Mexican border approximately 50 miles Southeast of Laredo (fig. 1). Since being displaced from its original location due to the construction of a dam on the Rio Grande River in 1953, Zapata has been forced to re-establish itself along with several other communities within the county of Zapata and along the Rio Grande. The benefits of the lake created in its place have made it a center for world class Bass fishing in addition to an already excellent eco-tourism environment. The 200 year long connection of the

Fig. 1

Fig. 2

people of Zapata with the land and its resources is what creates the need to protect historic and natural resources, and to insure a sustainable future. Zapata County has a population of just over 14,000 and covers approximately 677,000 acres of land and about 61 square miles of water. The Falcon International Reservoir is a large part of the local economy as it is a major tourist attraction for Catfish and Largemouth Bass fishing. Falcon Lake was named number one in "BASSMASTERS 100 Best Bass Lakes" in the United States in 2012. Zapata County is a destination for eco-tourism especially in the areas of Fishing, Hunting, and Birding. The land is rich with wildlife such as the South Texas White-Tailed Deer, White-Winged Dove, and Quail. There is also a pronounced Hispanic culture of music, art, and history with the neighboring town of San Ygnacio within the county and home to nationally recognized

historic buildings. A growing economy includes the influences of local entrepreneurs, ranchers, and the oil and gas industry.

Methods

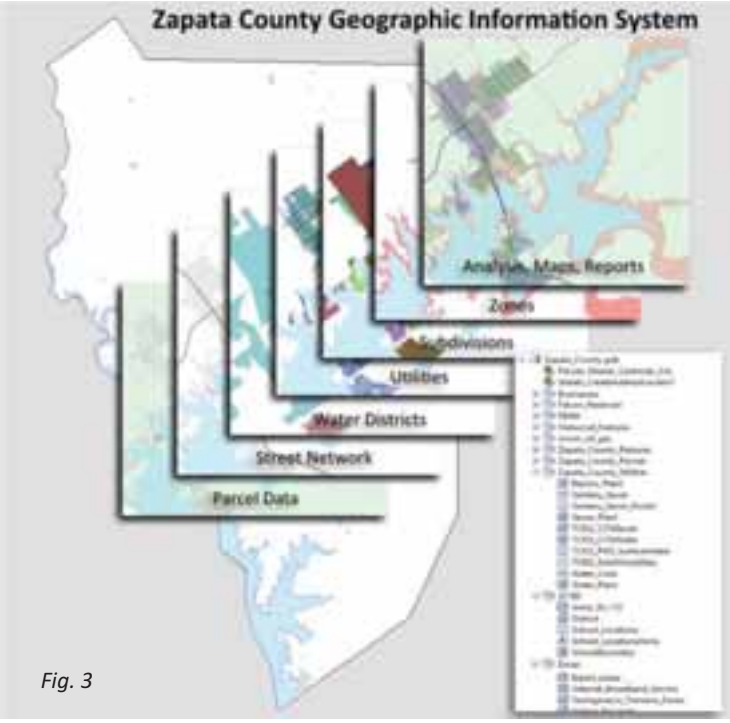

Fig. 3

The implementation of a countywide GIS using ESRI's ArcMap 10.1, was initiated for the purposes of compiling and using data pertaining to areas of development, economic growth, and patterns in tourism. To acquire the much needed authoritative data for this vital undertaking, having well established relationships with county departments and other local and state agencies was crucial. A large number of data sets used were acquired through many sources, some of which included countywide parcel data provided by the county appraisal district, local street networks with attribute data for geocoding provided by the local 911 coordinator, district and other geographic boundaries from various sources, oil and gas well data acquired through the Texas Railroad Commission, local infrastructure data provided by the water and sewer districts, flood plain data from the Federal Emergency Management Agency, Aerial and LiDAR data provided as a Digital Elevation Model (DEM) data provided by the International Boundary and Water Commission (IBWC). These data sets among many others were used in establishing base maps, operational layers, and developing a centralized geodatabase.

