QUALITY OF LIFE ASSESSMENT AS A PRELIMINARY STUDY ON THE SPATIAL APPRAISAL AND VALUATION OF ENVIRONMENT AND ECOSYSTEMS METHODOLOGY

A Thesis

by

ROSS HUNTER KLEIN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2010

Major Subject: Rangeland Ecology and Management

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Approved by:

Chair of Committee,	Douglas Koushen Loh
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ABSTRACT

Quality of Life Assessment as a Preliminary Study on the Spatial Appraisal and Valuation of Environment and Ecosystems Methodology. (December 2010)

Ross Hunter Klein, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Douglas Koushen Loh

The concept of quality of life (QOL) has been addressed for decades. It was not until recent times when geographical information systems (GIS) have become available that a locale-specific approach could be enabled. Even then, analysis to date has been conducted mostly at the resolution of city or county level. The study presented describes an innovative methodology that may appraise QOL at finer resolutions, i.e. more locale-specific. The new approach is called Spatial Appraisal and Valuation of Environment and Ecosystems, or SAVEE.

This thesis research is a proof-of-concept study as the first account of the SAVEE methodology. It is to set the stage for future studies toward a more comprehensive framework. In this preliminary study of locale-specific QOL, the SAVEE methodology was used to illustrate the possibility of handling QOL factors in a dynamic manner.

The assessment includes three major steps: 1) data preparation, 2) data conversion and normalization, and 3) combining contributions of factors being considered.

In the first step, the geospatial data layer of a factor in consideration was input into GIS to plot a proximity map of the feature, e.g. parks or fire stations. In Step Two, each factor was first assigned a range of weight according to the location of a site on a proximity map in terms of the factor's favorability-unfavorability.

In the third step, weights from each factor were combined in a pair-wise manner, e.g. park and fire station proximities, or two factors at a time. The weight combining is done by deploying map algebra formula derived from the expert system algorithm EMYCIN. The computation was done iteratively until all factors were exhausted. The final results were coded as a gradient map of an integrated and locale-specific QOL index in the range of (-1, +1).

In this preliminary study, the City of College Station, Texas was used as the study site. A set of factors and their respective ranges of weight were used in the study. By adjusting the incorporation of various factors and their ranges, a series of QOL maps for the city was generated. The resulting QOL maps indicate what factors and ranges may or may not have contributions toward a holistic overall picture of the QOL of a city in the locale-specific context. The SAVEE methodology proved to be successful in handling qualitative hedonic factors in a locale-specific quantitative manner through the GIS interface.

DEDICATION

I dedicate this work to my family that has assisted throughout my entire academic career. Without their love and support this would not have been possible.

ACKNOWLEDGEMENTS

I would like to acknowledge my family for their contribution to my work. Their emotional and financial support enabled me to stay actively involved in my studies. Without their help this work may not have been possible.

My advisor, Dr. Douglas Loh, has gone way beyond my expectations of an advisor in guiding me through this thesis. The advice and knowledge gained from him is shown in this work and will continue to carry over into future research. The framework that he provided to me to base this thesis on proved extremely helpful in developing this conceptual methodology.

I'd like to thank my committee members, Dr. Georgianne Moore and Dr. Emily Zechman. I am very grateful for the advice and contributions that they shared with me while working towards earning my Master of Science degree.

Kendall Ball was always there to lend a hand in assisting me through some of the difficulties faced in data manipulation. His GIS expertise proved very helpful at many steps along the way.

NOMENCLATURE

ANOVA	Analysis of Variance
EPA	Environmental Protection Agency
GIS	Geographic Information Systems
GUI	Graphic User Interface
INFORMS	Integrated Forest Resource Management System
NIMBY	Not In My Backyard
QOL	Quality of Life
SAVEE	Spatial Appraisal and Valuation of Environment and Ecosystems
SLD	Straight Line Distance
USDA	United States Department of Agriculture

TABLE OF CONTENTS

Page

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

1. INTRODUCTION

The concept of quality of life (QOL) has been addressed by urban developers, city planners, and other stakeholders for decades. It was not until recent times when geographical information systems (GIS) have become available that a locale-specific approach could be enabled. Even then, analysis to date has been conducted mostly at the resolution of city or county level. The study presented describes an innovative methodology that may appraise QOL at finer resolutions, i.e. more locale-specific. The new approach is called Spatial Appraisal and Valuation of Environment and Ecosystems, or SAVEE for short. It is innovative because it is the first of its kind to handle any number of QOL factors at never before seen resolutions tailored by the stakeholder.

Communities are often compared to others based on factors that attract the attention of residents, business entrepreneurs, skilled laborers, and policymakers (Blomquist *et al.* 1988, Shumway and Otterstrom 2001). Research has shown that the weighted factors used are not always identified, nor relevant, to the person of interest. Since the 1960's, QOL research has been conducted (Royuela 2009). A methodical process for establishing a city's overall QOL structured towards the individual has not been available, however. Although QOL has involved many ideas of concept (APPENDIX A)(Troyer 2002), it does not have a universally accepted definition (Troyer 2002). Nonetheless, it can be summed up as the extent to which people's 'happiness requirements' are met (McCall 1975).

This thesis follows the style of *International Journal Geographical Information Science.*

Current research has shown that there is no process that would allow for a stakeholder to heuristically determine the happiness requirement, or QOL, of a locale-specific site. A common barrier in modeling QOL has been the development of a model for weighting the different factors involved in the assessment (Blomquist *et al.* 1988). As GIS and geo-spatial data become more readily available, stakeholders may now be in a position to model and calculate QOL by incorporating factors of interest, and actively visualize how each factor may affect the total outcome. Moreover, relevant factors could be determined by stakeholders and be adjusted or changed dynamically. Previous research for modeling QOL has taken place at county-based resolution with results proving the possibility of modeling within urban areas (Blomquist *et al.* 1988).

The difficulty for a locale-specific hedonic, or pleasure related, model of this degree has been a fail-safe algorithm that can handle many factors on a single working module. To this end the SAVEE methodology was adopted as the general framework for this study. SAVEE is being conceived and developed at the STARR LAB (Laboratory for Systems Technology Applications in Renewable Resources) of Ecosystems Science and Management Department, Texas A&M University. SAVEE allows for spatial analysis of factors to determine locale-specific values, such as QOL, at any intended level of resolutions.

This thesis research is a preliminary implementation of the SAVEE methodology. The City of College Station, Texas was used as the study site. A set of factors and their respective ranges of weight were tried in quantifying the sensitivity of SAVEE. By adjusting the incorporation of various factors and their ranges, the research was able to generate a series of QOL maps of the city. These resulted QOL maps indicate the flexibility of the underlying methodology for such endeavors as QOL of a city in the locale-specific context.

2. LITERATURE REVIEW

Studies and analysis of spatially referenced information has always been a main thrust of many interrelated fields, e.g. environment, ecology, urban planning and city management (Ward 2007, Osborne *et al.* 2001, Geoghegan 1997, Prizzia 2009, Rosenthal *et al.* 1995, Forman 1995, Weng 2002, Pauleit and Duhme 2000, Campbell 1996). QOL analysis is one spatial analysis endeavor that cross-cut these fields. To date, literature shows that most QOL analysis works have been conducted at the city or regional level (Hostetter 2006, Blomquist *et al.* 1988, Reisig 2000). Such resolution does not provide information on a specific locale. As a real estate business motto goes: "Location, location, location!" (Geoghegan 1997). Generating information pertaining to locale-specific QOL is thus a research opportunity in demand. As GIS and geospatial data become more readily available, locale-specific analyse are now possible.

Current works on defining QOL value has been approached through several different methods. Although dissimilar, these methods have one commonality. They lack details for locale-specific information. For example, Hostetter (2006), Reisig (2000), and Blomquist *et al.* (1988) have each conducted studies on this topic. Each has established a well defined method and resolution to suit their purpose of study. However, reviewing these studies has turned up the same conclusion that explicit spatially referenced information is either absent or is not available at resolutions below the city or regional level.

One leader in urban sustainability is the Earth Day Network. Having created detailed urban reports for 72 of the largest cities in the United States, representing all 50 states, the Earth Day Network (Hostetter 2006) provides very detailed indicators that contribute to QOL such as air quality, vulnerable population index, and parks and recreation. In fact it is so detailed that 212 factors were identified and incorporated in its endeavors toward developing of such indicators. The essence of the method the Earth Day Network used is the incorporation of a penalty point system. This means that a scaled value between one and five is assigned. The values given for each factor is then manually calculated for a total lump sum. The decision to use this method was chosen because it allowed for showing the relative position in rank when compared to the 72 cities used in their study. However this method does not show how contribution of weights from each factor is accounted for when given the sum. The greatest weakness is that the resolution is at best the city scale. Some factors range all the way to the watershed scale (Hostteter 2006). The method used by the Earth Day Network also has no plans to go with a sub-city resolution. This inhibits the possibility of future incorporation of a locale-specific spatial appraisal or valuation.

In another case, Reisig conducted a spatial study on QOL in 2000. His area of research included Indianapolis, Indiana and St. Petersburg, Florida. His study deployed a survey of only 16 factors (Reisig 2000), but these factors were very specific. A few of these factors included perceived safety, race, sex, and education. In his endeavors, Reisig applied a numbered point system for each factor between one and four in which the numbers were summed together in the end to give a final totaled value. This system allows for resolution at best to be at the neighborhood level because of the study looking at neighborhoods as a whole. He further stated that research in this area for deciding hedonic value is sparse and a newer approach deserves consideration (Reisig 2000).

Through an extensive review of current models, the difficulty in spatially assessing pertinent indices was recognized (Blomquist *et al.* 1988). The research by Blomquist *et al.* (1988) across 253 urban counties within the United States has inspired many remarkable progresses for spatially assessing QOL. For example researchers have learned that QOL within urban areas are amenity based, and that investigating QOL variation within urban areas is possible (Blomquist *et al.* 1988). Unfortunately this and other researches mainly focused at the county resolution (Blomquist *et al.* 1988). The ability to incorporate this method into a locale-specific valuation has not possible due to the lack of resolution of the spatial factors being considered.

Although a locale-specific approach to QOL has been stipulated in previous studies (Blomquist *et al.* 1988), review of literature has shown that it has yet to be carried out in an explicit spatial context through the incorporation of GIS. A reason for this deficiency is the lack of an established framework for spatial assessment of factors. This is where GIS is useful and is needed. GIS provides the means to organize and store spatial information such as land records and use, natural resource features, and public infrastructure location, allowing easy inventory and recall (Geoghegan 1997). For example, the factors described by the Earth Day Network (2006) do contain spatially referenced attributes and thus are potentially useable for spatial analysis. However the Earth Day Network falls short of utilizing such attributes in its analysis endeavors.

"Clear concepts are needed to motivate and support research into the patterns and processes of urban and human-occupied ecosystems (Pickett *et al.* 1997)." To this end, an algorithm called EMYCIN is adopted for such endeavors. EMYCIN was developed in the 1970s as an expert system inference engine (Melle 1979, Buchanan 1983). Rather than building a knowledge-based system from scratch, EMYCIN was derived from MYCIN, an earlier system lacking domain knowledge. EMYCIN, or "Essential MYCIN", was developed incorporating goal-directed backward-chaining of rules (Melle 1979). "At any given time, EMYCIN is working toward establishing the value of some attribute (Melle 1979)." It was later adapted (Loh *et al.* 1994) into an integrated forest resource management system, called INFORMS, for use by the United States Department of Agriculture (USDA) Forest Service. INFORMS is the first endeavor that linked expert system, GIS, simulation models and relational database into an integrated spatial decision support system for resource planning (Loh *et al.* 1994). This approach was later applied to landscape ecology (Loh and Hsieh 1995) and wildlife management (Loh 1996). It was later enhanced with the ability for automated construction of rulebases for forest resource planning (Loh 1998). Through the paired use of EMYCIN and GIS, it allows for the stakeholder to spatially assess the value of an area. These described tools are the fundamental interworkings of the developed SAVEE methodology used herein. The SAVEE methodology has the capability of integrated analysis of factors to determine spatially referenced environmental/ecological indices at any intended level of resolutions.

3. RESEARCH METHOD

3.1 PURPOSE AND OBJECTIVES

The purpose of this study is a proof-of-concept on the flexibility of the SAVEE methodology as is applied to locale-specific QOL analysis. SAVEE stands for Spatial Appraisal and Valuation of Environment and Ecosystems. It is being conceived and developed at the STARR LAB (Laboratory for Systems Technology Applications in Renewable Resources) of Ecosystem Science and Management Department, Texas A&M University.

The specific objective of this study is to apply the introduced SAVEE methodology in quantifying QOL at the locale-specific level of resolution. In doing so, the flexibility of the SAVEE methodology's capability in generating the QOL indices will also be determined.

3.2 THE SAVEE METHODOLOGY

The SAVEE endeavors include three major steps: 1) data preparation, 2) data conversion and normalization, and 3) combining contributions of factors being considered.

In the first step, the geospatial data layer of a factor in consideration was input into GIS to generate a proximity map of the feature, e.g. parks or fire stations. In Step Two, each factor was first assigned a range of weight according to the location of a site on a proximity map in terms of the factor's favorability-unfavorability. The range is set between (-1, +1) to normalize among the various factors. This way, all factors were converted into quantitative information and normalized into numeric values between (-1, +1). This maneuver places all things considered on an even keel for mathematical and map algebra manipulations.

In the third step, weights from each factor were combined in a pair-wise manner, e.g. park and fire station proximities, or two factors at a time. The weight combining is done by deploying map algebra formula derived from an expert system algorithm called EMYCIN (Melle 1979), illustrated on page 16. The computation was done iteratively until all factors were exhausted. The final results were coded as a gradient map of an integrated and locale-specific value such as the QOL index range of (-1, +1).

3.3 THE STUDY SITE

The City of College Station, Texas was chosen as the site of the study. The location of College Station is in the Brazos County, Texas, USA (Figure 1). It is known to be the home of Texas A&M University.

According to the United States Census Bureau, a population of 67,890 was recorded at the 2000 census. The latest census estimate from July 1, 2006 was 74,125 showing an increase in population by 8.6%.

The reason for selecting this study site is the data availability from Texas A&M University, the City of College Station, Brazos County, Bureau of Census and many other sources. The data abundance has greatly expedited the study. In essence, for all factors that may contribute to QOL index development, one may easily get his/her hand on their corresponding geospatial datasets. For this study, a rather comprehensive library of datasets have been collected and organized. It includes such layers as city boundary, digital elevation model (DEM), streets and roads, flood plains, park distribution, school locations, Census data (the 2000 version), landfills and oil well locations, just to name a few.

