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Suitability Analysis Guidebook/Training Materials: Manual for Application of Suitability Analysis for a Selected Region in Texas

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Section I: Background and Application Process

1. Background

This Guidebook is prepared as part of Task 2 of implementation project 5-5667, which focuses on the development of a prototype application of the Suitability Analysis model using GIS for a selected region in Texas. It is organized into two sections. Section I provides a description of the study area and background information on data collection and analysis process. Section II introduces a prototype model with a step-by-step process to run it. Appendices to the Guidebook give additional details about each component of the model along with the required data and GIS tools to run the model, and results of each step.

2. Study Area

We selected the Austin Region for the development of a prototype application model using Suitability Analysis. The study region is comprised of three counties (Hays, Travis, and Williamson) out of the five counties that are within the Austin–Round Rock–San Marcos metropolitan area.

3. Process

As mentioned in the report, this model follows a four-step process.

1) Projection of Employment and Households
2) Calculation of Required Land
3) Suitability Analysis
4) Allocation of Employment and Households

Projection of Employment and Household

3.1.1 Data

Table 3.1 shows types of employment and household data with their sources collected for this study.

Table 3.1: Data Types and Sources

Data Type	Year	Source
Population and households	2005	U.S. Census Bureau
Population and households	2014 projected	ESRI
Population	2005-2040 projected	Texas State Data Center
Average parcel size for each land use		CAPCOG data clearinghouse
Total employment projections		Austin's Capital Area Metropolitan Planning Organization (CAMPO)
Employment (2 digit NAICS)	2009	Texas Comptroller Office
Employment Estimation (4 digit NAICS)	2006	Texas Workforce Commission
Employment Projection (4 digit NAICS)	2016	Texas Workforce Commission
Employment Estimation (2 digit NAICS)	2008	ESRI Business Analyst
Employment Projection (2 digit NAICS)	2013	ESRI Business Analyst

After collecting required data for employment and household, this data was classified into different categories.

3.1.2 Employment Classification

For this study purpose, 17 categories of employment were developed based on the data collected from Texas Workforce Commission for 2006. This report consolidated 4-digit NAICS codes into the 2-digit NAICS categories.

Table 3.2 shows 2-digit NAICS employment categories with percentage of employees in each category for all three counties (Hays, Travis, and Williamson) for 2006. The purpose of showing employment categories in percentage is to break down total projected employment data from CAMPO into 2-digit NAICS categories for each projection year.

Table 3.2: Employment Categories in Percentage

Employment Categories	Employment Percentage		
	Hays	**Travis**	**Williamson**
Accommodation and Food Services	7.80	8.30	7.80
Administrative and Support and Waste Management and Remediation Services	6.30	14.80	6.30
Agriculture, Forestry, Fishing and Hunting	0.80	0.10	0.80
Arts, Entertainment, and Recreation	1.50	1.90	1.50
Construction	15.30	10.6	15.30
Educational Services	47.50	37.40	47.50
Finance and Insurance	3.00	3.20	3.00
Health Care and Social Assistance	3.50	3.90	3.50
Information	0.00	0.60	0.00
Manufacturing	3.50	7.20	3.50
Other Services (except Public Administration)	1.60	1.60	1.60
Professional, Scientific, and Technical Services	1.70	3.60	1.70
Real Estate and Rental and Leasing	0.40	0.70	0.40
Retail Trade	6.90	4.90	6.90
Transportation and Warehousing	0.00	0.60	0.00
Utilities	0.3	0.00	0.3
Wholesale Trade	0.40	0.50	0.40
Total	**100%**	**100%**	**100%**

Average area per employee needs to be calculated to find out how much land would be required for projected employment. Average area per employee was calculated by dividing the existing area with the number of employees in every 2-digit NAICS category. Table 3.3 shows average area per employment in square foot for Hays County. Average area for Travis and Williamson County can be calculated similarly.

Table 3.3: Average Area per Employment

Employment Categories	Number of Employment	Area (Sq.Ft)	Area per Employment (Sq.Ft)
Accommodation and Food Services	4,786	2,548,750	532.54
Administrative and Support and Waste Management and Remediation Services	587	776,250	1,322.40
Agriculture, Forestry, Fishing and Hunting	101	296,250	2,933.17
Arts, Entertainment, and Recreation	637	1,032,500	1,620.88
Construction	3,238	3,520,000	1,087.09
Educational Services	5,460	4,170,000	763.74
Finance and Insurance	753	940,000	1,248.34
Health Care and Social Assistance	3,537	3,395,000	959.85
Information	630	1,250,000	1,984.13
Manufacturing	3,413	3,562,500	1,007.14
Other Services (except Public Administration)	1,894	3,958,750	2,090.15
Professional, Scientific, and Technical Services	1,626	2,377,500	1,462.18
Real Estate and Rental and Leasing	1,215	3,133,750	2,579.22
Retail Trade	1,928	1,711,250	887.58
Transportation and Warehousing	665	1,088,750	1,637.22
Utilities	157	487,500	3,105.10
Wholesale Trade	1,810	3,157,500	1,744.48

Employment was categorized into basic and service sectors using the result of Location Quotient Technique. The following formula was used to calculate the number of basic sector employment for Hays County. The same formula can be used to calculate the number of basic sector employment for other counties or areas.

$$\text{Basic Sector Employment} = \frac{\text{Hays County Employment Industry}}{\text{Texas Employment Industry}} - \frac{\text{Total Hays County Employment}}{\text{Total Texas Employment}} \times \text{Texas Employment Industry}$$

Table 3.4 shows basic and service sector employment in Hays County for the year 2005 and 2010.

Table 3.4: Basic and Service Employment in Hays County

Employment Categories	2005		2010	
	Basic	Service	Basic	Service
Accommodation and Food Services	0	3,227	0	3,855
Administrative and Support and Waste Management and Remediation Services	0	2,625	0	3,189
Agriculture, Forestry, Fishing and Hunting	0	0	0	0
Arts, Entertainment, and Recreation	0	638	0	749
Construction	849	5,496	1,107	6,482
Educational Services	3,191	16,453	3,698	20,242
Finance and Insurance	0	1,247	0	1,445
Health Care and Social Assistance	0	1,458	0	1,772
Information	0	15	0	15
Manufacturing	22	1,443	95	1,613
Other Services (except Public Administration)	67	608	86	697
Professional, Scientific, and Technical Services	0	711	0	861
Real Estate and Rental and Leasing	0	181	0	209
Retail Trade	939	1,903	1,142	2,201
Transportation and Warehousing	0	0	0	0
Utilities	20	111	13	121
Wholesale Trade	0	145	0	162

3.1.3 Household Classification

The household (single family and multifamily) classification of the study area was categorized into three groups as shown in Table 3.5 based on household income level. Such categorization of household is required for input in TDM.

Table 3.5: Household Categories

Household Income Level (in U.S. Dollars)	Income Category
<50,000	Low Income
50,000 – 99,999	Medium Income
>100,000	High Income

Table 3.6 shows total number of households with income categories in Hays County for 2005 and 2010.

Table 3.6: Households in Hays County

Income Category	2005	2010
Low Income	24,197	25,430
Medium Income	15,135	22,084
High Income	8,160	14,851
Grand Total	**47,492**	**62,365**

By adding the number of households with income categories of Hays, Travis, and Williamson County, we have the total number of households with income categories for the entire study area.

Table 3.7: Households of the Study Area

Income Category	2005	2010
Low Income	232,370	205,998
Medium Income	176,815	225,196
High Income	73,934	130,494
Grand Total	**483,119**	**561,687**

Required Land

Required land is the amount of land that is needed to accommodate future/projected employment and household. To calculate the future required land, we needed the average land area for each employment and household categories. This data was obtained from parcel data provided by CAPCOG.

3.1.4 Required Land for Employment

Table 3.8 shows the required land for both basic and service sector employment for the year 2010 for Hays County. To get the required land for basic and service sector employment: 1) find the difference between the number of employment for 2005 and 2010 for both basic and service sectors by using data from Table 3.4, and 2) multiply the difference with the average area per employment as shown in Table 3.3.

Table 3.8: Required Land for Employment in Hays County

Employment Categories	Growth 2005-2010		Required Land (Sq.Ft)	
	Basic	Service	Basic	Service
Accommodation and Food Services	0	628	0	334,463
Administrative and Support and Waste Management and Remediation Services	0	564	0	745,797
Agriculture, Forestry, Fishing and Hunting	0	0	0	0
Arts, Entertainment, and Recreation	0	111	0	179,990
Construction	258	987	800,673	3,063,549
Educational Services	507	3,789	387,004	2,893,702
Finance and Insurance	0	198	0	247,284
Health Care and Social Assistance	0	315	0	302,081
Information	0	1	0	1,364
Manufacturing	74	170	87,959	194,399
Other Services (except Public Administration)	20	90	41,710	187,227
Professional, Scientific, and Technical Services	0	150	0	219,377
Real Estate and Rental and Leasing	0	28	0	72,177
Retail Trade	202	297	223,750	327,560
Transportation and Warehousing	0	0	0	0
Utilities	-7	10	-6,101	8,692
Wholesale Trade	0	17	0	16,173

Table 3.9 shows the total required land for basic and service sector employment of the entire study area. It was obtained by adding required land for basic and service sector employment of Hays, Travis, and Williamson County.