Falcon Reservoir, considered a permanent feature, has its water surface elevation and spatial distribution changing with regard to space and time. The geometrical transformation which occurs is that of size and form affecting the fishery and other lake activities. Spatial relationships among other objects may also change as a consequence (Yeung and Lo, 2002). Beginning the analysis pertaining to Falcon Reservoir and the local tourism economy consisted of the determination of the limits and occurrences of lake level fluctuations. Falcon lake storage data was provided by Water Data for Texas with historical daily statistics and capacities (Fig. 4) (WDFT, 2014). The

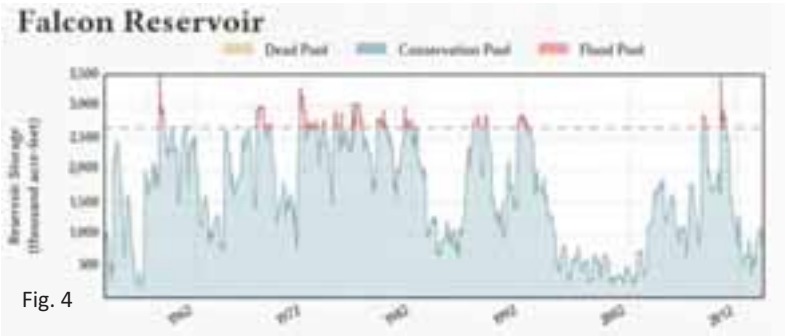

Fig. 4

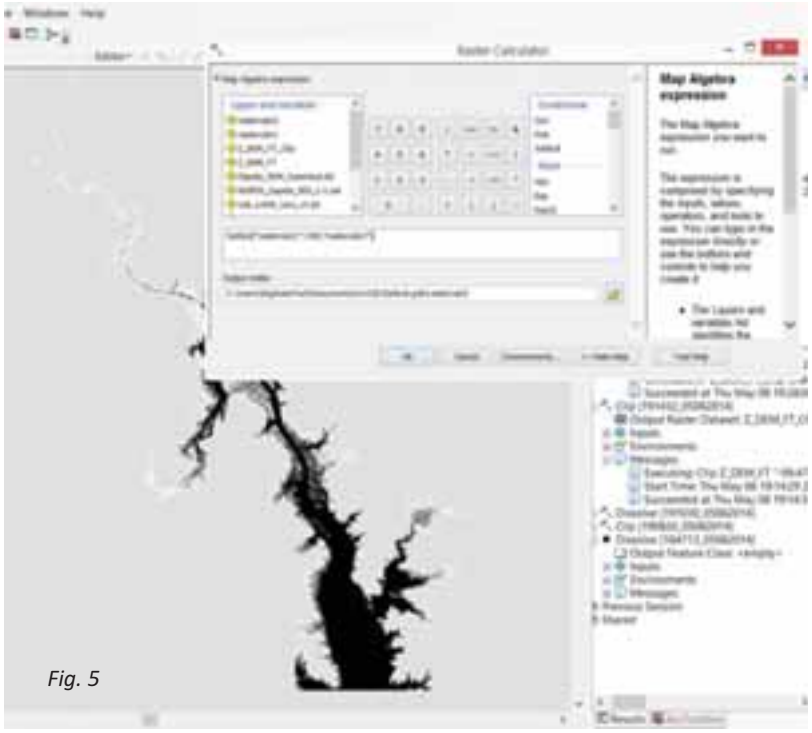

Fig. 5

Bare Earth LiDAR DEM acquired from the IBWC is combined from a mosaic to create a new raster that contains the entire reservoir. The raster math calculator is used to extract only the elevations that are pertinent to the study site. After eliminating all DEM pixel values of 0, the elimination of all values greater than 300 is executed using the raster calculator map algebra expression (fig 5). This DEM output is then used to generate contours at 1 foot intervals. Contour elevations at every 5 feet and at other key elevations are extracted to generate filled polygons representing lake boundaries at various levels. The polygons generated are generalized and dissolved in order to make rendering more efficient. Having the date attribute in this layer's attribute table allows for time awareness to be enabled within ArcMap, and doing so will render only the features for the selected time frame. This same time aware enabling is added to the other time aware layers as well.