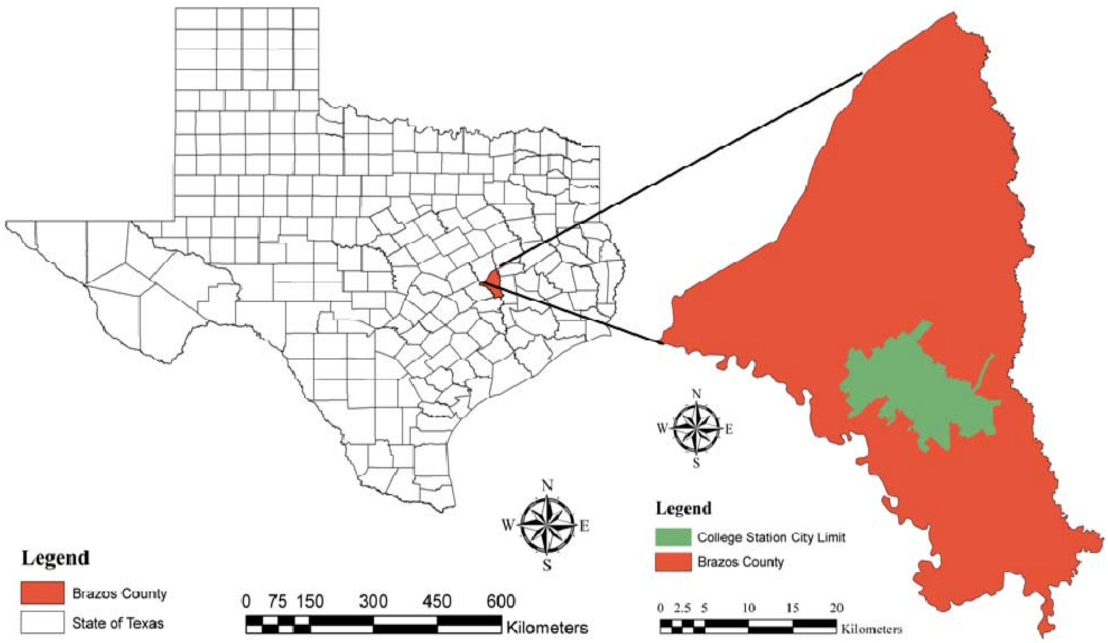

Figure 1. Map of Texas with Brazos County expanded illustrating the city of College Station.

3.4 PROCEDURES AND STEPS

Following the SAVEE methodology, this study was conducted in three major steps: 1) data preparation; 2) conversion and normalization of data; and 3) combining contributions to factors under consideration.

3.4.1 STEP 1: DATA PREPARATION

The first step was to decide upon a candidate set of factors. This was achieved through contact with a local real estate agent and review of literature. A local real estate agent was utilized in order to gather information concerning the most common factors clients are interested in while finding a home to purchase. Additionally many articles were sought that assisted in supporting the information gathered from the real estate agent.

Next the list of contributing factors for defining QOL was selected. Selection of factors for analysis was determined by two criteria: 1) availability of spatial data, and 2) the most commonly referenced QOL indicators. Research for all spatial data pertinent to the study site was conducted in order to identify the potential factors for analysis. Dependent upon the available data, only those factors that were commonly mentioned from the real estate agent and backing literature were used.

After factors were selected, their corresponding datasets were acquired through three main local sources: Texas A&M University, the City of College Station, and Brazos County. Many online resources are available for data acquisition.

Many datasets had their extent beyond the city limit of College Station. Therefore, further processing such as clipping was done after their acquisitions. This was done to extract data to be within only the boundary of this study.

Once the datasets were prepared for the geographic extent of the study area, a proximity map or distance distribution map for features of each factor was generated. These proximity maps were then further processed in the next step.

3.4.2 STEP 2: DATA CONVERSION AND NORMALIZATION

Upon completion of preparation, data was ready for conversion and normalization. This step is needed to bring all factors considered on a uniform and normal scale so that their contributions toward QOL could be mathematically manipulated.

In this endeavor, each factor was first assigned a range of weight according to the location of a site on a proximity map in terms of the factor's favorability-unfavorability. The range is set somewhere between (-1, +1). This way, all factors were converted and into quantitative information and were all normalized into numeric values between (-1, +1). This maneuver places all things considered on an even keel for mathematical and map algebra manipulations.

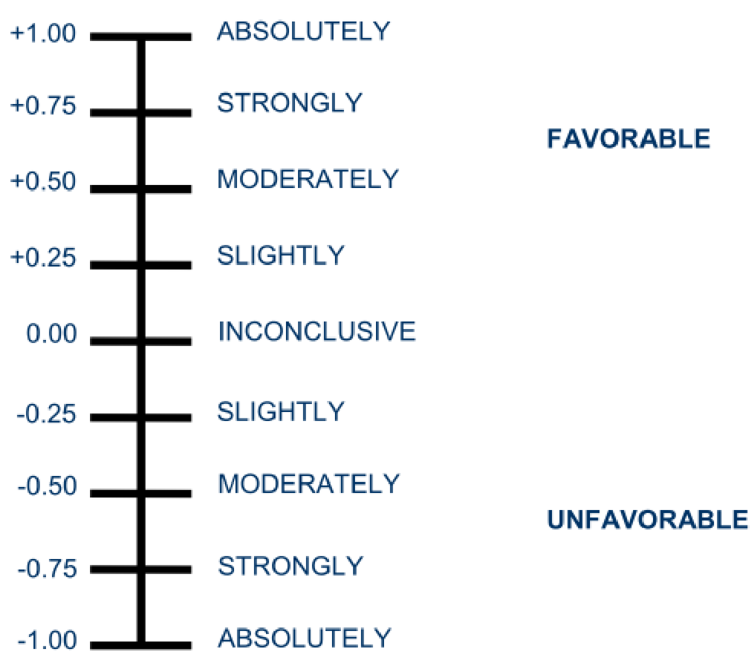

Figure 2. Favorability-Unfavorability conversion scale wherein contribution or weight is interchangeable between qualitative-quantitative representation.

Conversion is the idea of converting qualitative opinions into their corresponding quantitative values. Figure 2 is a scale designed for the mapping for the qualitative-quantitative information of favorability/unfavorability of opinions pertaining to a factor. It should be noted that the weights and ranges assigned in this study were hypothetical. In a real world situation, they could be well determined by holding public hearings, by conducting neighborhood meetings or by collecting surveys/polls.

To enable normalization, distance boundaries were set for each factor. Distance boundaries allow the equation to have break values for when the equation either becomes null, or possibly where to start its evaluation. In this study two equations were used for defining each factors spatial condition. All data is normalized in the same fashion except for using different conditionals for each data set input, creating the QOL factor.

For normalization, a number of candidate mathematical functions have been used to generate the hypothetical values in accordance to the distance distribution of features of a factor. Following are some examples:

Normalization Conditional Equation 1

The first equation, which will be referenced herein as Equation 1, states: "The closer to the layer is the worst but after X distance the value becomes null." Equation 1 was used for all factors that are deemed negative towards QOL. Figure 3 represents the behavior of Equation 1 with X equal to 1000 meters. Within the equation, [input] is whatever factor that is to be normalized, and "X" is the distance specified by the stakeholder for cutoff of the equation.

Normalization output = con([input] < X, Pow(- Exp (-1 * ([input] + 1) / X), 5), 0)

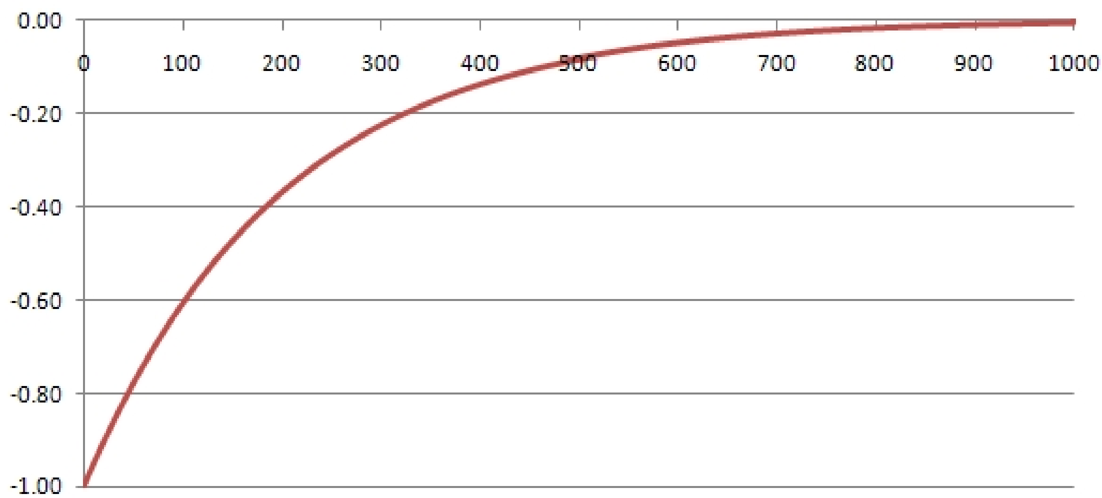

Figure 3. Normalization conditional example displaying the behavior of Equation 1.

Normalization Conditional Equation 2

The second equation, which will be referenced herein as Equation 2, states: “As close as you get is best but within X distance is good but outside of X distance is null.” Equation 2 was used for all factors that are deemed positive towards QOL. Figure 4 represents the behavior of Equation 2 with X equal to 1000 meters. Within the equation, [input] is whatever factor that is to be normalized, and “X” is the distance specified by the stakeholder for cutoff of the equation.

Normalization output = con([input] < X, Pow(Exp(-1 * ([input] + 1) / X), 5), 0)

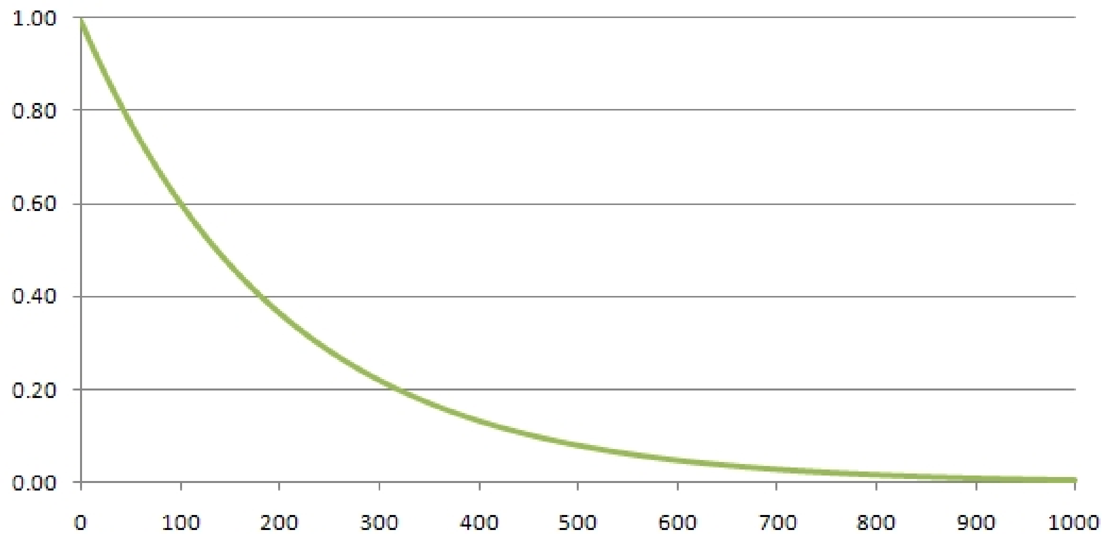

Figure 4. Normalization conditional example displaying the behavior of Equation 2.

By applying the above equations, the respective contributions or weights to QOL by all factors considered can be systematically generated for further combining in the next step.

3.4.3 STEP 3: COMBINING CONTRIBUTIONS FROM FACTORS BEING CONSIDERED

Weights or contributions from each factor were combined in a pair-wise manner two factors at a time. The weight combining is done by deploying map algebra formula derived from an expert system algorithm called EMYCIN (Melle 1979). The computation was done iteratively until all factors were exhausted. The final results were coded as a gradient map of an integrated and locale-specific value such as the QOL index in the range of (-1, +1).

The EMYCIN equations (Figure 5) work through the use of the following principles: 1) regardless of how many factors are being used, only two are being operated at each iteration (i.e. pair-wise calculation); 2) depending on the score values of the two factors, only one of the equations is applicable; 3) this formula allows for both positive and negative contributions of factors under consideration; 4) regardless of the number of factors being computed, the resulted score will always be bounded between -1 and +1; 5) regardless of the sequence each factor is put into pair-wise calculation, the result is always the same; 6) once all factors are exhausted in the calculation, the result can always reference the scale depicted in Figure 2 to be converted back to a qualitative scheme for better interpretation by stakeholders.

$$Score = \begin{cases} I_A + I_B - (I_A \times I_B) & I_A > 0 \quad I_B > 0 \\ I_A + I_B + (I_A \times I_B) & I_A < 0 \quad I_B < 0 \\ \dfrac{I_A + I_B}{1 - \min[|I_A|, |I_B|]} & Otherwise \end{cases}$$

Equation (1)

Equation (2)

Equation (3)

Figure 5. The EMYCIN Equations.

Equation 1 of the EMYCIN algorithm is utilized for two factors that have a score greater than 0, i.e. two positively scored values. Likewise, Equation 2 is used for two score values that are less than 0. Equation 3 is implemented when a positive and a negative score is encountered. It does not matter which factor, either I_A or I_B, is negative and which is positive when using Equation 3.

In utilizing EMYCIN to compile spatial data the following equation is used in order to satisfy the three EMYCIN equations:

con([Factor A] > 0 & [Factor B] > 0, [Factor A] + [Factor B] – [Factor A] * [Factor B],

con([Factor A] < 0 & [Factor B] < 0, [Factor A] + [Factor B] + [Factor A] * [Factor B],

con([Factor A] + [Factor B]) / (1 - Min(Abs([Factor A]), Abs([Factor B])))))

In looking at the previous equation line by line the following is what's happening. Figure 6 is provided for spatial reference.