Table 3.9: Required Land for Employment in the Study Area

Employment Categories	Required Land (Sq.Ft)	
	Basic	**Service**
Accommodation and Food Services	266,572	266,448
Administrative and Support and Waste Management and Remediation Services	1,580,969	5,451,375
Agriculture, Forestry, Fishing and Hunting		
Arts, Entertainment, and Recreation	151,756	1,382,763
Construction	1,473,996	11,229,201
Educational Services	1,735,968	31,467,342
Finance and Insurance	0	1,145,659
Health Care and Social Assistance	0	2,347,173
Information	-354,996	237,304
Manufacturing	-859,341	841,043
Other Services (except Public Administration)	105,826	990,066
Professional, Scientific, and Technical Services	688,862	1,774,061
Real Estate and Rental and Leasing	0	658,817
Retail Trade	956,184	3,104,811
Transportation and Warehousing	0	56,919
Utilities	-7,677	64,662
Wholesale Trade	85,208	308,845
Grand Total	**5,823,329**	**63,726,487**

3.1.5 Required Land for Household

Based on the result of the regression analysis (for census block groups data of the study area with variables: total number of low income, medium income and high income, sum of area of single family, sum of area of multifamily, and total count of single family), we derived a formula (Table 3.10) to calculate the required land for household. Table 3.11 shows the required land for household of the study area.

Table 3.10: Formula from Regression Analysis

Income Category	**Area for**						
Low Income	MF	=	2021.1	X	Change in Household	-	9378.4
	SF		2234.4			+	11836006.9
Medium Income	MF		1221.7				402759.4
	SF		31167.2				4828423.1
High Income	MF		888.6				583922.5
	SF		45120.5				6300425.4

Table 3.11: Total Required Land

Income Category	2005	2010	Change	Required Land (Sq.Ft)	
				Single Family	Multifamily
Low Income	232,370	205,998	-26,373	-1,183,641,079	-22,850,703
Medium Income	176,815	225,196	48,381	621,940,250	97,773,923
High Income	73,934	130,494	56,560	1,767,634,394	69,501,686
Grand Total	**483,119**	**561,687**	**78,568**	**1,205,933,565**	**144,424,906**

Note: Negative (-) sign indicates loss of projected household and required land.

Suitability Analysis

Suitability analysis is a 4-step process.

1. Selection of Suitability Factors
2. Selection of Land uses
3. Range of Buffer
4. Rating and Weighting

3.1.6 Selection of Suitability Factors

Suitability factors—both natural environmental and built environmental—need to be selected for suitability analysis. Selection of suitability factors is subjective and depends upon the purpose and the location of the study area. Table 3.12 shows the selected suitability factors for this study.

Table 3.12: Selected Suitability Factors

Natural Environmental	Built Environmental
Water Bodies	Highways
Wetlands	Intersections
Texas Ecological Assessment Protocol (TEAP)	Employment Centers
Karst (geological formations with aquifers, also a habitat for some endangered species)	Airports
	Existing Land use

3.1.7 Selection of Land uses

Identifying land uses for the suitability analysis was based on employment and household categories. Selection of land uses is also subjective and depends upon the purpose and location of the study area. Table 3.13 shows the selected land uses for this study.

Table 3.13: Selected Land Uses

Use Categories	Activities
Single-Family residential (SF)	
Multi-Family residential (MF)	
Basic Low Commercial (BLC) Service Low Commercial (SLC)	Offices, assisted living, day care, retail sales and services, restaurants, banks, nursery or greenhouse, grocery sales, pharmacies, fitness centers, dance and music academies, artist studio, colleges and universities, bed and breakfast.
Basic High Commercial (BHC) Service High Commercial (SHC)	Any use in Low Commercial plus bar, nightclub, entertainment venues, hospital, hotel, liquor store, office/warehouse, vehicle and equipment sales, leasing and repair, furniture sales, pet shop, wholesale activities.
Basic Light Industrial (BLI) Service Light Industrial (SLI)	Any use in HC plus commercial laundry, contractor storage yard, lumber yards, indoor manufacture, assembly and processing, mini-warehouse, RV, trailer and boat storage, SOB's, testing and research, warehouse and distribution, wholesale, wrecker impoundment.
Basic Heavy Industrial (BHI) Service Heavy Industrial (SHI)	Any use in LI plus outdoor manufacture, assembly and processing.
Open Space (OS)	City parks, pocket parks , community gardens, outdoor recreational areas, natural areas, environmentally sensitive areas, greenways

3.1.8 Suitability Factors' Categories

Proximity/accessibility to the suitability factors was used to determine the location of future development. Proximity/accessibility was defined by buffer ranges around each factor. Buffer values are included in the rating table. Table 3.14 shows a range of buffers for the selected suitability factors.

Table 3.14: Suitability Factors' Categories

Factors	Analysis	Suitability Factors' Categories
Highway	Proximity	50, 200, 500, 1000, 2000, 10000 feet
Intersection	Accessibility	0.5, 1, 2, 3 miles
Employment Centers	Accessibility	1000, 5000, 10000, 15000, 20000 feet
Shopping Centers	Accessibility	1000, 5000, 10000, 15000, 20000 feet
Airport	Accessibility	1000, 5000, 10000, 15000, 20000 feet
Karst	Assignment Features	zone 1, zone 2, zone 3
Endangered Species	Proximity	328, 984, 2296, 4921 feet
Water Bodies	Proximity	98, 328, 656, 3280 feet
Wetlands	Proximity	98, 328, 918, 3280 feet
TEAP	Assignment Raster	1, 10, 25, 50 (in percent of the total area)
Existing Land use	Assignment	Vacant Lots and Tracts, Qualified Agricultural Land, Farm and Ranch Improvements (because we want to focus on undeveloped areas)

3.1.9 Rating

Each of the suitability factors' categories was rated based on its suitability for each land use with a scale of -10 to 10. A sample rating table for the suitability factor "Highway" is shown in Table 3.15. Columns "Buffer_From" and "Buffer_To" show the range of buffers. Green columns show different land use categories by way of their ratings with respect to a range of buffers.

Table 3.15: Sample Rating Table

Buffer_From	Buffer_To	MF	SF	BHC	BHI	BLC	SHC	SHI	SLC	SLI	OS
0	50	-10	-10	10	-5	10	10	-5	10	-4	2
50	200	-5	-7	10	0	10	10	0	10	0	4
200	500	0	-3	7	2	5	8	4	5	3	1
500	1000	1	0	3	6	0	3	6	0	5	0
1000	2000	2	1	0	8	-2	0	8	-5	1	0
2000	10000	5	3	-4	-2	-3	-4	-3	-3	-5	-10

For this study, rating tables for all the selected suitability factors were created in Microsoft Access as ".mdb" file, as shown in Figure 3.1.

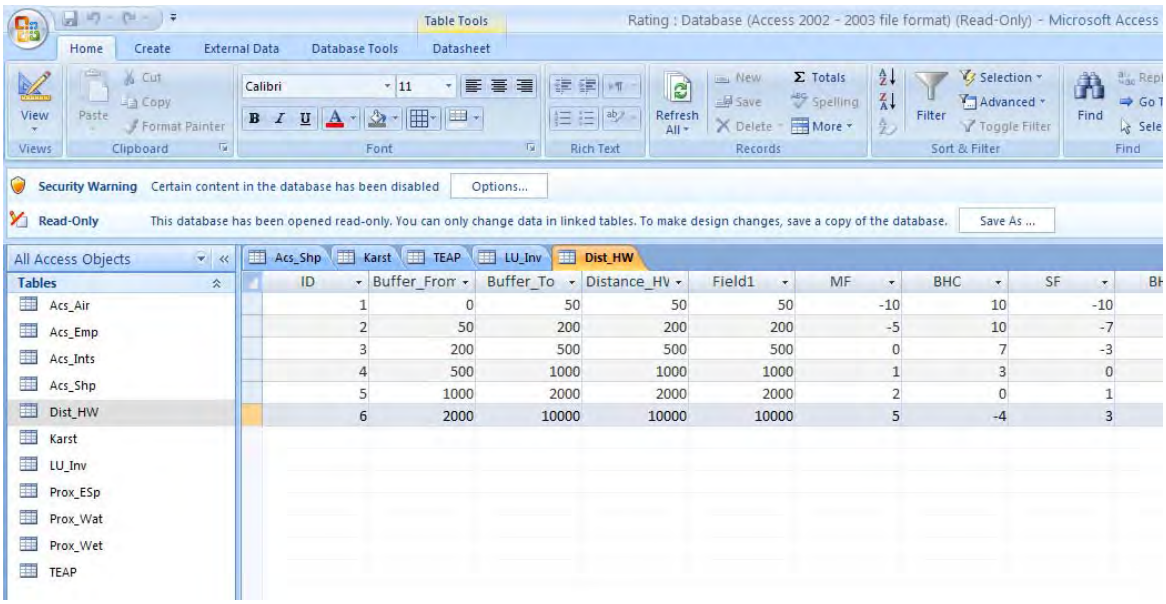

Figure 3.1: Screenshot of Rating Table in Microsoft Office Access
Note: Any land use that is rated "-11" is considered "null" and masked.

3.1.10 Weighting

For calculating each factor's weight, the AHP model was used. Therefore, all factors were compared with each other in a pair-wise comparison matrix, which is a measure to express the relative preference among the factors. Each factor was weighted expressing a judgment of the relative importance or preference of one factor against other as tabulated in .dbf format (shown in Figure 3.2).