Hotel revenue data acquired through the Texas Comptroller's Office is compiled per quarter and associated with the geographic locations of corresponding hotels. Point features with hotel revenue and date attributes are quantified with circles as graduated symbols using the Natural Breaks classification method. Retail Sales data is added for the entire county and is associated with a point centered in the town to represent Total Hotel Receipts normalized by the percent of Total Sales, and Total Retail Sales normalized by the percent of Total Sales. These data are symbolized with a Column Chart to show the two totals at a specific point in time as this layer is also time-enabled (Fig 6).

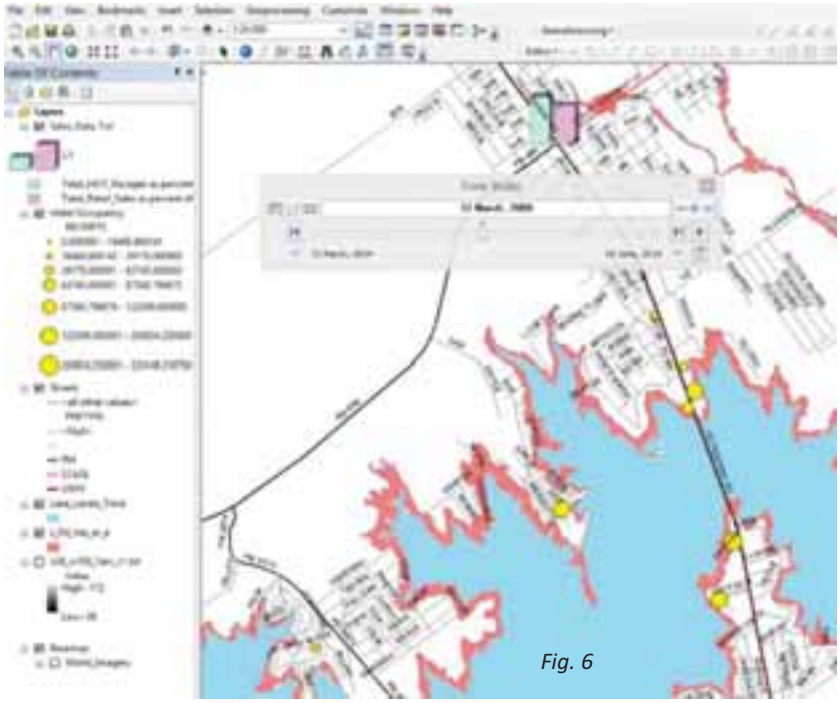

Fig. 6

ArcScene is used for 3D visualization using a DEM as a base layer. Orthoimagery also provided by the IBWC along with street network data is draped over the DEM offering a 3D perspective on the physical appearance of the lake fluctuations. The hotel receipts data are now shown as bars rising vertically from the base elevation as graduated symbols (Fig. 7). Using the time slider in either ArcMap or ArcScene, the time aware layers can be viewed dynamically and changes can be seen over time. The animation tool in ArcScene allows for different viewpoints to be set at various keyframes and exported to a video file for demonstration or uploading to the web.

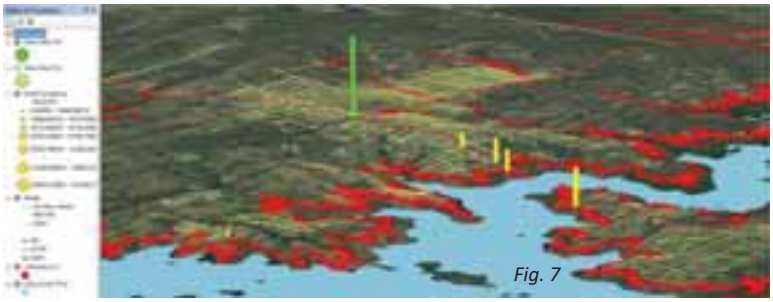

Fig. 7

ArcGIS online is used by the ZEDC to create an online portal or geoportal with access to a variety of highly focused special purpose maps and spatial information pertaining to the county. A geoportal facilitates the sharing of geospatial information in maps, geoprocessing tools, GIS data, and metadata (Fu, Sun, 2010). Some of the items in the gallery are as follows: an editable map of the most comprehensive local business listings with their locations, voting districts, FEMA flood zone areas, platted subdivisions, county garbage pickup schedule areas, and school locations and boundaries. These highly focused maps are published for the purpose of increasing public awareness of available community assets, development constraints, and countywide economic activity (Fig. 8). In addition to the local business locations map as a simple 'point and click query' map, a dynamic mapping interface has been added to the online portal offering novice and advanced users the ability to run pre-generated queries for searching for businesses by industry, name, and other attributes.