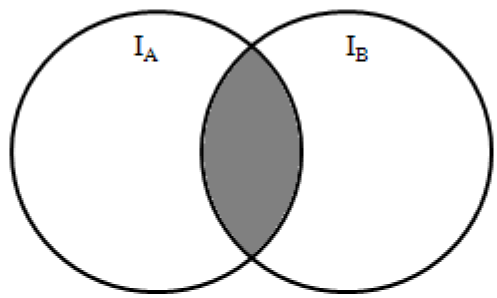

Figure 6. This diagram portrays how the EMYCIN algorithm handles data across overlapping spatial scales.

con([Factor A] > 0 & [Factor B] > 0, [Factor A] + [Factor B] – [Factor A] * [Factor B]

Translation

Score = $I_A + I_B - I_A * I_B$ If both I_A and $I_B > 0$

con([Factor A] < 0 & [Factor B] < 0, [Factor A] + [Factor B] + [Factor A] * [Factor B]

Translation

Score = $I_A + I_B + I_A * I_B$ If both I_A and $I_B < 0$

con([Factor A] + [Factor B]) / (1 - Min(Abs([Factor A]), Abs([Factor B])))))

Translation

Score = $(I_A + I_B) / (1 - \text{Min}[\,|I_A|, |I_B|\,])$ Otherwise

It should be noted that the quantitative inputs for the EMYCIN algorithm always will be bound between (-1, +1), however never with a score actually obtaining that of (-1, +1). The reason for this is because the other scores will no longer have an influence in the study. This should not be a surprise. When a score is given of Absolutely Favorable/Unfavorable then why bother assessing other factors when an absolute value has been assigned. Instead of using an Absolute score of -1 or +1, a score of -0.95 or +0.95 would be better suited as hardly anyone can claim anything is absolutely "good" or "bad".

In order to incorporate EMYCIN into the SAVEE methodology, all input values must have previously been normalized between the set values of +1 and -1 for EMYCIN to run. The data sets are entered into the EMYCIN algorithm in pairs. The order that the data sets are combined does not matter as it will always give the same output no matter the arrangement that each was calculated. The first result of the EMYCIN algorithm will then become the new data input for the next data set iteration. Each run of the algorithm will be run with another data set until all data sets have been entered. This process can be run for an unlimited amount of times until the user has satisfied the number of required inputs. For this application of the SAVEE methodology, the final result displays the overall QOL.

Figure 7 shows the iteration of the third step with regard to combining of factors. In this step, all converted and normalized data were combined in a pair-wise manner through the use of EMYCIN until factors under consideration were all exhausted. In essence, the EMYCIN algorithm takes two pixel values in the same location and evaluates them.

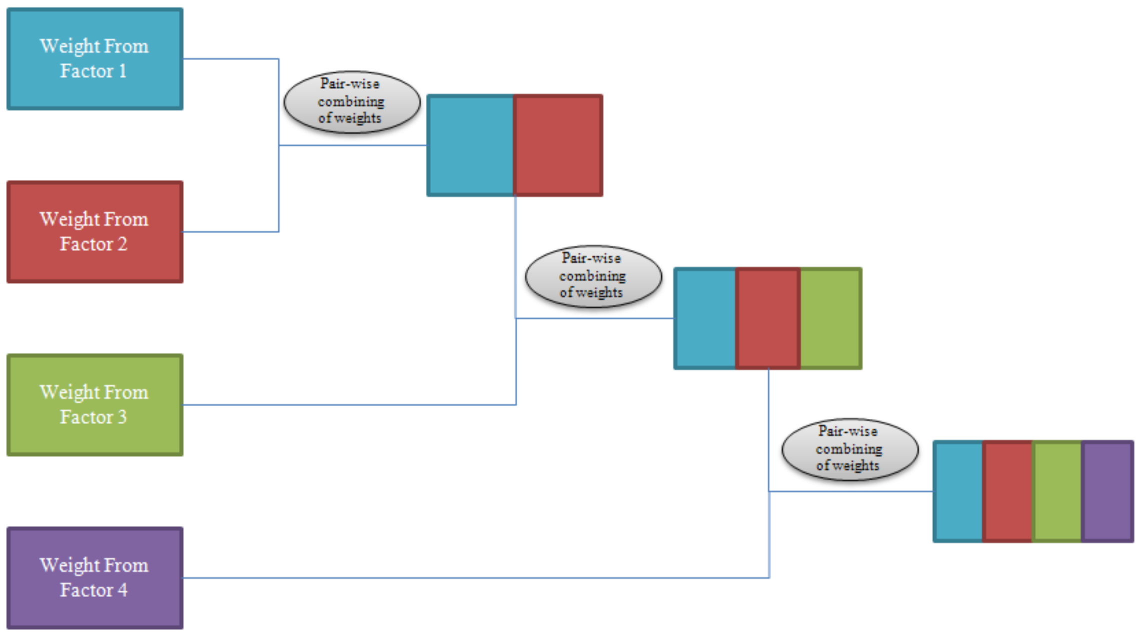

Figure 7. Combining of contributions of factors being considered through the use of EMYCIN in its map algebra form.

3.5 IMPLEMENTATIONS AND OPERATIONS

ESRI® ArcGIS™ 9 - ArcEditor™ 9.3.1 and Extensions was used for the implementation of the aforementioned SAVEE procedures and steps. The use of ArcGIS™ 9 allows for a friendly graphic user interface (GUI) and convenient manipulation, conversion, editing, and spatial calculations. Following are operational steps for the implementation of this study.

3.5.1 ADDITION OF SPATIAL DATA

Each data set that contributes to QOL was added into ArcGIS™ using the Add Data tool. Additional data was added to include: streets, subdivisions, city of College Station boundary, Brazos County boundary, and the State of Texas boundary for spatial reference purposes only, not analysis.

3.5.2 DATA ACQUIRED FOR DATA BASE MAP

The following data sets mentioned were added into the QOL analysis to visually enhance and set reference to location in and around the City of College Station, Texas.

The State of State boundary was downloaded from Columbia Regional Geospatial Service Center. I was also able to separate out Brazos County from the original file downloaded. The State of Texas and Brazos County boundaries were important so that the city of College Station could be better referenced for users that are not familiar with its geographic location.

Street line data was acquired through two sources. The street data managed by the county was downloaded from the Brazos County GIS website. City managed street data pertinent to the city of College Station was downloaded from the City of College Station GIS website. With these two separate files, the Merge tool located within ArcGIS™ was used to combine the two files into one. This way the map displayed all of the streets so that potential users could quickly and easily locate a specific locale.

Additionally a dataset containing all of the subdivisions within the city of College Station was included. The purpose of this dataset was to mask the final QOL output to that of the subdivisions so that only livable habitat could be included in the final analysis.

3.5.3 FACTORS CONTRIBUTING TO QUALITY OF LIFE

The following are the factors that were used in modeling a stakeholders hypothetical QOL and their role. For the sake of proof of concept of this tool, all factors were assigned values based on previous assessments wherever possible. Any unknown factors were assigned values based on 'best guess' estimates. These values should not be considered representative of actual QOL assessment; rather they are intended to demonstrate the versatility of the tool.

Fire Stations

The location of the fire stations in and around the city of College Station was acquired through the Department of Ecosystem Science and Management at Texas A&M University, College Station, Texas course titled "RENR 405 – GIS for Environmental Problem Solving" on January 16, 2010. Fire stations were modeled as a positive attribute for up to 5000 meters. Living as close to one was modeled as the best, but after 5000 meters the response time would be quite long, but still positive. Outside of 5000 meters the value would become null. It was found that living as close as possible to a fire station was most ideal (Toregas *et al.* 1971).

Greenways

The spatial data pertaining to the greenways, or corridors of protected land in a natural state, in and around the city of College Station was downloaded from the City of

College Station GIS website. The data was last modified July 25, 2008 and posted on October 20, 2009. The greenways were modeled as a positive input due to the increasingly number of people that value the aesthetic backdrop that it provides (Deller *et al.* 2001). An additional factor that makes greenways an attractive attribute to QOL is that they provide a natural sound break to decrease noise pollution (Bolund 1999, Brons 2003). A distance of 50 meters was given as a conditional stating its positive attributes; the reason for this is because only those bordering the edge or very close would have the most benefit. Once there are a few houses between the individual and the greenway, the value becomes null due to the loss of visual appeal.

Medical Facilities

The location of the medical facilities in and around the city of College Station was acquired through the Department of Ecosystem Science and Management at Texas A&M University, College Station, Texas course titled "RENR 405 – GIS for Environmental Problem Solving" on January 16, 2010. Just like that of the fire station locations, the medical facilities were a positive attribute for up to 5000 meters.

Parks

City park data was downloaded from the City of College Station website and contains all park locations in and around the city of College Station. The spatial data was last modified on July 25, 2008 and posted on October 20, 2009. The park locations were factored as positive attributes within 1000 meter proximity. Most people enjoy the green space set aside and the space needed to socialize or recreational activities.

Airports

The location of the airports in and around the city of College Station was acquired through the Department of Ecosystem Science and Management at Texas A&M University, College Station, Texas course titled "RENR 405 – GIS for Environmental Problem Solving" on January 16, 2010. Proximity from airports was determined as a negative contributing factor towards QOL by various sources (Vandell 1995, Praag and Baarsma 2005, Staples *et al.* 1999, Cohen *et al.* 2008). It was found that noise has the potential to create health problems for people, especially in urban areas (Bolund 1999, Brons 2003, Cohen *et al.* 2008), as well as to lower property values (Praag and Baarsma 2005, Espey 2000). Maximizing the distance from such noise is crucial; a doubling of the distance decreases the sound by 3 dB(A) (Bolund 1999, Brons 2003). Due to the variation in noise which is dependent upon type of aircraft and time of day, a proximity distance of 5000 meters was used to specify the furthest extent of noise pollution before full dissipation.

Environmental Protection Agency Environmental Hazardous Sites

The spatial data for all Environmental Protection Agency (EPA) environmental hazardous sites, current as of January 2009, was downloaded from the EPA's GIS website. These site locations were considered a negative factor towards stakeholder QOL for up to 1000 meters. These sites include garbage disposal locations (e.g. landfills) and waste water treatment plant locations. Voogd (1999) advocates these social dilemmas as NIMBY (Not In My Back Yard). Having a city waste disposal service is a luxury that no one wants directly near them. Other types of sites include industrial plants and other factories that would pose an environmental and health risk.

Oil Wells

The location of the oil wells within the city of College Station was acquired through the Department of Ecosystem Science and Management at Texas A&M University, College Station, Texas course titled "RENR 405 – GIS for Environmental Problem Solving" on January 16, 2010. The oil well locations were modeled as negative factors towards QOL for up to 1000 meters. The logic behind this proximity is that they pose an environmental and safety risk to those that live nearby.

Railroad

The railroad lines were downloaded from the Brazos County GIS website on November 17, 2009. Railroads were found to contribute towards a stakeholders QOL as a negative factor (Vandell 1995). It was found that noise from traffic and other sources has the potential to create health problems for people, especially in urban areas (Bolund 1999, Brons 2003, Cohen *et al.* 2008). Maximizing the distance from such noise is crucial; a doubling of the distance decreases the sound by 3 dB(A) (Bolund 1999, Brons 2003). For this reason railroads were given a maximum distance of 3000 meters before noise dissipation was at a tolerable level. Furthermore railroads can be a nuisance during heavy commuting times when having to wait for extended periods of time for the train to pass through an intersection with a street.

3.5.4 DATA PROJECTIONS

Spatial data comes in many different Projections depending upon its source. All data used in this study was Projected, if its coordinate system was undefined, into North American Datum 1983 Universal Transverse Mercator Zone 14N, or Reprojected if it was other than that mentioned.

3.5.5 CREATION OF BUFFER

It was found that some data was either on, or just outside of, the city of College Station boundary. This data was important for including into the QOL analysis so that the area would be better represented and to remove any possible source of error near the city limits. Using the Buffer tool within ArcGIS™, a 1000 meter buffer was created to satisfy the distance criteria (Longley *et al.* 2001) in order to include the outlying data (Figure 8).

3.5.6 CLIPPING OF DATA

Once the newly created buffer of the city of College Station was added as a data layer, all factors and GIS data was clipped so that its extent would not exceed that of the created buffer. Using the Clip tool within ArcGIS™, the extent was set to that of the Buffer and each GIS data file was clipped. The purpose in doing so creates a better visualization of the area of importance and defining the distance to examine (Mitchell 1999). By clipping out of data that extends beyond the city of College Station buffer the computer is being told to omit that data and only run analysis on the data within the boundary of the buffer.

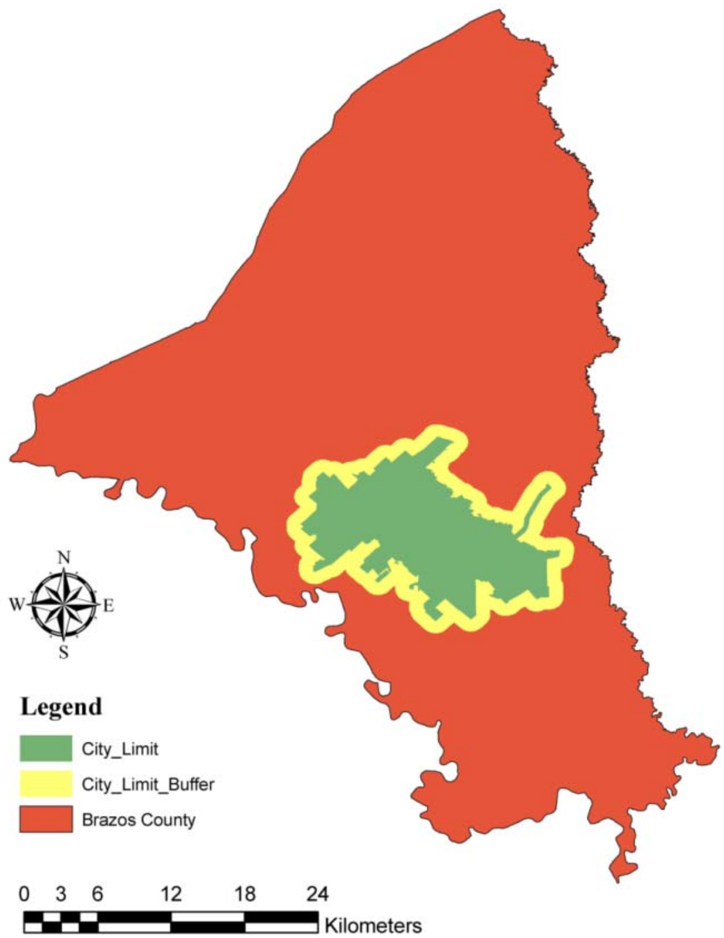

Figure 8. Use of the Buffer tool to delineate a 1000 meter buffer surrounding the city limits of College Station, Texas.