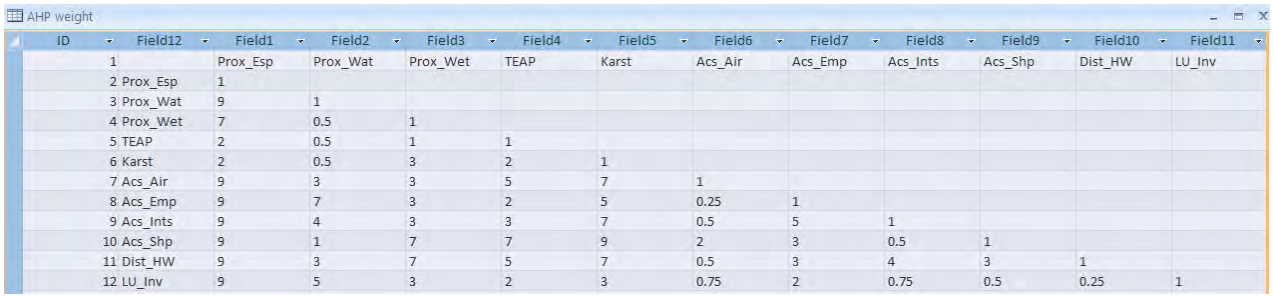

Figure 3.2: Screenshot of the AHP Weighting Table in Microsoft Office Access

The table was then entered in the AHP Extension to get weighting for all the land uses, as shown in Figure 3.3. AHP Extension can be downloaded from http://arcscripts.esri.com/details.asp?dbid=13764.

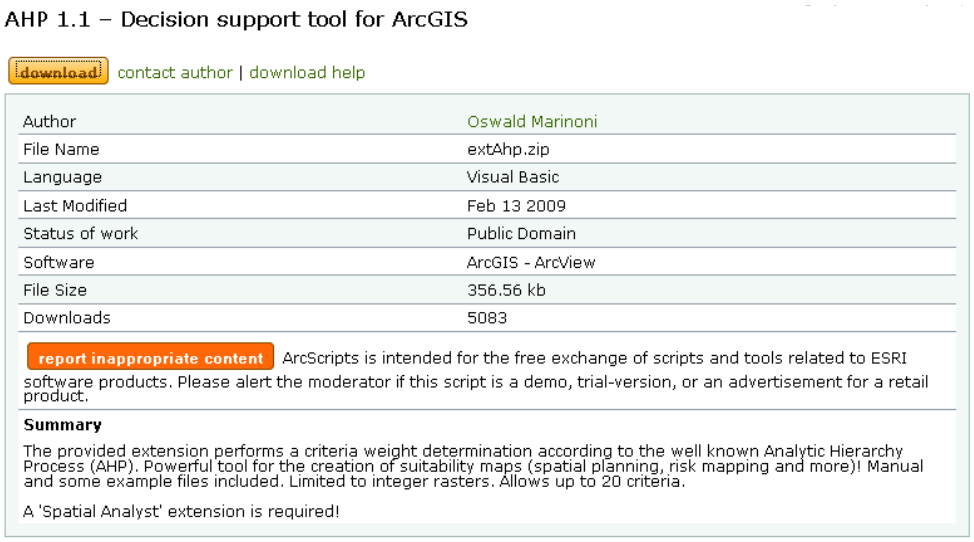

Figure 3.3: Screenshot of Download Page

3.1.10.1 Running the AHP Extension in ArcGIS

Steps:

1) Launch ArcGIS.
2) From the Tools Menu, choose Customize.
3) "Add from file" field (Figure 3.4).

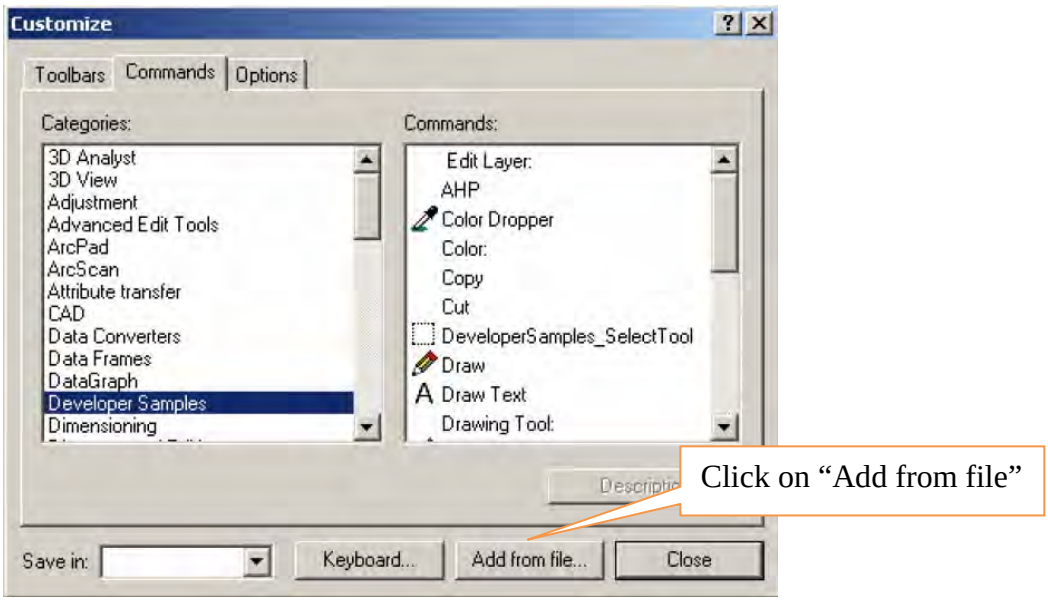

Figure 3.4: Customize Option in the Tools Menu

4) Browse the extension "extahp.dll" and OK (Figure 3.5).

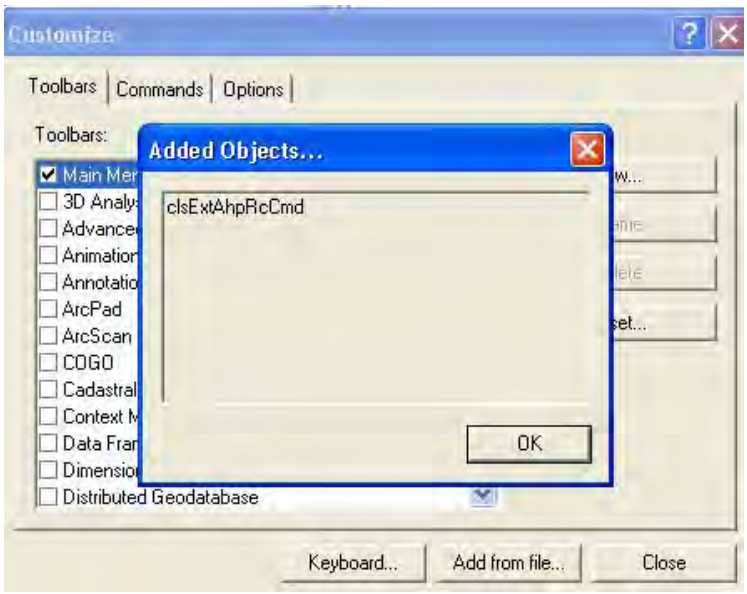

Figure 3.5: Adding the AHP Extension

5) On the Commands tab, choose "Developer Samples" from "Categories."
6) Choose AHP from the "Commands" list box.
7) Drag AHP onto the ArcMap environment (Figure 3.6).

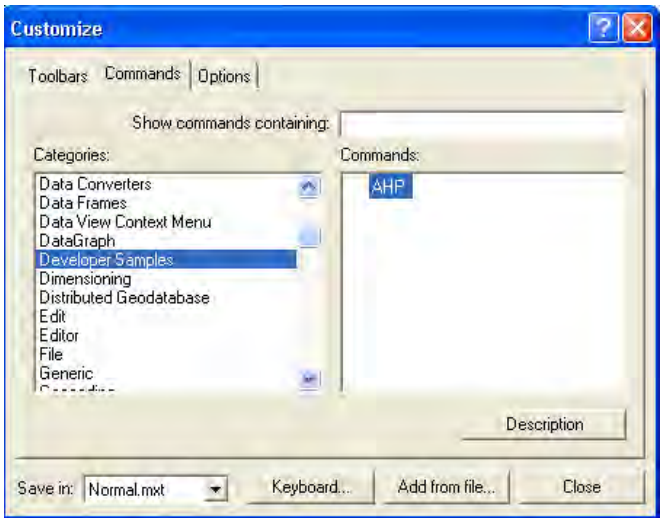

Figure 3.6: Adding AHP Toolbar

The ArcMap environment looks like this (Figure 3.7):

Figure 3.7: AHP Toolbar

8) Click on the “AHP” and define the criteria (Figures 3.8 and 3.9). The number of criteria is restricted to a minimum of 2 and a maximum of 20.