Fig. 8

Results

The countywide GIS has been effective in giving the ZEDC the ability to use much of the data that is continuously researched in developing analysis and producing reports that satisfy the requirements of its economic development programs. New spatial data sets have been added to the scope of the ZEDC's typical research. As the endeavor to collect many of these data sets is a first for our county, there has been quite a challenge as the availability of data is limited where much of the infrastructure has not been mapped or not adequately archived. As a result, more work will be required in the future to physically locate and field collect the data for some of the infrastructure such as water and sewer line features. The importance of obtaining a complete inventory of infrastructure and community assets is to enable the assessment of local and regional capacity, and quality of life. Having inventoried local infrastructure and having it readily available within a GIS enables the ZEDC as an economic development organization to more efficiently respond to site selectors for potential economic development projects.

This demonstration does not show that hotel and retail sales are directly correlated with the rise and fall of lake levels, but the relationship of hotel receipts and retail sales with fluctuations in the reservoir levels is shown to be that when the lake rises and is relatively constant, revenues are generally higher. Since the study gives some insight as to the relationship between lake levels and revenues, suppositions can be inferred that assist in creating policy that will support improved management of the fishery and water resources.

The dissemination of newly compiled and processed data is carried out with ArcGIS Online. This allows end users, whether local or potential investors from elsewhere, to query and discover in focused storytelling maps or user driven interactive map applications enabling more intelligent decision making and for marketing our community. Presentations regarding ZEDC functions and the use of the GIS have been delivered in public forums to special interest groups and local government. Responses from audiences have been very positive and the efforts and GIS concepts explained have been well received. Public audiences have shown a great interest in using the GIS technology while local government officials have also made it clear that they look forward to utilizing the information being made available in future decision making.

Discussion

The GIS allows for the visualization of various data sets and respective circumstances while giving the ZEDC's staff the ability to forecast and provide highly informative reports for use in decision making and planning, and the dissemination of information to local government and the public. Additional maps are expected to be added to the online portal to allow for query of land parcels with associated public records and a property inventory including rent, lease, and sale of vacant or developed properties. These additional special purpose maps will be dynamic where simple pre-generated queries can be run or custom queries can be created by advanced users such as site selectors for finding sites that suit specific requirements such as acreage, lot dimensions, frontage, etc. Site selectors will also be

able to add additional operational layers such as water and sewer utilities and flood zones, and overlay them to further enhance their site suitability analyses.

The examination of the impact of the fluctuating levels of Falcon Reservoir on the local economy is multidimensional with time aware functionality built into ArcMap and ArcScene where the temporal dimension is added. Utilizing animation techniques in conjunction with time aware layers is used to visualize changes in the spatial distribution of the lake over time.

The methods to implementing a countywide GIS and the results thereof are in an effort to lead to an improved local economy, better decision making with respect to policy, and better quality of life. Sustainable development as a term is used to describe this effort for this community. This requires that development and capacity with regard to Infrastructure and Leadership are put as a priority. In addition, the promotion and protection of agriculture is essential as it can work hand in hand with the environment. Methods can be developed to gauge the agricultural and environmental impact on wildlife and the environment. It is predicted that this will show no adverse impacts from the local agriculture industry with the exception of feed lots which are nonexistent in Zapata County. When it comes to policy making with regard to sustainable development, however, we need to keep in mind that there should also be consideration for the natural rights of citizens. Policies should not be designed to infringe on property rights or to micromanage other aspects of everyday lives. The supervision of the policy making process within government is ultimately the burden of the citizens.

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