3.5.7 EUCLIDEAN STRAIGHT LINE DISTANCE

After the QOL factor data has been added into ArcGIS™ and the aforementioned processes carried out, the next step is to use Euclidean Straight Line Distance (SLD). SLD is a tool found within the Spatial Analyst extension in ArcGIS™ that lays down a spatially referenced grid in order to assign distances radiating away from the data course. SLD simply marks off distance radians in meters projecting away from the data in preparation for the next data process to be implemented (Figure 9).

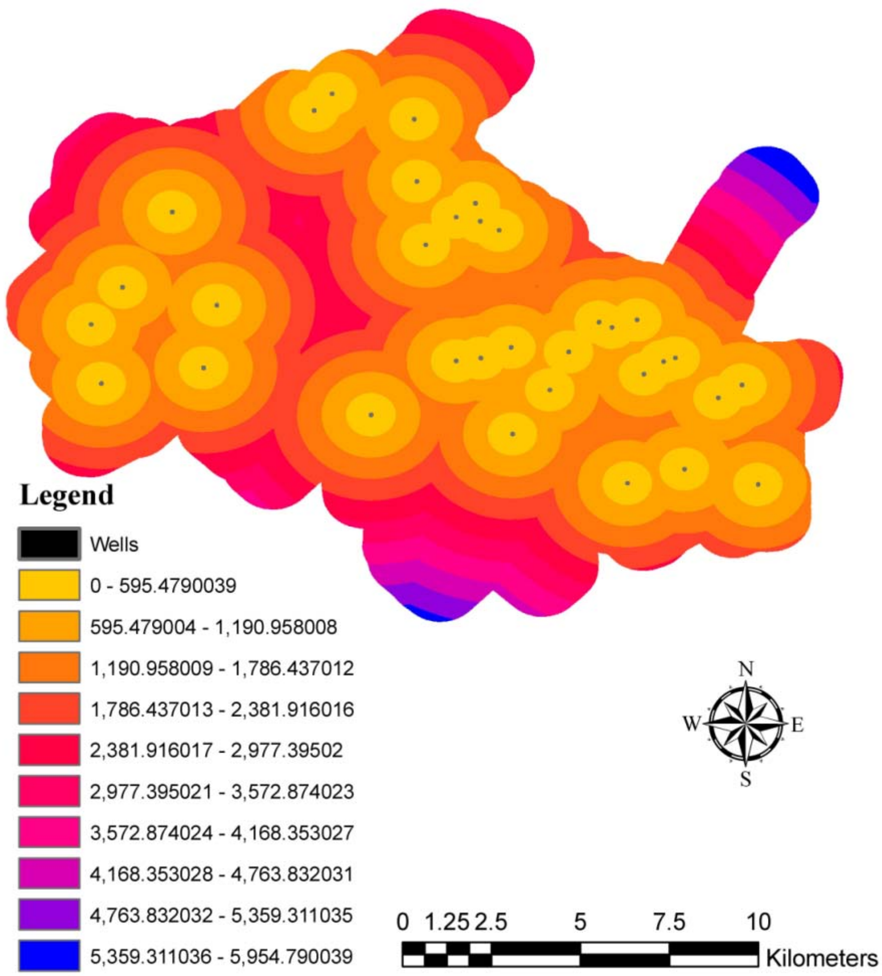

Figure 9. Use of Euclidean Straight Line Distance to establish distance from each factor. This example shows its use for oil wells.

Also during this process certain options need to be changed within Spatial Analyst. The spatial extent needs to be set to the output file of the city of College Station Buffer that was created, and cell size set to 5. A cell size of five specifies that each pixel represents a delineated spatial area on the ground as a 5 x 5 square meter. Therefore, the precision after running the QOL analysis will then automatically be set to a five meter resolution. After the SLD tool has been properly carried out for each set of data, each data set can now be normalized.

3.5.8 NORMALIZATION

For each QOL factor it had to be determined if it would have a positive or negative contribution to towards QOL. After that was determined, the correct equation could be assigned as well as the distance boundary that would be used. Table 1 shows the determination for each of the eight factors.

Table 1. The factors used towards QOL and the determination for normalization.

Parameter	Contribution	Maximum Distance
Airports	Negative	5000
EPA Hazardous Sites	Negative	1000
Oil Wells	Negative	1000
Railroad	Negative	3000
Fire Stations	Positive	5000
Greenways	Positive	50
Parks	Positive	1000
Medical Facilities	Positive	5000

The normalization conditional equation for each factor is analyzed using Raster Calculator found within the Spatial Analyst extension in ArcGIS™. A new output filename needs to be given and the input file is defined as the output previously created from SLD. This was completed for each factor contributing to QOL. In showing the use of normalization, Figure 10 shows the oil well factor following normalization using Equation 1 with a distance boundary of 1000 meters.

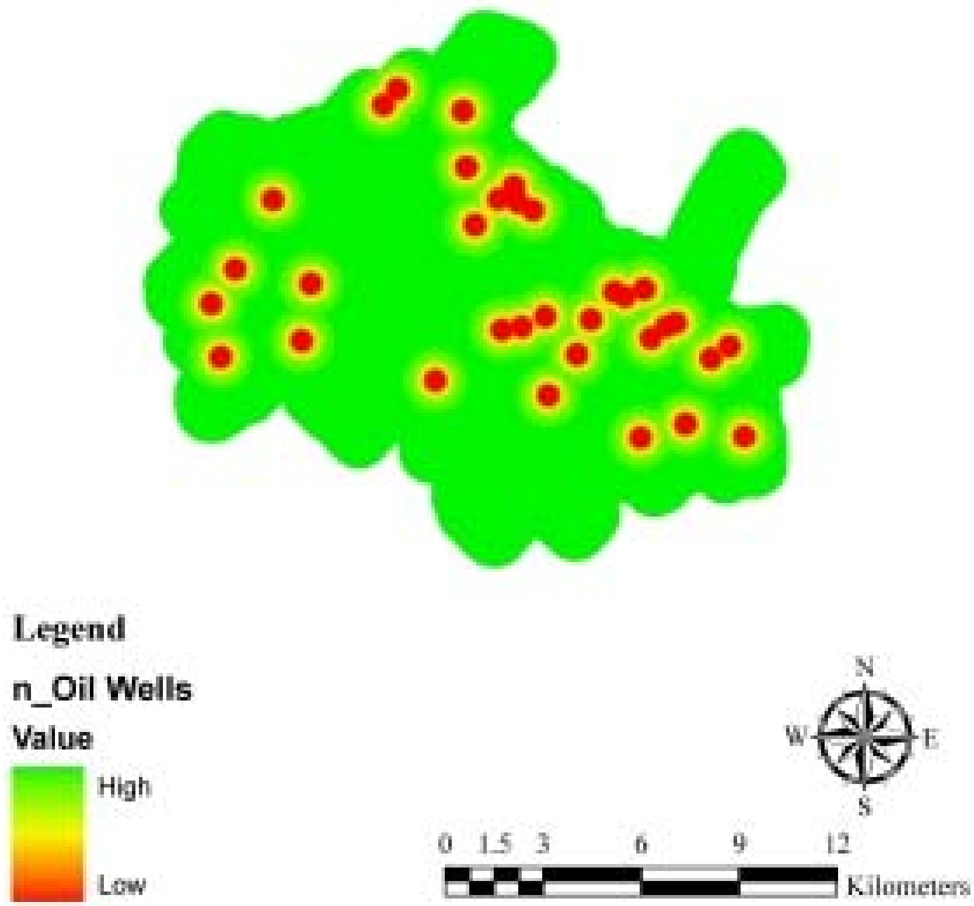

Figure 10. Normalization of the oil wells within the city of College Station buffer boundary.

3.5.9 EMYCIN

As previously described, the map algebra form of EMYCIN is used for combining factors for spatial analysis. All eight factors used for modeling QOL were combined in the same fashion until the last one was combined, ending with the final QOL output. Table 2 shows the method used for this step.

Table 2. Steps taken for carrying out EMYCIN for all eight factors.

<table>
<tr><th>Parameter</th><th colspan="7">EMYCIN Sequence</th></tr>
<tr><td>Airports</td><td rowspan="2">e_ae</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>EPA Hazardous Sites</td><td rowspan="2">e_aeo</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Oil Wells</td><td></td><td rowspan="2">e_aeor</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Railroad</td><td></td><td></td><td rowspan="2">e_aeorf</td><td></td><td></td><td></td></tr>
<tr><td>Fire Stations</td><td></td><td></td><td></td><td rowspan="2">e_aeorfg</td><td></td><td></td></tr>
<tr><td>Greenways</td><td></td><td></td><td></td><td></td><td rowspan="2">e_aeorfgp</td><td></td></tr>
<tr><td>Parks</td><td></td><td></td><td></td><td></td><td></td><td rowspan="2">e_aeorfgpm</td></tr>
<tr><td>Medical Facilities</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

3.5.10 MODELING DYNAMIC FLEXIBILITY OF SAVEE

In order to show the dynamic interworking of the SAVEE methodology, one factor was modeled with three different normalization equations. By changing a normalization equation for just one factor, it was hypothesized that the model will provide the flexibility to reflect that change. Not only would changing the normalization equation display the dynamisms of SAVEE, it also would allow for a comparison between the models to determine any significant change. To quantify any change, I compared the final QOL end results of the three outputs. This was done to determine if there are any significant differences among them following its mask to the subdivisions within the city of College Station. The sample size for comparison among models was 486 random samples collected at the same locations on each map. Through the attribute table for the selected points, a database file was created and exported into a Microsoft®

Excel™ spreadsheet. Then an F-test in Single-Factor Analysis of Variance (ANOVA) tested for differences among the three models at the 95% level.

The factor chosen for manipulating a change in the normalization conditional was the medical facilities. As with all of the other factors contributing to QOL the medical facilities was modeled with an exponential decay normalization conditional like that of Equation 2. The two additional equations chosen were a quadratic equation (con([Factor] <= X, - ([Factor] - X) * ([Factor]) * 0.00000009, 0)) and a linear equation (con([Factor] <= X, -0.0001998 * [Factor] + 0.999, 0)). As with the medical facility factor, these two additional equations could be applied to any factor according to stakeholder needs.

The quadratic equation was chosen to model the hedonic nature a stakeholder may have if he/she does not necessarily wish to live directly next to a medical facility, but would still like to live relatively close. However at some distance the benefit of living too far away from the medical facility would start to trail off, although still being a positive factor. An example of this would be if the noise created by the emergency helicopters was too deafening close by a medical facility so a distance of 2500 meters would be sufficiently far away. However the proximity from a medical facility beyond 2500 meters would start to taper towards neutral, although still being positive. This scenario is described by the following quadratic equation:

con([Medical Facility] <= 5000, - ([Medical Facility] - 5000) * ([Medical Facility]) * 0.00000009, 0)

The equation states that within proximity of 5000 meters from a medical facility the QOL value is positive. However a peak positive value of 0.56 is given at 2500 meters; anything before and after 2500 meters would bend towards neutral (Figure 11).

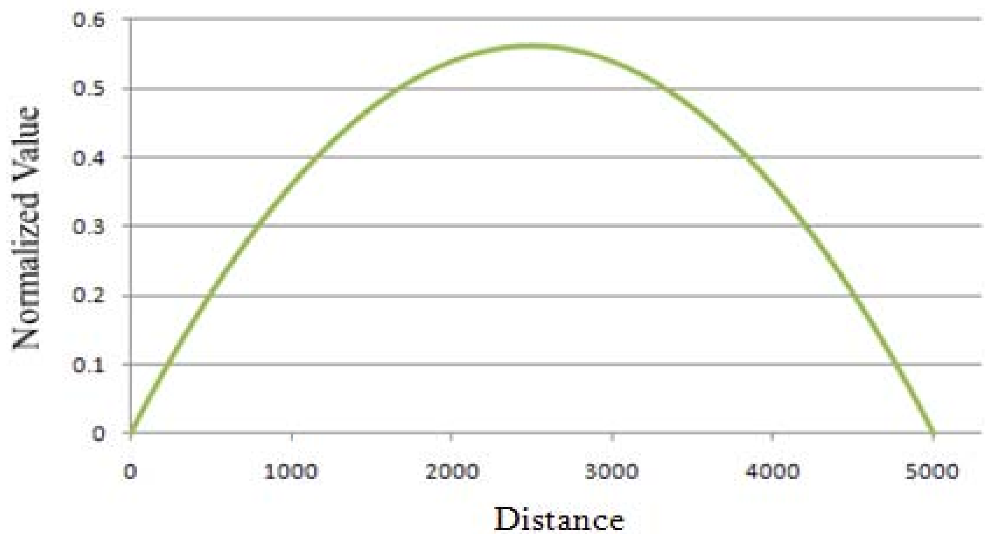

Figure 11: Plotted normalized values when given the quadratic equation to represent spatial QOL.

The linear equation was also used to positively model the QOL value of a medical facility. This function (Figure 12) states that living directly next to a medical facility is ideally positive but as the proximity expands beyond the boundary of the medical facility to 5000 meters, the QOL value is decreasing. The function used to describe this is given as:

con([Medical Facility] <= 5000, -0.0001998 * [Medical Facility] + 0.999, 0)

This equation could be best suited for someone that has a strong want to live as close as possible to a Medical Facility.