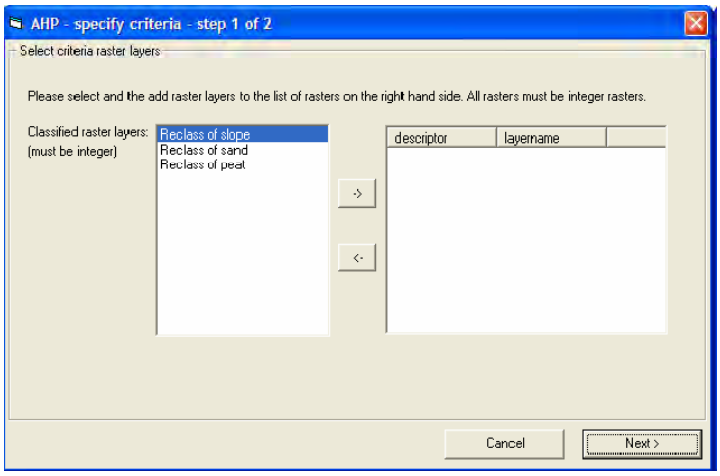

Figure 3.8: Defining Criteria (Factors) for Weighting

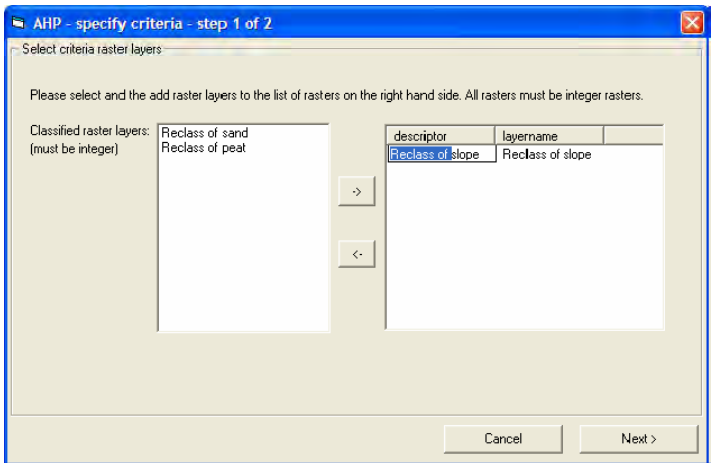

Figure 3.9: Adding Description to the Criteria

9) After all criteria are defined, click *Next* to reach the screen shown in Figure 3.10.

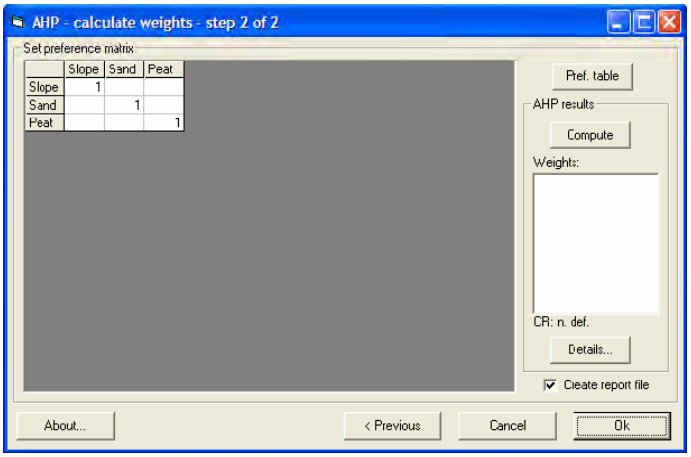

Figure 3.10: Pair-wise Comparison in AHP

10) Put values in the matrix for all the factors and click *Compute* and *Ok*.
11) The result of the AHP for the selected suitability factors in the study is shown in Figure 3.11:

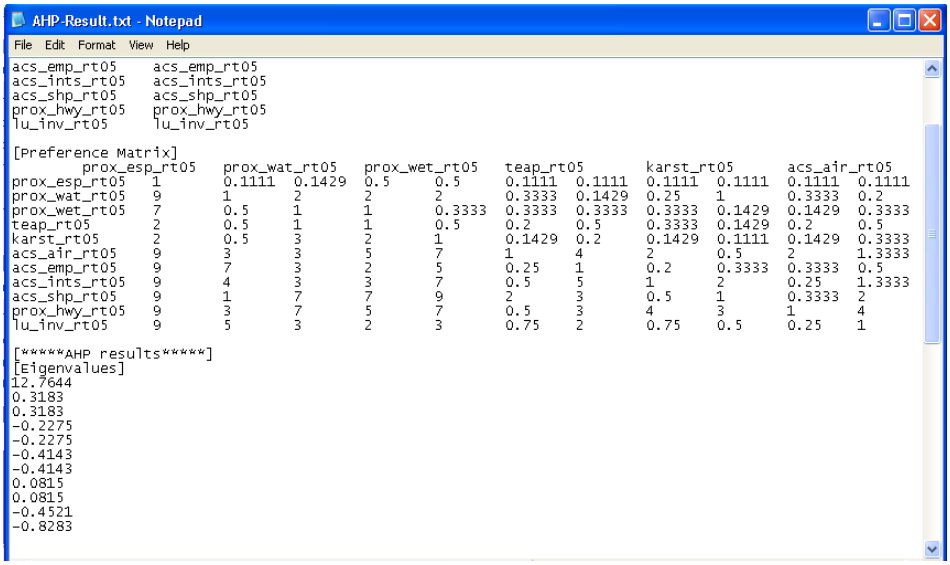

Figure 3.11: AHP Result

The AHP result was entered into the Weighting Toolset (see Section II, 4.1.5), as depicted in Figure 3.12.

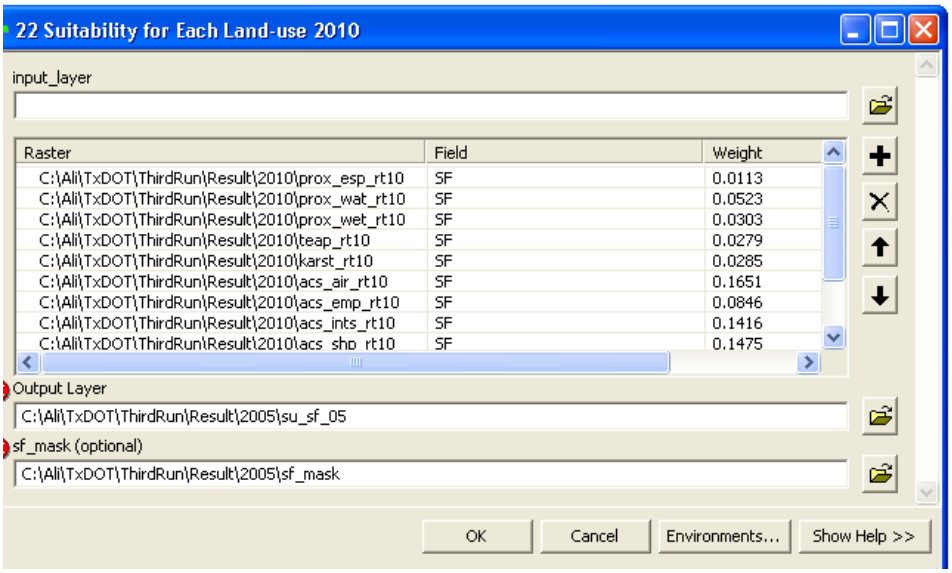

Figure 3.12: Entering AHP Result into the Weighting Toolset

3.1.10.2 Mask

After rating and weighting, the next step was to mask the area that is not available for development. In this model, the process is called "Masking." The purpose of this process is to exclude water bodies, environmentally sensitive areas, and undevelopable land uses from allocation. This process ensures that allocation of projected employment and household will not take place in these masked areas.

Allocation of Employment and Households

Allocation of the projected employment and household into developable land (supply) is based on how much required land (demand) is needed to accommodate them. This process involves determining the order of allocation into the most suitable developable land in the region. LUM essentially allocates projected economy growth, represented by employment and household growth; the order for allocation is based on how an area developed according to the economic base theory. For this project the order of allocation was determined as:

Basic Heavy Industrial (BHI)
Basic High Commercial (BHC)
Basic Light Industrial (BLI)
Basic Low Commercial (BLC)
Multi Family (MF)
Single Family (SF)
Open Space (OS)
Service Heavy Industrial (SHI)
Service High Commercial (SHC)
Service Light Industrial (SLI)
Service Low Commercial (SLC)

Section II: Prototype Model and Step-by-Step Process

Section II is intended to provide user friendly step-by-step guide to run the SA Model for similar types of applications.

4. Running the SA Model Toolbox in ArcGIS

The SA model application in ArcGIS was developed using Model Builder. The following are the steps performed to run the model:

1) Open ArcMap.
2) Open Arc Toolbox and add Toolbox (Figure 4.1).