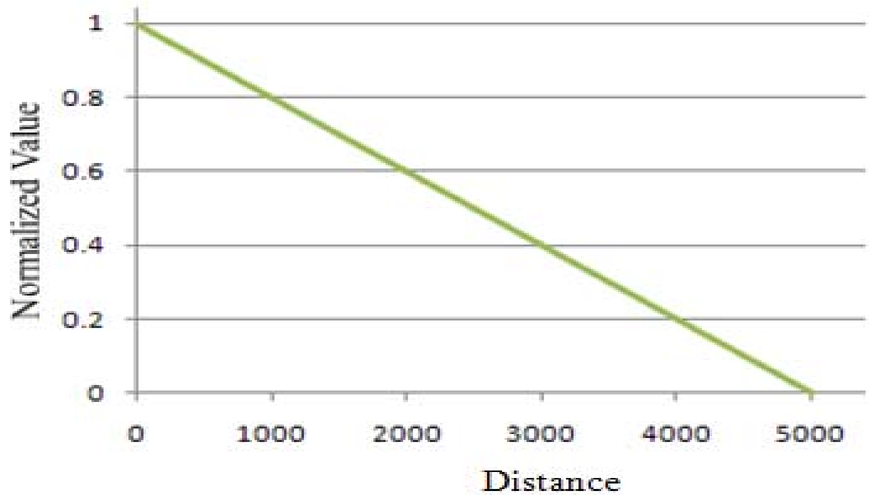

Figure 12: Plotted normalized values when given the quadratic equation to represent spatial QOL.

3.5.11 MASK OVERLAY OF SUBDIVISIONS

A large portion of the city of College Station is uninhabitable due to industrial property, roadways, and other tracts of land deemed inappropriate for living. For this reason all data was finally masked to that of the subdivisions within the boundary of the city of College Station. This provided a more realistic analysis of ideal and less ideal locations to live.

3.5.12 PREPERATION OF DATA FOR FINAL EXPORT

There are commonly two types of GIS data, vectors and rasters. Vector data, composed of lines and points, do not distort as they are increased or shrunk in display size. The disadvantage is that they can take up a large amount of file space depending on the detail. Rasters, like photos and shapes, distort very easily as they are manipulated. The advantage of saving in raster format is that raster images do not take up nearly as much file space when compared to vectors. When the final QOL data analysis was complete for each scenario, and additional features added to the map, each map was exported in vector format with raster markers. The file format used was Enhanced Metafile (.emf) which allows for very clean and clear map outputs so that they could be later enlarged or cropped depending on later need.

With the ArcGIS™ GUI, the outputs are shown as gradient maps, and at the same time quantitative values can quickly be determined by zooming in to a specific locale. The maps portray the QOL value ranging from -1 (Unfavorable) to +1 (Favorable) using different color gradients. A value approaching -1 is illustrated as Low and shown in the color red. A value approaching +1 is illustrated as High and shown in the color green. QOL values near 0, or neutral, are shown as yellow.

4. RESULTS AND DISCUSSION

The results show the outputs following pair-wise (two input) calculation of normalized factors pertinent to QOL of College Station, Texas.

4.1 COMBINING OF FACTORS – STEP 3

4.1.1 RESULTS OF AIRPORTS AND EPA HAZARDOUS SITES

The first combining of contribution, labeled as e_ae, included the input of the airports and EPA hazardous sites (Figure 13). With the first two factors weighted together being negative, the combined results contribute a strong negative impact on the overall QOL value for the city of College Station.

There was only one airport that was within the boundary of the city of College Station buffer, located on the western edge. Its distance from the city center resulted in a minimal impact on the surrounding area. However, given the maximum proximity for the negative value of 5000 meters, it has an influence on the QOL value for a large area.

Eight EPA hazardous sites were registered within the boundary as displayed on the map (Figure 13). These sites were dispersed enough to affect a greater portion of the overall area as compared to the airport. The negative range for this factor was 1000 meters, compared to 5000 for the airport, creating a broadly-distributed, but isolated, impact on the surrounding community.

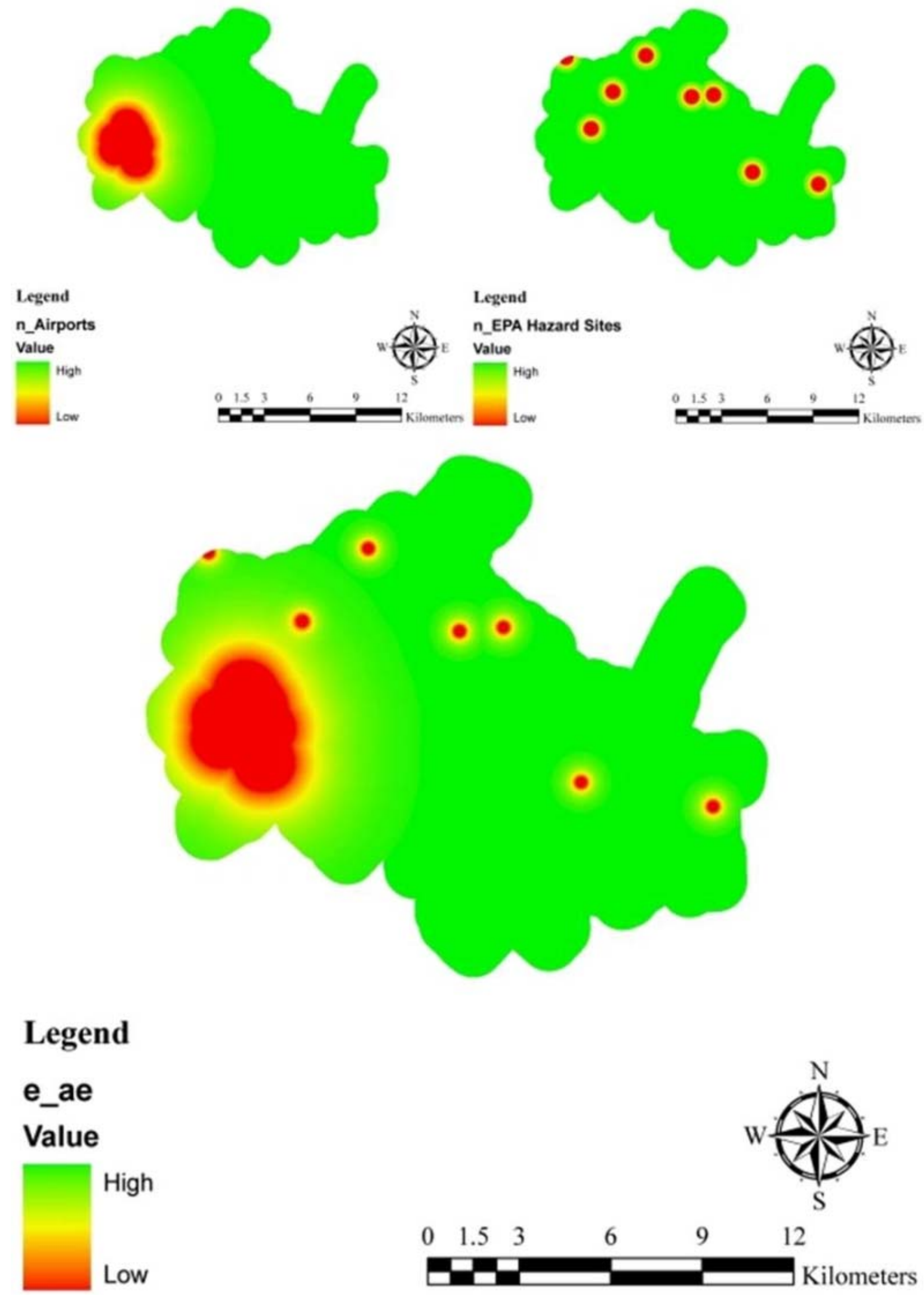

Figure 13. First combining of contributions output of airports and EPA hazardous sites.

4.1.2 RESULTS OF AIRPORTS, EPA HAZARDOUS SITES, AND OIL WELLS

The next combining of contributions included the previous output, e_ae, with the addition of a third factor, the oil well locations (Figure 14). Much like that of the EPA hazardous sites, the oil well locations are spread out across a greater region of the study area. With the number of oil well locations being plentiful within the study area, this resulted in a widely dispersed and a very strong negative influence on the overall QOL. It should be noted that the oil well locations are spread across the entire study area rather evenly posing a potential environmental risk across the entire spatial scale. It has been observed that these oil well locations are quite transparent to the general public, reinstating that many hazards go unnoticed until an accident occurs.

4.1.3 RESULTS OF AIRPORTS, EPA HAZARDOUS SITES, OIL WELLS, AND RAILROAD

The third combining of contributions, and the last of the negative factors used in this study, included the addition of the railroad line. The railroad line runs between the middle and western portion of the study site creating a more negative bias for that area while creating little affect on the eastern portion of the study site.

Although the railroad line itself only encompasses a few meters in width, the negative range of 3000 meters due to the noise disturbance resulted in a broad linear feature running north-south through the western side of town. Some of this affected area overlaps with the airport. Consequently, these weights have affected the QOL value for a large portion of the western area of the study site (Figure 15).

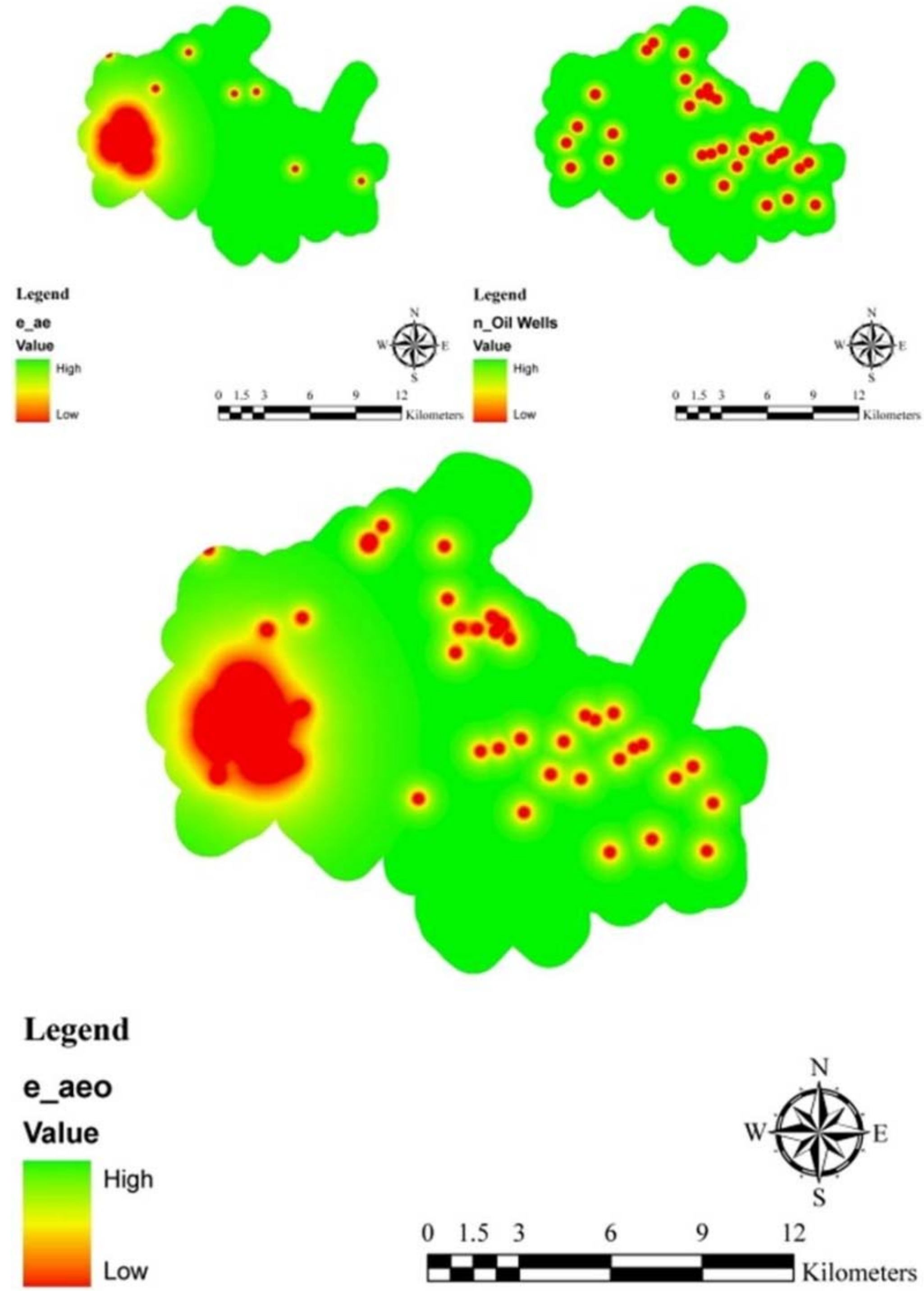

Figure 14. Combining of contributions output for the combination of airports, EPA hazardous sites, and oil wells.

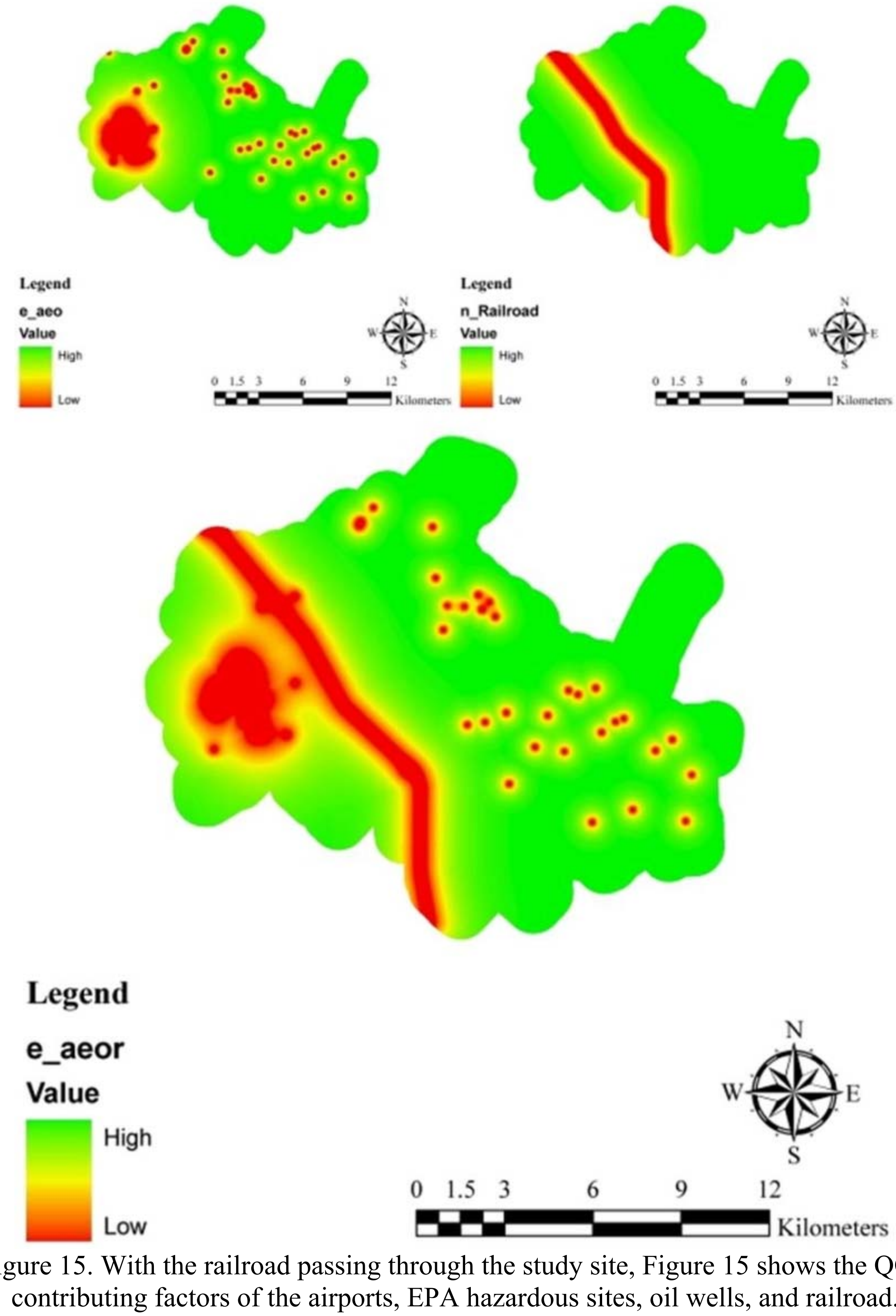

Figure 15. With the railroad passing through the study site, Figure 15 shows the QOL contributing factors of the airports, EPA hazardous sites, oil wells, and railroad.