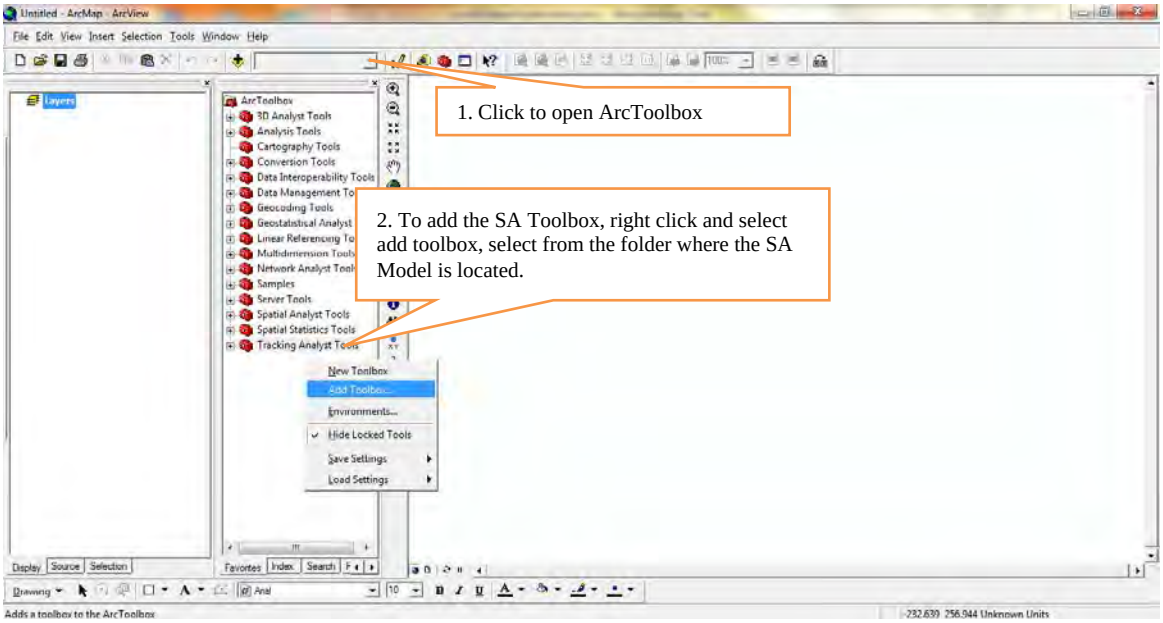

Figure 4.1: Adding the Model Toolbox

3) Add the SA Model toolbox (Figure 4.2).

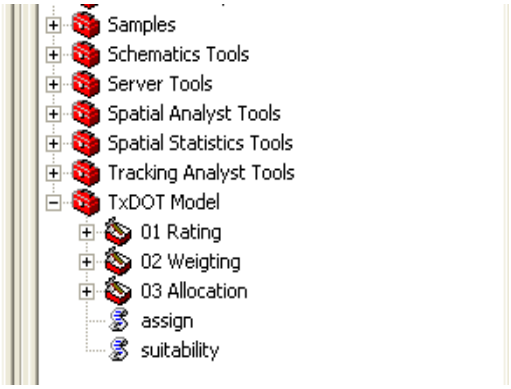

Figure 4.2: The Model in ArcToolbox

The prototype model is divided into three toolsets: *Rating, Weighting,* and *Allocation*.

Rating Toolset

The *Rating* toolset performs the straight-line distance analysis for the related suitability factors, assigns the rating tables (.mdb), and produces a raster layer, which includes the ratings for each land use in its attribute table.

4.1.1 Proximity

SA Model ⟶ Rating ⟶ Proximity

Proximity selects the first component *rating* to perform *buffering* and assigns *rating* values to the factors. The *Proximity* tool (Figure 4.3) produces a straight-line distance from the suitability factor and assigns rating value to these distances (*Buffer_From* and Buffer_To).

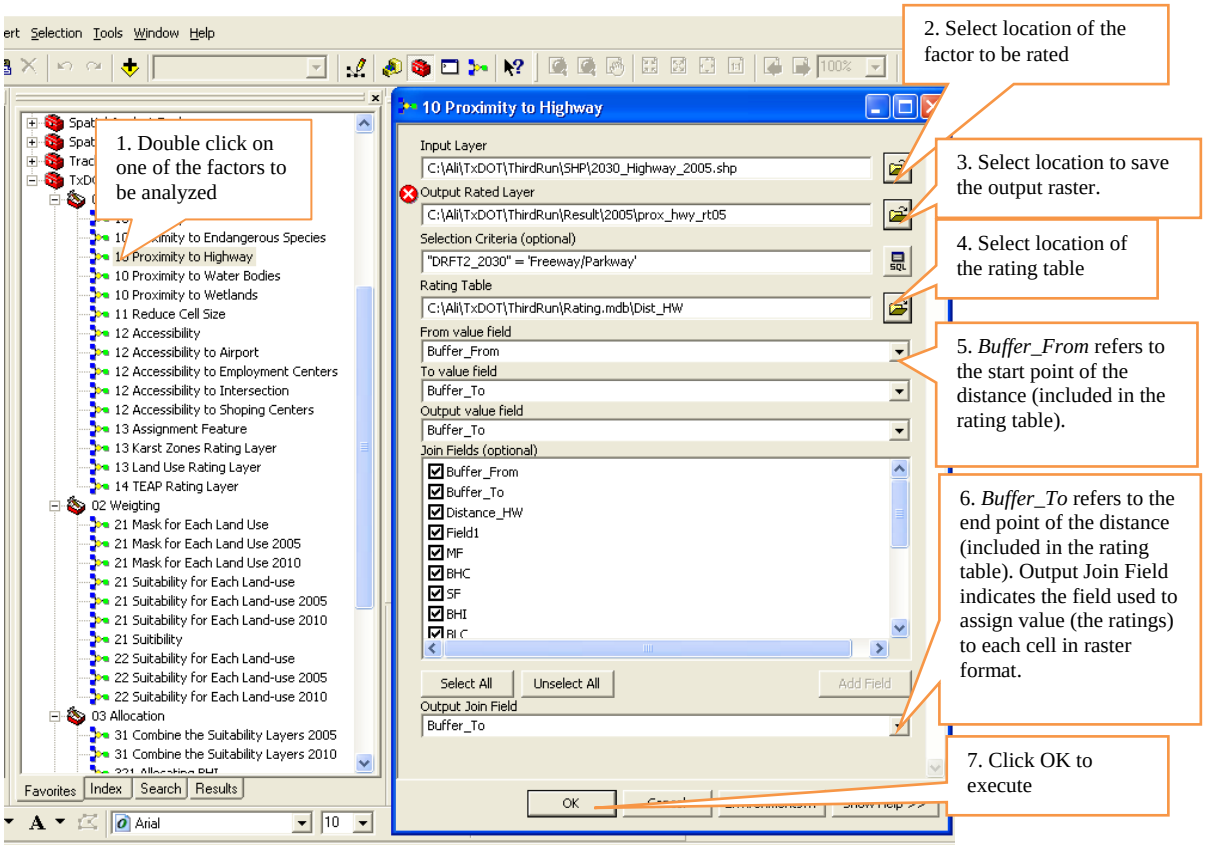

Figure 4.3: Example of Proximity Tool (Proximity to Highway)

4.1.2 Accessibility

SA Model ⟶ Rating ⟶ Accessibility

Select *Accessibility* tool (Figure 4.4) to perform the accessibility a*nalysis*. This tool produces distances based on the transportation network, the rating tables (.mdb), and a raster layer, which includes the ratings for each land use in its attribute table.

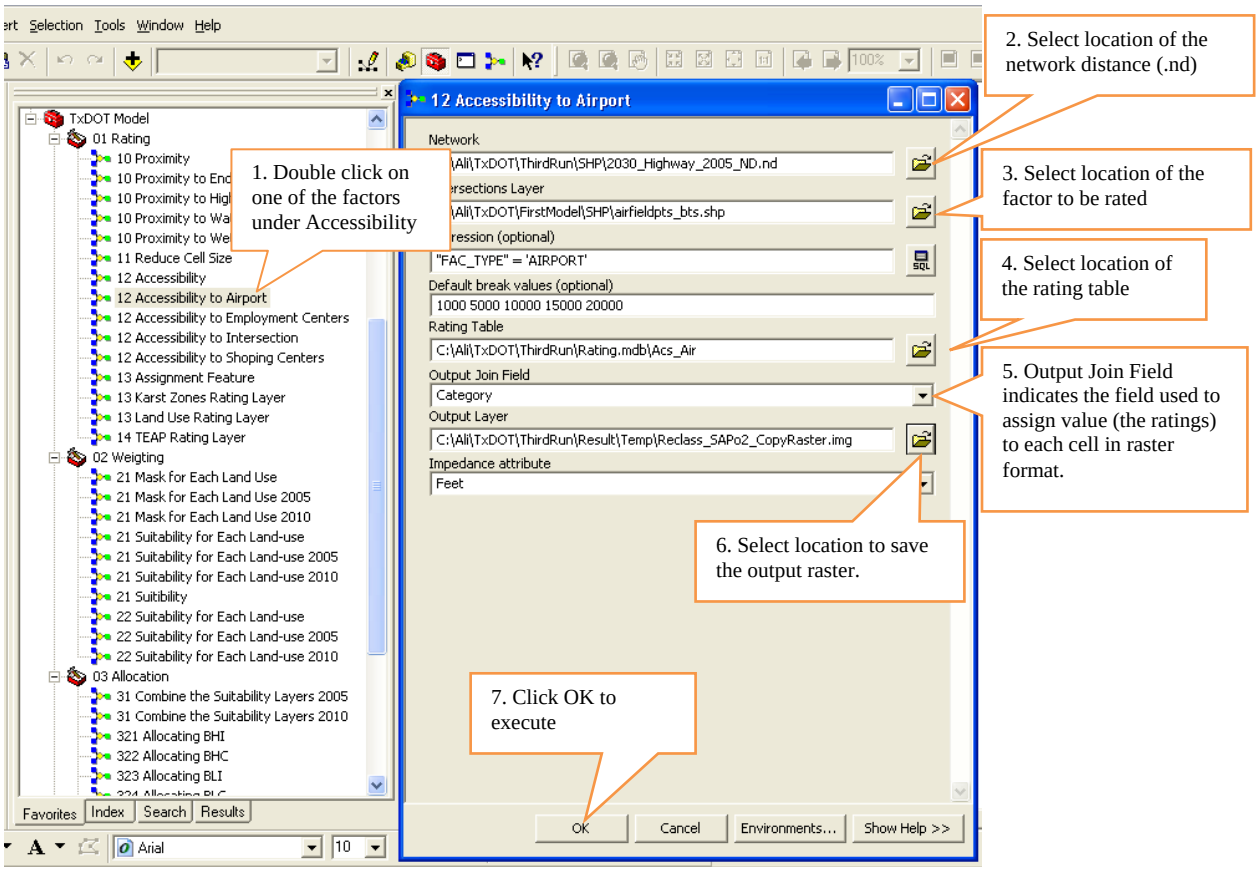

Figure 4.4: Example of Accessibility Tool (Accessibility to Airport)

4.1.3 Assignment

SA Model ⟶ Rating ⟶ Assignment

Select *Assignment* tool (Figure 4.5) to assign the rating table to unique categories of suitability factors such as land use, Karst Zone, and TEAP. This tool does not perform distance analysis. It produces a raster file.

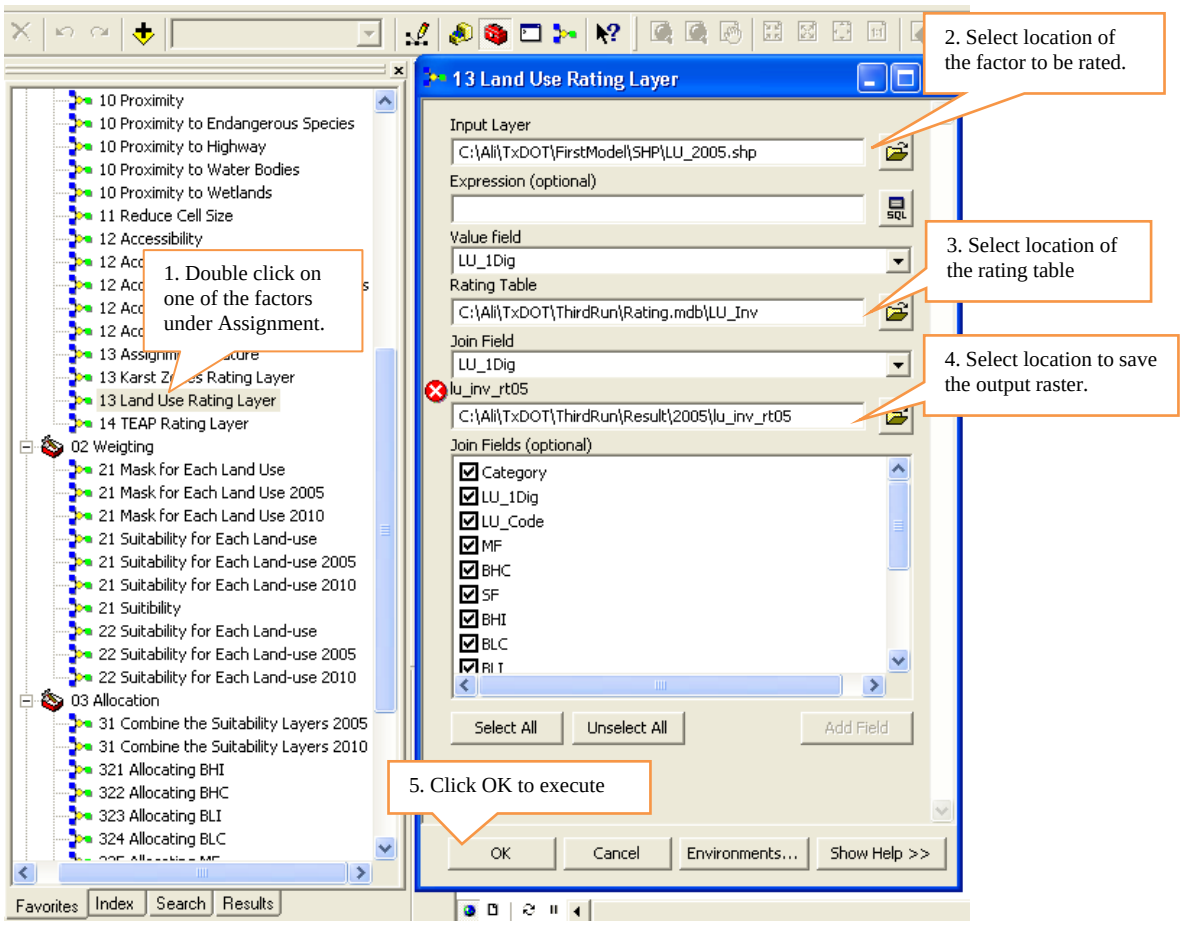

Figure 4.5: Example of Assignment Tool (Land Use Rating Layer)

Weighting Toolset

The *Weighting* toolset assigns weights to all the suitability factors and generates a suitability map for each of the land use categories.

This tool has two sub-tools and performs two major tasks: 1) masking and 2) assigning weights. The two sub-tools are Mask for Each Land Use and Suitability for Each Land Use.

4.1.4 Mask for Each Land Use

The purpose of this sub-tool is to mask the area that cannot be developed for reasons such as wetlands, endangered species, etc. This sub-tool masks all the cells in each land use category that are rated "-11" for each suitability factor.

Steps:
SA Model ⟶ Weighting ⟶ Mask for Each Land Use

1. Define the expression for each land use; for example, for Single Family Residential, put the expression as "SF" = -11.
2. Specify the name and location of the output mask layer.

3. Put raster datasets of all the selected suitability factors from the database. For example, for wetlands, put the raster file “prox_wet_rt10.”
4. Click OK.

Similarly, we can perform masking for other land use categories, as shown in Figure 4.6.

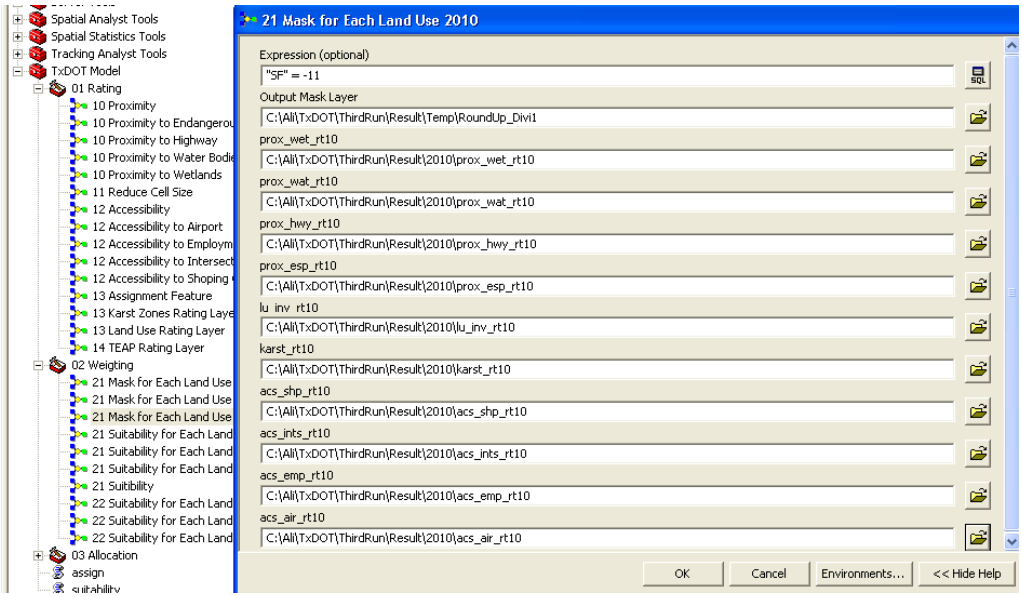

Figure 4.6: Mask Tool for Each Land Use

Result: The white areas of the map are masked for Single Family (SF) development (Figure 4.7). This means SF development cannot be allocated in these areas.

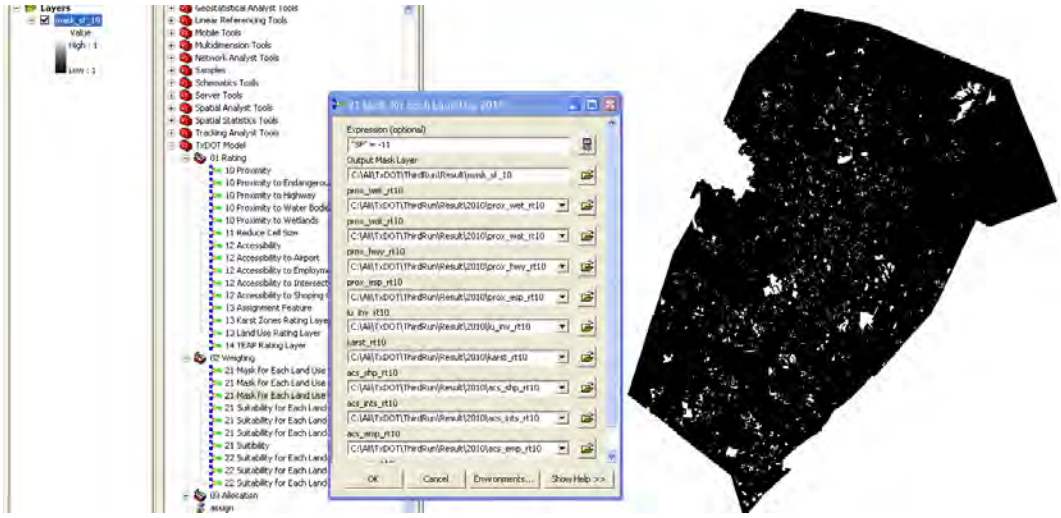

Figure 4.7: Result of the Mask Tool

4.1.5 Suitability for Each Land Use

This component of the Weighting tool uses AHP results (weight scores) for each land use to get the suitability layers.