4.1.4 RESULTS OF AIRPORTS, EPA HAZARDOUS SITES, OIL WELLS, RAILROAD, AND FIRE STATIONS

The next combination, and the first of the positive factors, was the addition of the fire stations (Figure 16). Located primarily within the central interior of the city and widely distributed, this spatial distribution is ideal in sense that its positive influence on QOL assists in raising the QOL value for a large area. With the inclusion of the positive QOL factor, the overall percentage QOL value is as follows: Favorable 8%, Neutral 71%, and Negative 21%. The resulting map shows the overall QOL value starting to lean towards a more neutral value for the city.

Modeled with distance proximity of 5000 meters, it is clear that the five fire stations in the study site covered a large portion of the surrounding community. In the real world this is important for quicker response times and site selection for future locations (Toregas *et al.* 1971). Many homeowners and businesses could take further advantage of this attribute as it grants the potential for lowered insurance premiums.

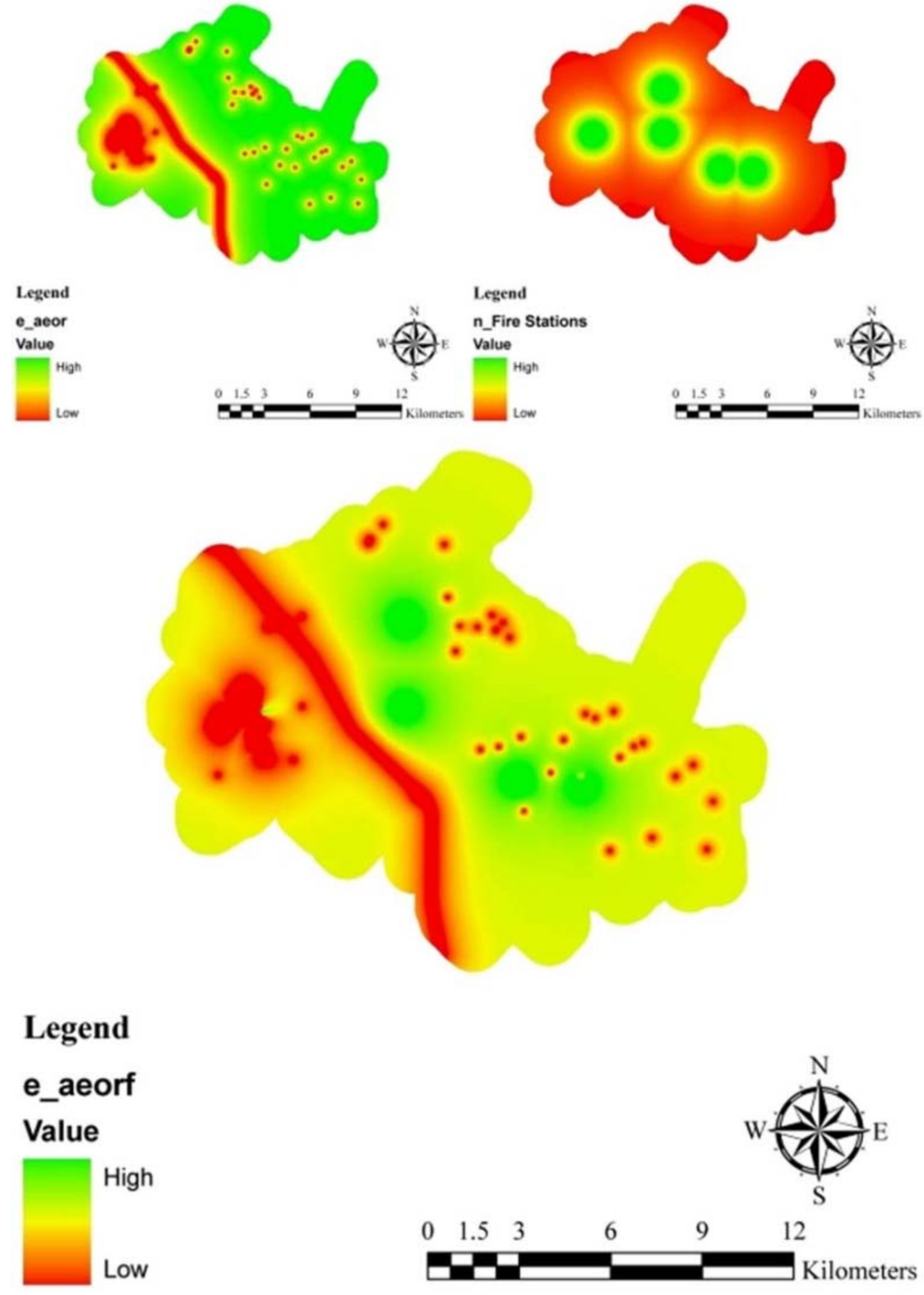

Figure 16. Combining of contributions output for the combination of airports, EPA hazardous sites, oil wells, railroad, and fire stations.

4.1.5 RESULTS OF AIRPORTS, EPA HAZARDOUS SITES, OIL WELLS, RAILROAD, FIRE STATIONS, AND GREENWAYS

The fifth combining of contributions included the greenways (Figure 17). The greenways, modeled as a positive QOL value, contributed to a high QOL value within the central portion of the study area. Greenways follow creeks due to the abundant availability of moisture, so appear as networks through the study area. The overall percentage QOL value is as follows: Favorable 12%, Neutral 68%, and Negative 20%.

At this iteration four negative factors and two positive factors have been computed. Observation reveals sharp contrasts between the locations of each positive and negative factor, with the areas between trending toward a neutral QOL value.

4.1.6 RESULTS OF AIRPORTS, EPA HAZARDOUS SITES, OIL WELLS, RAILROAD, FIRE STATIONS, GREENWAYS, AND PARKS

The next additional factor used in assessing the QOL for College Station was the parks. Parks are distributed throughout the city and encompass a very large collective area (Figure 18). At this point many of the individual factors are still evident although beginning to blend together. For example, the negative area given from the contribution of the airport has been reduced. The overall percentage QOL value is as follows: Favorable 23%, Neutral 59%, and Negative 18%.

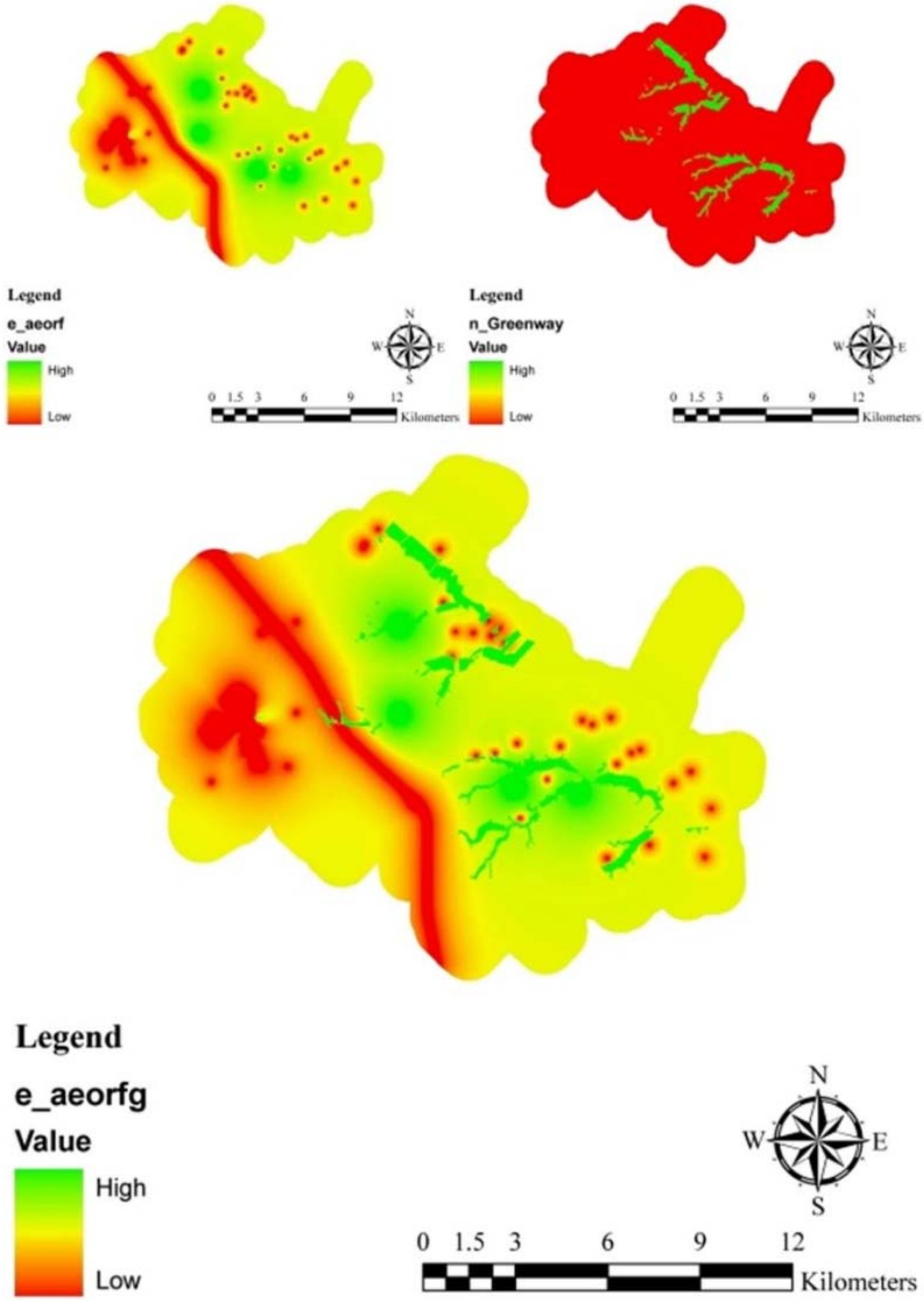

Figure 17. This illustrates the combination of airports, EPA hazardous sites, oil wells, railroad, fire stations, and greenways.

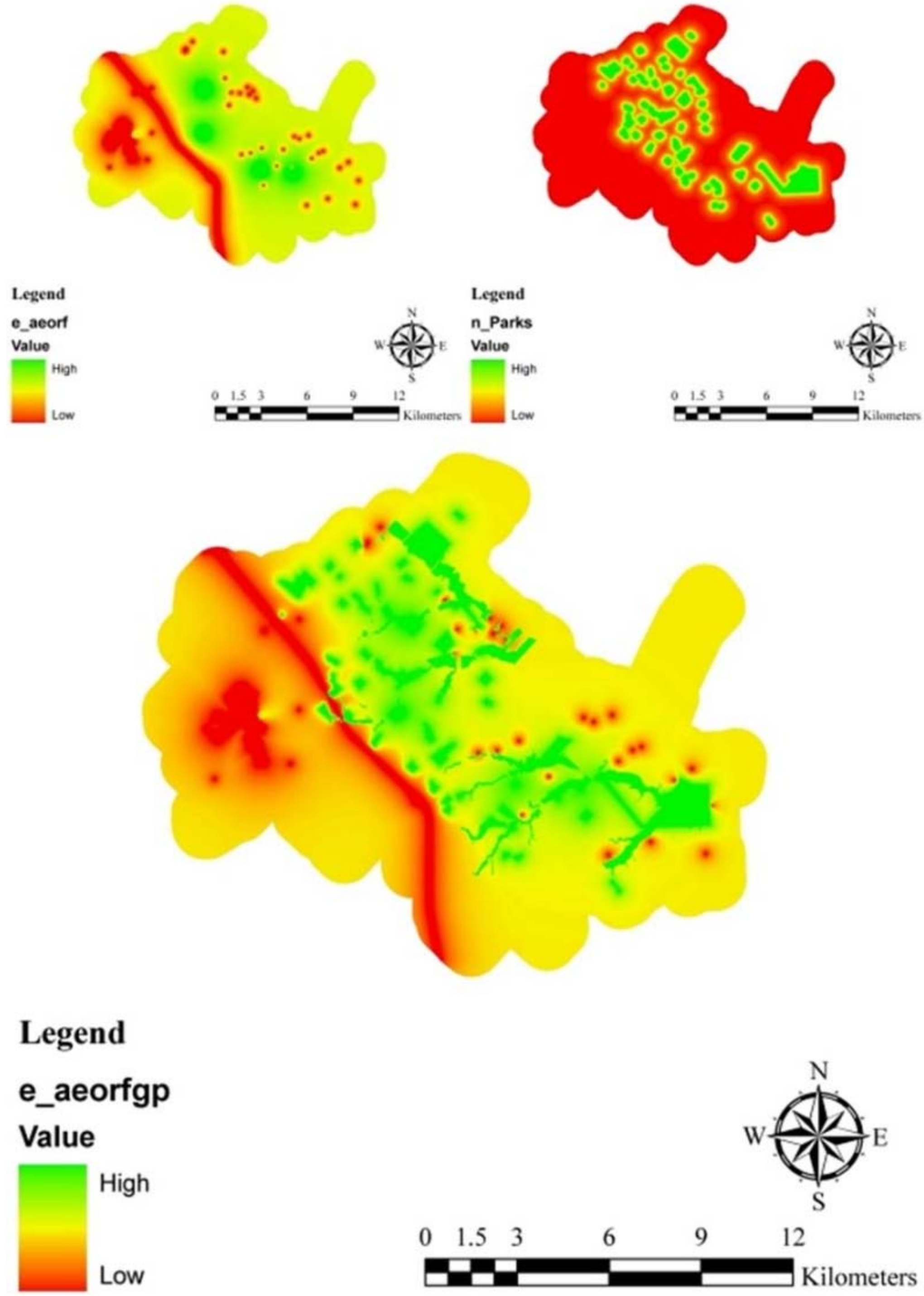

Figure 18. Combining of contributions output for the combination of airports, EPA hazardous sites, oil wells, railroad, fire stations, greenway, and parks. This illustrates how this positive factor, when combined with the other factors, gives more positive weight to the overall city QOL value.