Steps:
SA Model ⟶ Weighting ⟶ Suitability for Each Land Use

1. Put raster files of all the suitability factors in the "input layer."
2. Select the land use under "Field;" here the selected land use is SF.
3. Use the weights that are generated by AHP (refer to section 2.3.5.1).
4. Specify the name and location of the "Output Layer."
5. Put the mask layer. For example, here the mask layer for SF is "sf_mask" (as shown in Figure 4.8).
6. Click OK.

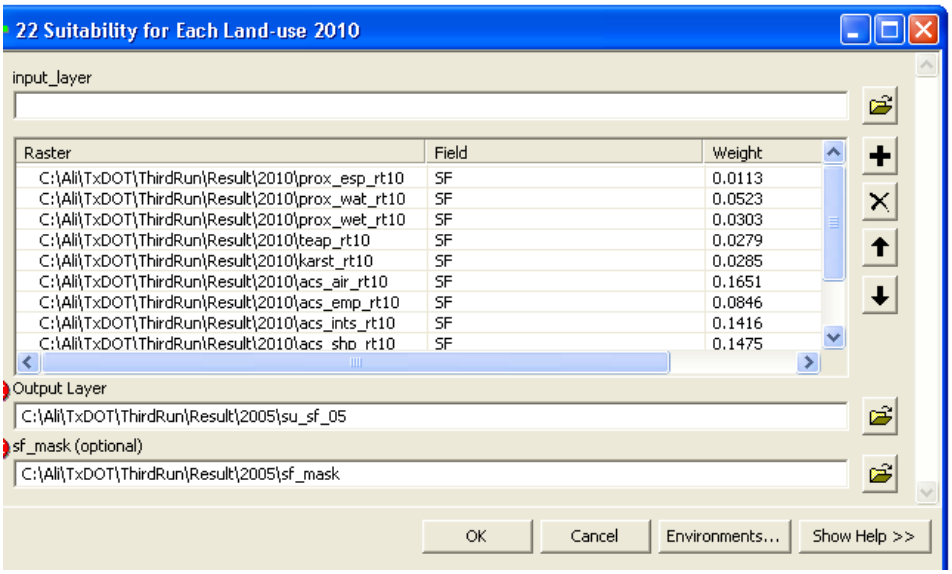

Figure 4.8: Suitability for Each Land Use Tool

Allocation Toolset

The *Allocation* toolset combines the entire suitability map for all land use categories, allocates each land use into the most suitable location, and produces the composite allocation map. This tool has three sub-tools.

4.1.6 Combine the Suitability Layers

Select the *Combine the Suitability Layers 2010* to combine the entire suitability layers of each land use. This tool creates one composite raster layer that has the values of each land use in different fields in its attribute table.

Steps:
SA Model ⟶ Allocation ⟶ Combine the Suitability Layers 2010

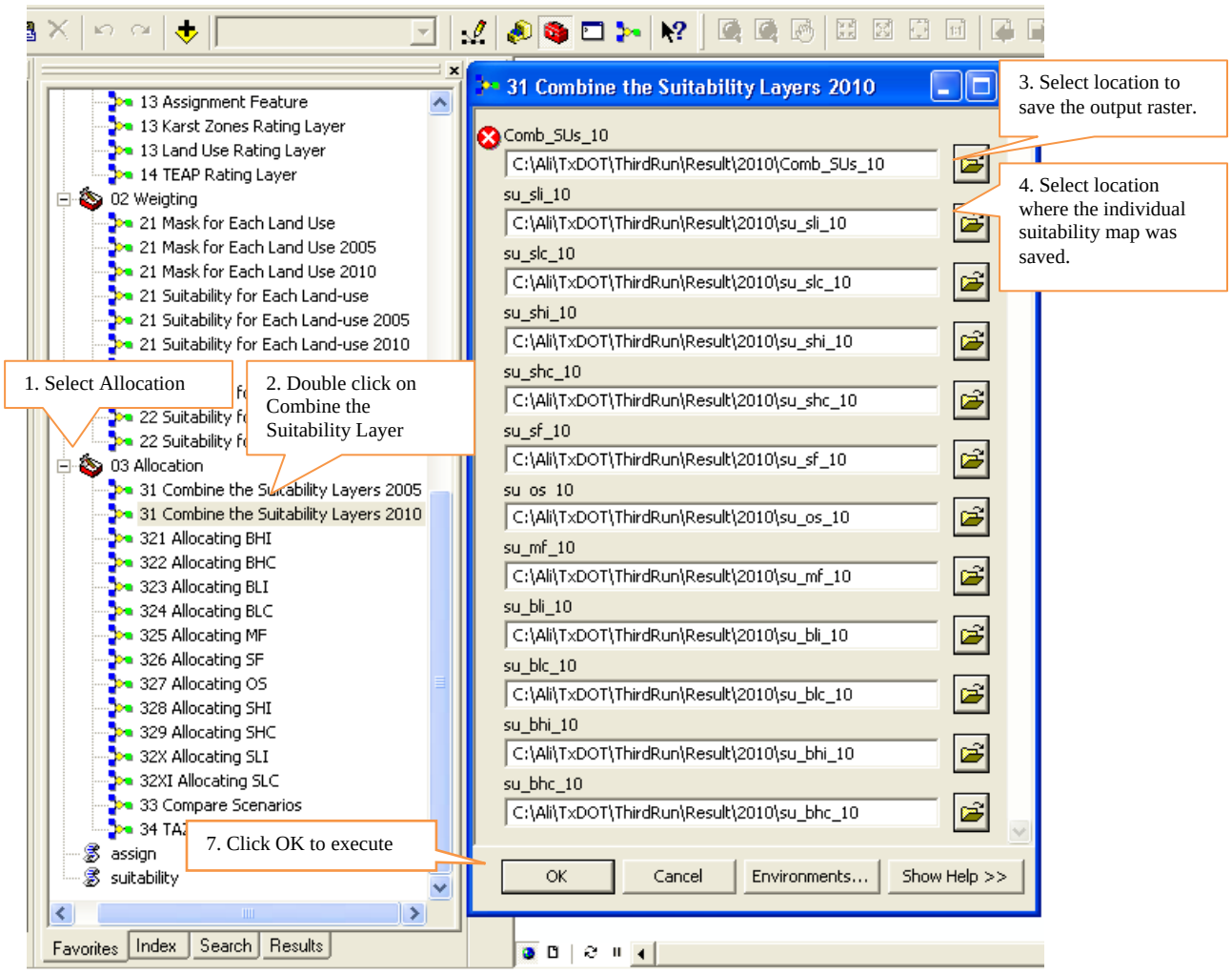

Figure 4.9: Combine the Suitability Layers Tool

4.1.7 Allocating

The *Allocating* toolset is used to allocate the required land (from section 2.2) on suitable land for each land use.

Steps:
SA Model ⟶ Allocation ⟶ Allocating

Currently, the value of required land is set based on 2010 household and employment projections. However, this value can be adjusted for running different scenarios for employment and population growth.

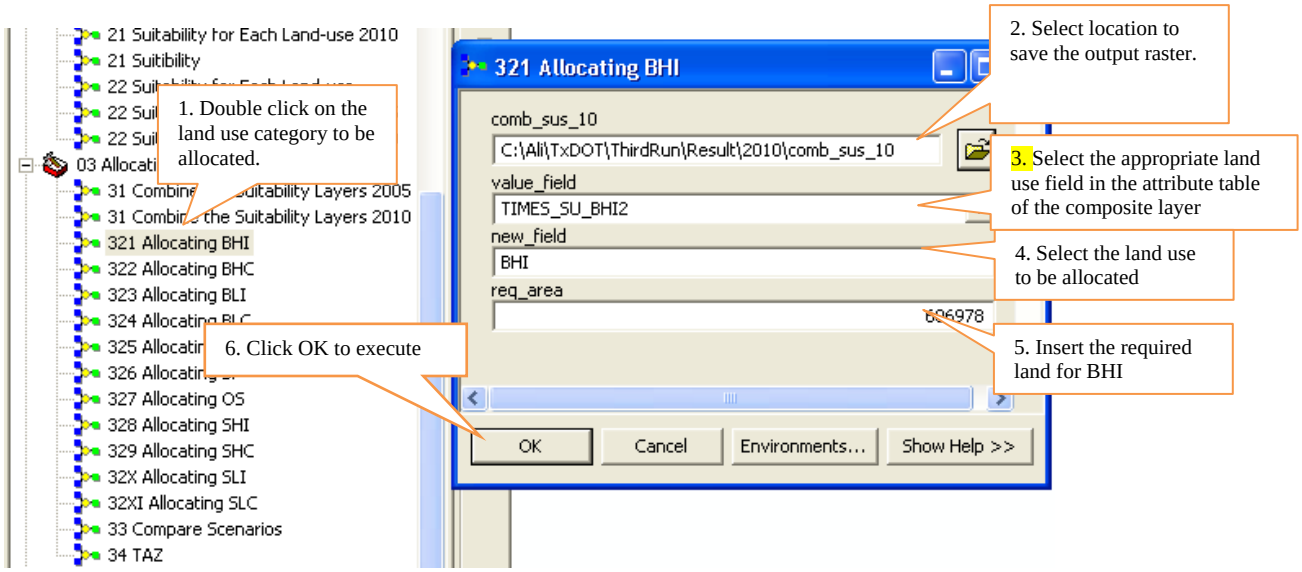

Figure 4.10: Example of Allocation Tool (Allocating BHI)

4.1.8 Compare Scenarios

This tool compares results from two different scenarios/projections using the *Cut/Fill* function in Spatial Analyst Extension. The *Compare Scenarios* tool compares the 2005 to 2010 projections results of the study area based on two scenarios (with and without SH 130 and Ronald Reagan extension).