4.1.7 RESULTS OF AIRPORTS, EPA HAZARDOUS SITES, OIL WELLS, RAILROAD, FIRE STATIONS, GREENWAYS, PARKS, AND MEDICAL FACILITIES

The final combining of contributions involved the addition of the medical facilities to the already created QOL model that includes the airports, EPA hazardous sites, oil wells, railroad, fire stations, greenway, and parks (Figure 18). Three major medical facilities are located in the northern and central area. Two of the three medical facilities are clustered closely together in the northern end of the study area. This is far less than ideal as travel time in the event of an emergency could be increased.

The additional step of masking the area to the subdivisions within the city of College Station is illustrated in Figures 19, 20, and 21. This added step was important in excluding all areas that are uninhabitable.

Figure 19 shows the final QOL value for the city of College Station with the medical facility locations using the exponential decay Equation 2; Figure 20 uses the quadratic equation and Figure 21 uses the linear equation. Visually there is a difference in the final QOL value maps when only one factor is given a different normalization equation.

The exponential decay function used for the medical facilities (Figure 19) shows results of a fairly evenly distributed QOL index. The most prominent negative area is near the western central portion of the study area. A value of neutral to slightly unfavorable QOL extends beyond the boundary starting from the western edge of the study area, wrapping around to the south, and continuing until the eastern edge. The cause for this can be determined from the lack of positive factors for those areas. The most favorable QOL values were concentrated near the interior and northern boundary of the study site. This is consistent with the data where many of the positive factors were spatially located. The overall percentage QOL value is as follows: Favorable 48%, Neutral 41%, and Negative 11%.

The use of the quadratic equation for the medical facilities (Figure 20) is very similar to the results from the exponential decay function (illustrated in Figure 19). The overall percentage QOL value is as follows: Favorable 61%, Neutral 31%, and Negative 8%. There is only a slight increase in favorable QOL value within the interior of the study area. This can be contributed to the wider area that the function used to set the positive range. Unlike the exponential decay function where the favorable range drops exponentially, the quadratic function, although using the same proximity distance, delineates a wider coverage of favorable area.

The linear function was applied to the medical facilities and it shown in Figure 21. It had a profound effect on the entire study area. Using the same distance proximity as the exponential decay and quadratic functions, 5000 meters, it created a change to the overall QOL value. The most favorable locations are still within the interior and northern portion of the study area as the other functions used, but greater areas of unfavorable conditions now exist. The overall percentage QOL value is as follows: Favorable 60%, Neutral 32%, and Negative 8%. The western and southern boundaries of the study area are now highly unfavorable. With the previous equations these areas were more neutral.

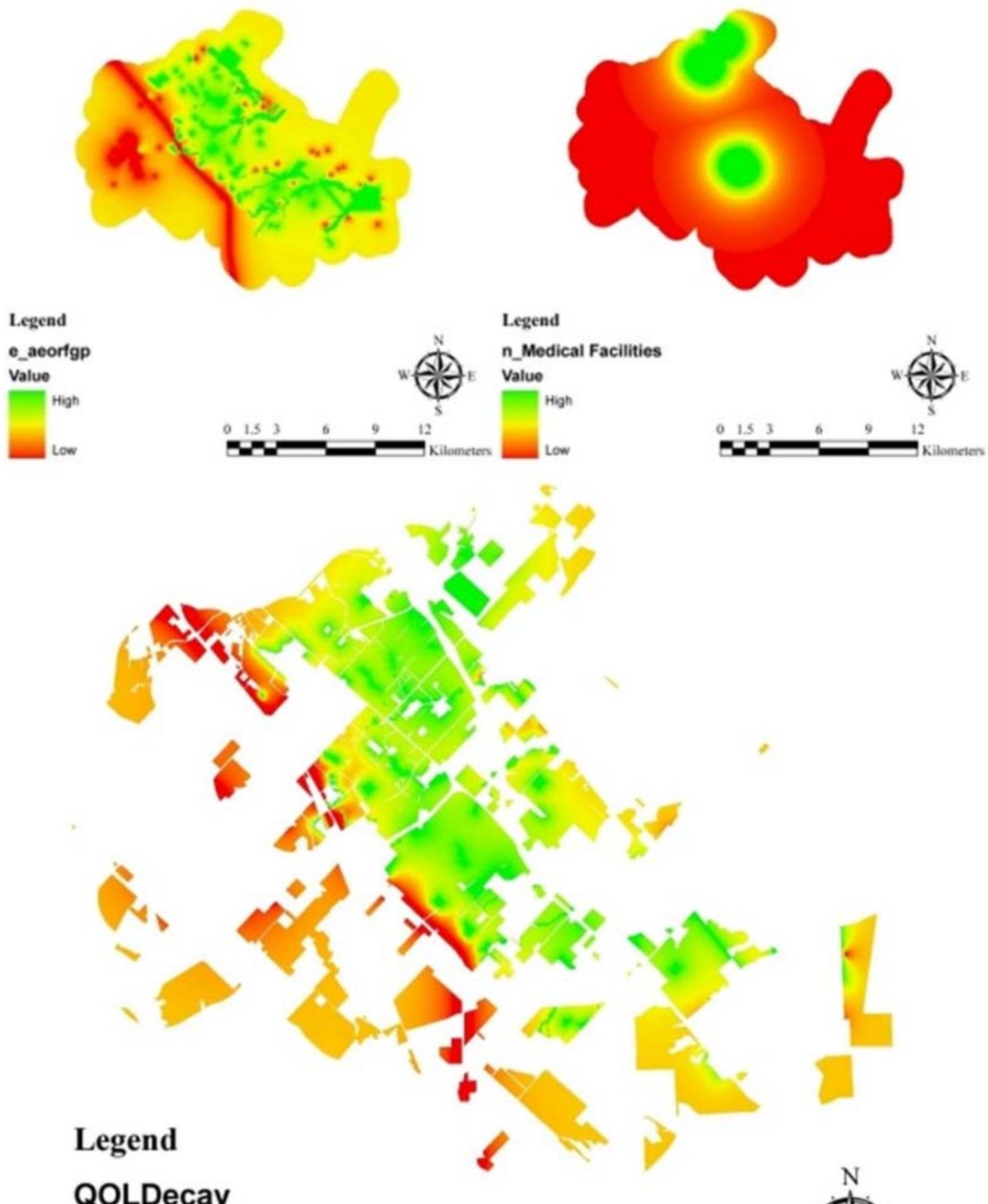

Figure 19. Combining of contributions output following the combination of airports, EPA hazardous sites, oil wells, railroad, fire stations, greenway, parks, and medical facilities using the exponential decay normalization equation masked to the city of College Station subdivisions.

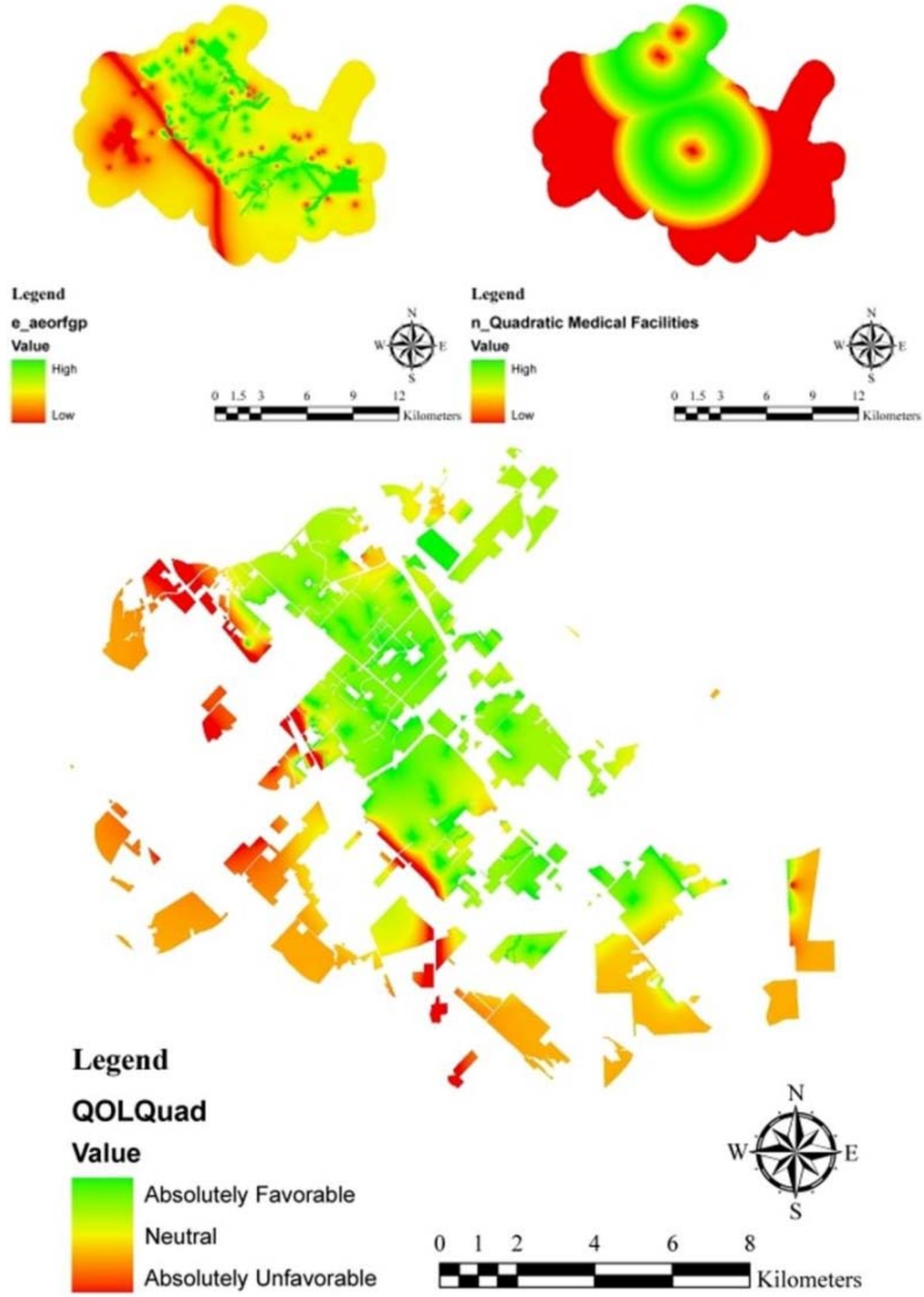

Figure 20. Combining of contributions output following the combination of airports, EPA hazardous sites, oil wells, railroad, fire stations, greenway, parks, and medical facilities using the quadratic normalization equation masked to the city of College Station subdivisions.

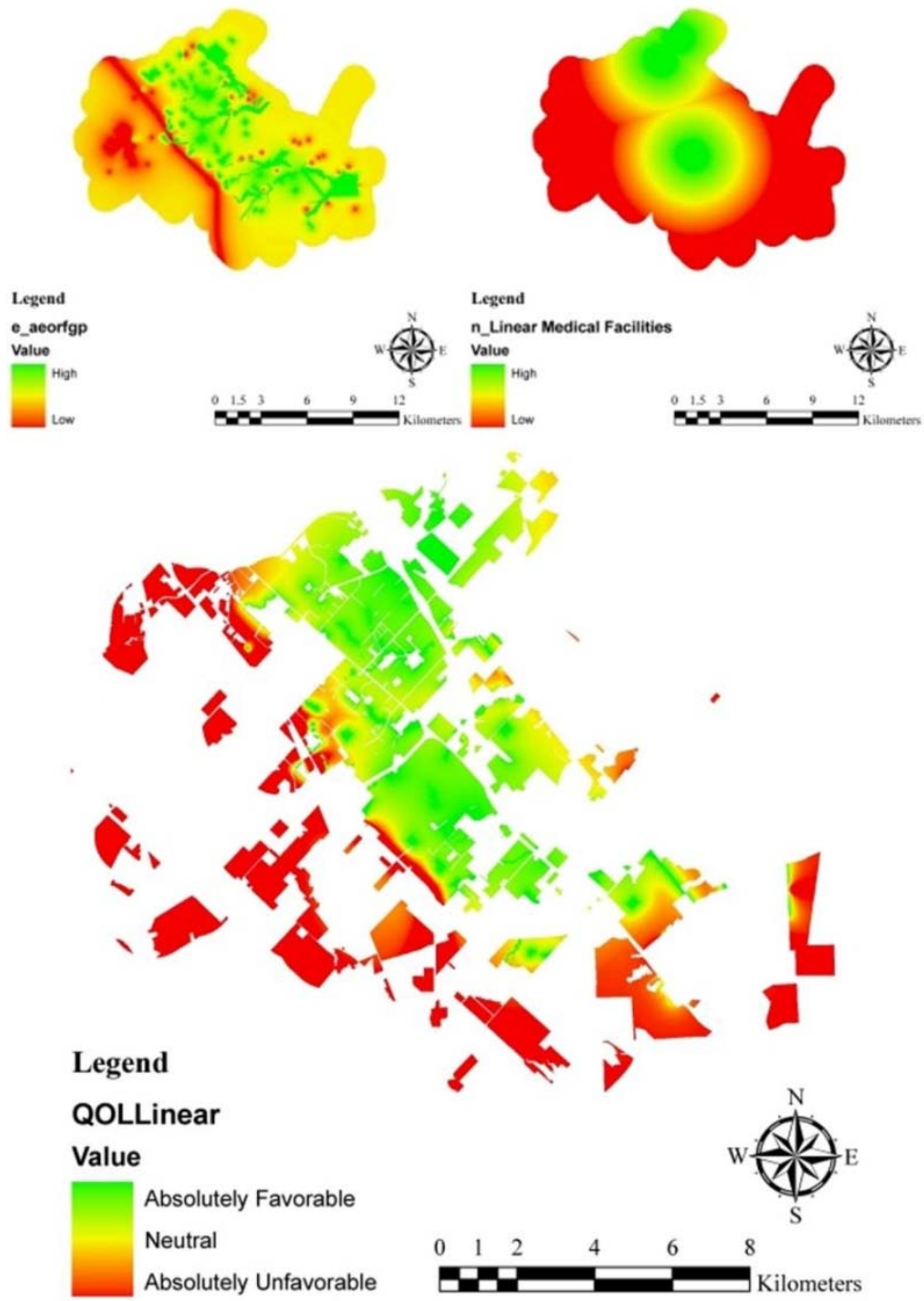

Figure 21. Combining of contributions output following the combination of airports, EPA hazardous sites, oil wells, railroad, fire stations, greenway, parks, and medical facilities using the linear normalization equation masked to the city of College Station subdivisions.

4.2 SPATIAL ANALYSIS

In order to compare the results among the three equations, a statistical analysis F-test was performed. This indicates if there is a difference in using the three equations to evaluate QOL values. Table 3 shows the results following the statistics run for the 486 randomly selected points (SS= Sum of Squares, df= degrees of freedom, MS= Mean of Squares).

The samples were considered into two groups: “within groups” which takes into account the variations of QOL values in each equation, and “between groups” which measures the variations of QOL values among the three equations.

Table 3. The conducted F-test provided evidence that the models were significantly different.

Variation	SS	df	MS	F	P-value	F critical
Between Groups	9.72105	2	4.8605272	23.0242344	1.4311E-10	3.0019
Within Groups	307.15753	1455	0.2111048			
Total	316.8785	1457				

The F-statistic is greater than the critical value (3.0016) at 0.05 level of significance. Therefore, the null hypothesis is rejected indicating that the variations between the groups are significant. That is, there is a 95% chance that a different equation generates distinguished final QOL outputs.

During analysis the mean for each final QOL output was also computed. The mean QOL value for the three models is given in Table 4. The mean QOL value while studying the exponential decay output was 0.22, showing an overall Slightly Favorable

QOL. The mean QOL value while studying the quadratic function on only the medical facilities was 0.37. This value shows that the overall QOL was Moderately Favorable. The mean QOL value while studying the linear function on only the medical facilities was 0.41, Moderately Favorable.

Table 4. Mean value and variance for each final QOL output.

Equation Used	Sample Size	Sum	Mean	Variance
Exponential	486	108.1406162	0.222511556	0.195738169
Quadratic	486	182.318685	0.375141327	0.192315312
Linear	486	199.6342401	0.410770041	0.245261033

4.3 A SYNOPSIS

The SAVEE methodology is useful to provide a locale-specific QOL application (Figure 22), which can be completed for any location of interest. To demonstrate this point: Figure 22 illustrates the high resolution and sensitivity of SAVEE in defining the value of pinpoint locations on a single street.

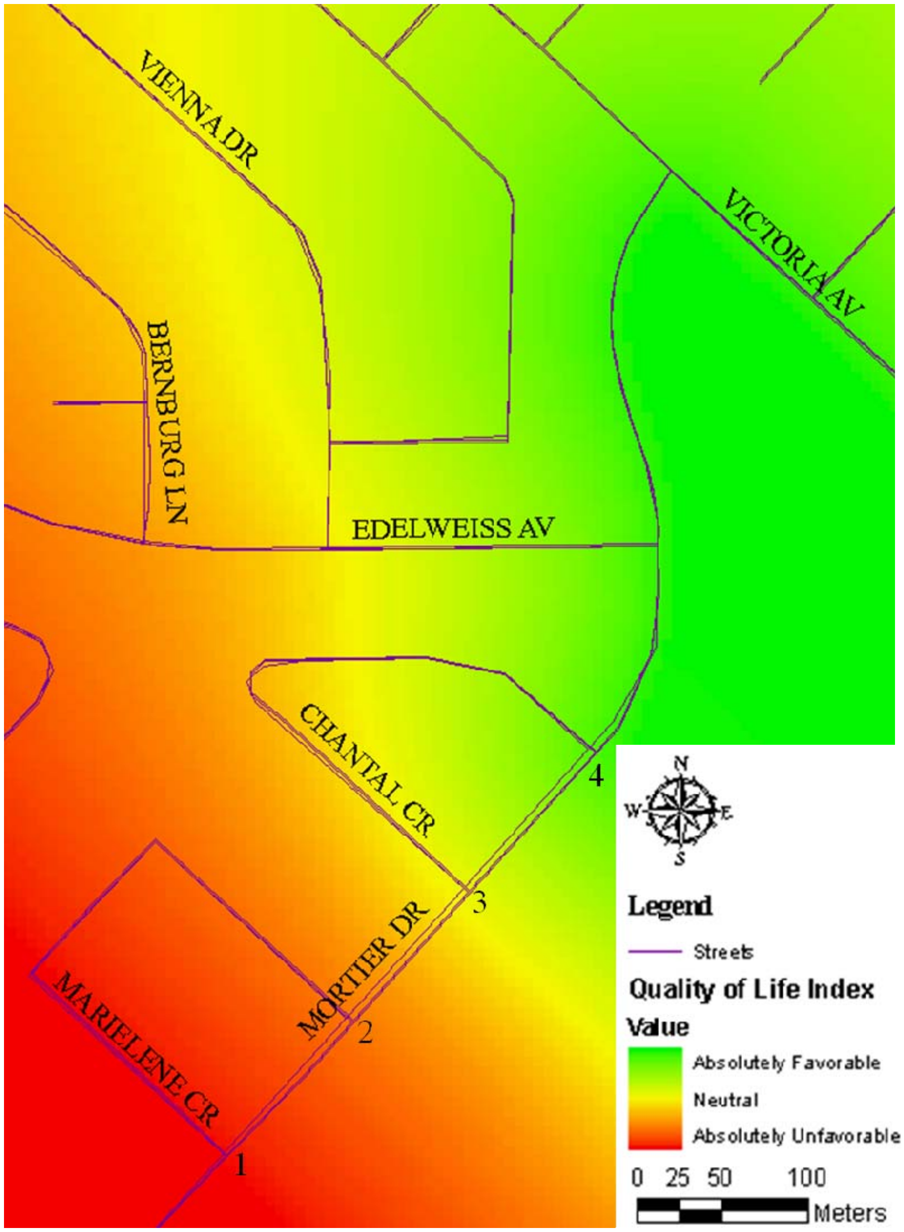

Figure 22. Locale-specific use of the SAVEE methodology in assessing QOL.

Using the Identify tool within ArcGIS™ the quantitative value was quickly given as follows: (1) -0.59; (2) -0.26; (3) +0.30; and (4) +0.83. This locale-specific quantitative and qualitative analysis can be completed for any locale on the map.

4.4 STAKEHOLDER FLEXIBILITY

Each factor that contributes to ones QOL is subjective. The value and range is variable and can be defined by the stakeholder, giving flexibility. The following is an example as to why flexibility is important. A medical facility may be viewed by some as having a value of +0.8, or strongly favorable, when living directly next to its premises because of short travel times during an emergency. Others may feel that living next to a medical facility would be valued only +0.2, or slightly favorable, due to the loud noise of emergency vehicles coming and going at all hours of the day. However at a distance of 500 meters, for example, that value may have increased to +0.6 since he/she is still close in proximity in need of emergency care and now the noise is far less than it was before. The ability for stakeholders to customize their own QOL assessment has never been available at this level of detail.

An additional example of how normalization is valuable in assigning QOL value across a given proximity is for an oil well. It is widely generalized that an oil well would be a negative factor when choosing a location to live. Having an oil well in a stakeholder's backyard may pose a value of -0.95, or absolutely unfavorable, or possibly -0.25, or slightly unfavorable. Additionally the specified distance to the oil well may also be a required adjustment. These values are flexible and can be tailored to the stakeholder's own opinions.

These scenarios can be had for each factor contributing to QOL. There are an infinite number of conditional equations that can be used to describe/define each stakeholder’s personal preference. In this assessment, only two equations were used in order to demonstrate the tool’s simplicity, versatility, and to provide proof-of-concept.

5. CONCLUSIONS AND FUTURE WORKS

In summary, the SAVEE methodology illustrated the potential for an application in assigning a locale-specific QOL value through using GIS. The robust nature of the aforementioned method provides a framework for use in future planning of cities and states. Furthermore the factors used in combining of weights is only limited to the extent set by the stakeholder.

Through the use of the SAVEE methodology, determining QOL using GIS accurately defines QOL score based on spatial distribution and perceived values. This method of determining QOL is innovative in obtaining QOL value. It also provides a visual representation of QOL for the end user based upon his/her standards and requirements. This creates an entirely new approach to current uses of the term Quality of Life by providing a way to validate claims of a high quality for a localized area.

The implementation of combining of contributions into a user interface is a drastic approach for the future planning of cities and states based on current findings. The term good quality of life can not necessarily have a distinct value because when calculating this value it will vary from person to person. However, there can be middle ground found for calculating a discrete value for QOL. This can be done by taking into account very generic factors to contribute to the overall value. Such values are incorporated into this particular assessment. For example, not too many people want to live near a landfill and most people would consider living near a park to be a positive factor when choosing a place to live. “Creating amenity spots such as parks, greenbelts, and open space within a city will increase household incentives to live in the city, but will reduce land available for residential development (Wu 2001).” The criteria used to evaluate decisions must accurately reflect the values of the people who will be affected (Aronoff 1989).

The number of factors chosen should also be considered; as more factors were added to the model, the amount of neutral space became further reduced. It is quite possible that with too many factors, the output could produce sharp contrasts of QOL hotspot values across a narrow distance (Figure 22). It should be noted, however, that other studies across spatial scales have experienced and addressed this same spatial differentiation and fragmentation effect (Geoghegan 1997, Petrucci and D'Andrea 2002, Pickett *et al.* 1997, Vandell 1995).

Through the use of the SAVEE methodology for modeling QOL, it was shown that the steps carried out herein were successful in creating a locale specific hedonic model. Although the distances used were arbitrary, they were sufficient to illustrating this proof-of-concept.

Additionally with the use of GIS and the Spatial Analyst extension, QOL can be calculated numerically. This numerical result can then be used to assist a person in evaluating an area to live without actually having to go to that location. Also the cell size could be further reduced to decrease the generalization of a particular area and enhance resolution. The analysis can become more accurate if additional pertinent factors were considered. Overall the results from this small scale calculation appear to be accurate with the given amount of factors.

In using a quadratic function and a linear function, there was shown a significant difference ($P < 0.05$) in the final output of the QOL value with only one factor modified. This finding was important because it shows that the addition or subtraction of just one factor can affect the entire outcome in determining a locale-specific value. For example, if a stakeholder hears news that his/her home is located within a Federal Emergency Management Agency's 100 year floodplain, the SAVEE methodology allows for that individual to quickly, and with ease, modify the previous model to include this new factor.

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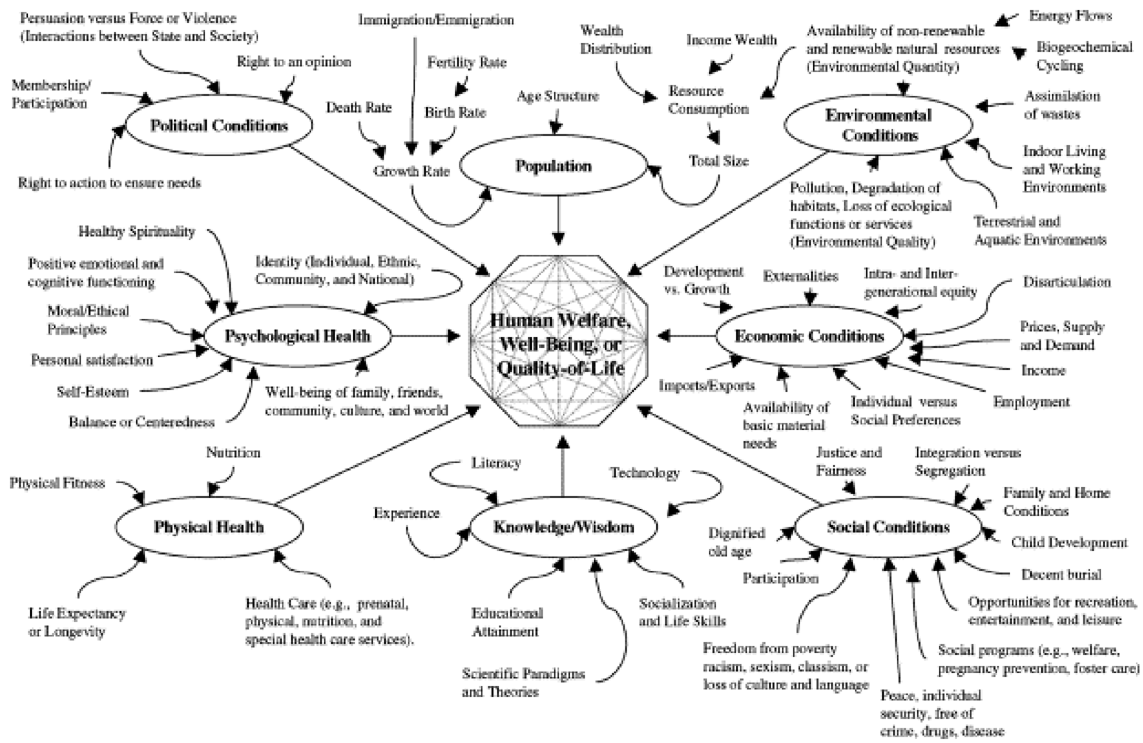
APPENDIX A

FACTORS THAT CONTRIBUTE TO ONES QUALITY OF LIFE (Troyer 2002)



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