Steps:
SA Model ⟶ Allocation ⟶ Compare Scenarios

1) Put the composite suitability map of 2005 under “Scenario 1”

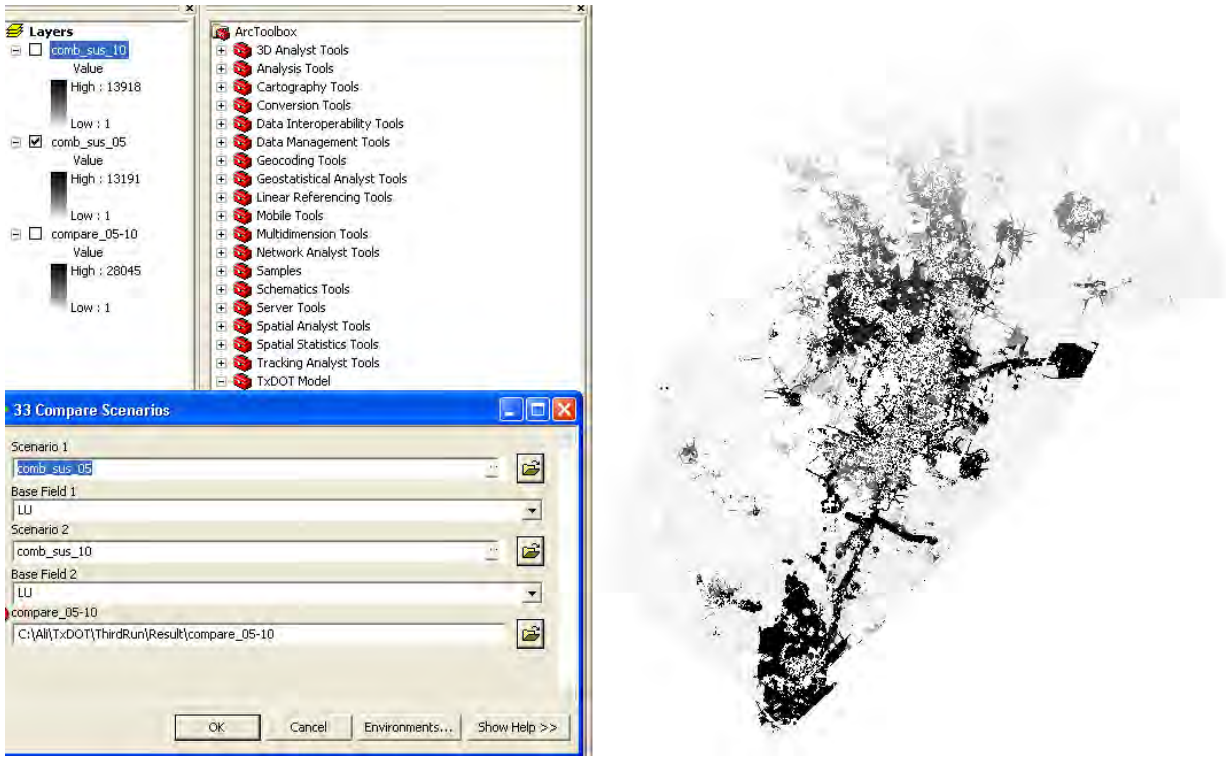

Figure 4.11: Adding Scenario 1 Result in Compare Scenarios Tool

2) Select the land use type of interest under "Base Field 1)."
3) Put the composite suitability map of 2010 under "Scenario 2."

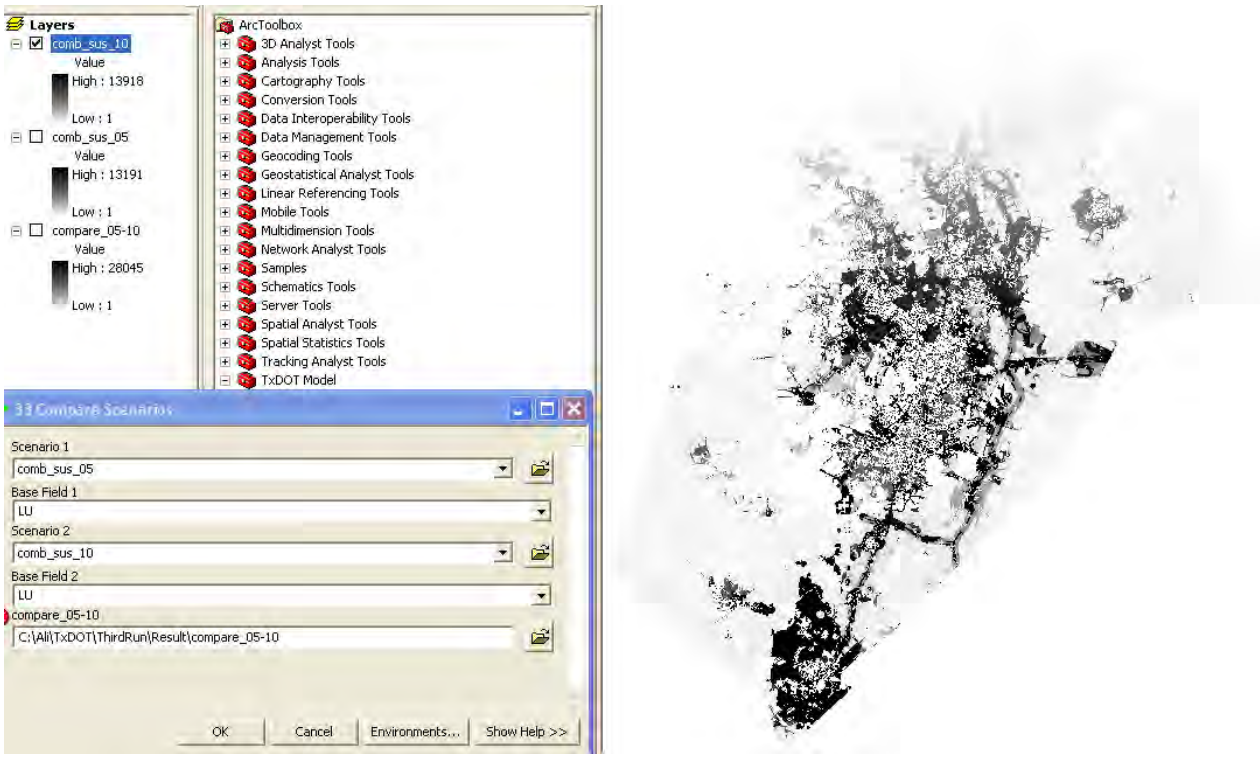

Figure 4.12: Adding Scenario 2 Result in Compare Scenario Tool

4) Select the land use type of interest related to step 2 under “Base Field 2).”
5) Specify the name and location of the result under “Compare _05-10).”

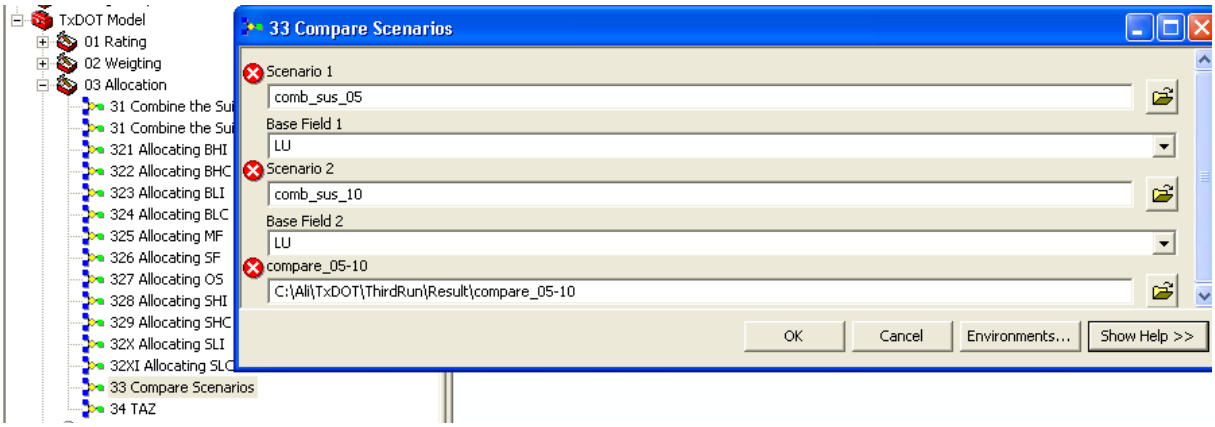

Figure 4.13: Specifying Name and Location of Result

The following map shows the net gain/loss of the development due to scenario change. See *Cut/Fill* function explanation in the *ArcGIS Desktop Help*.

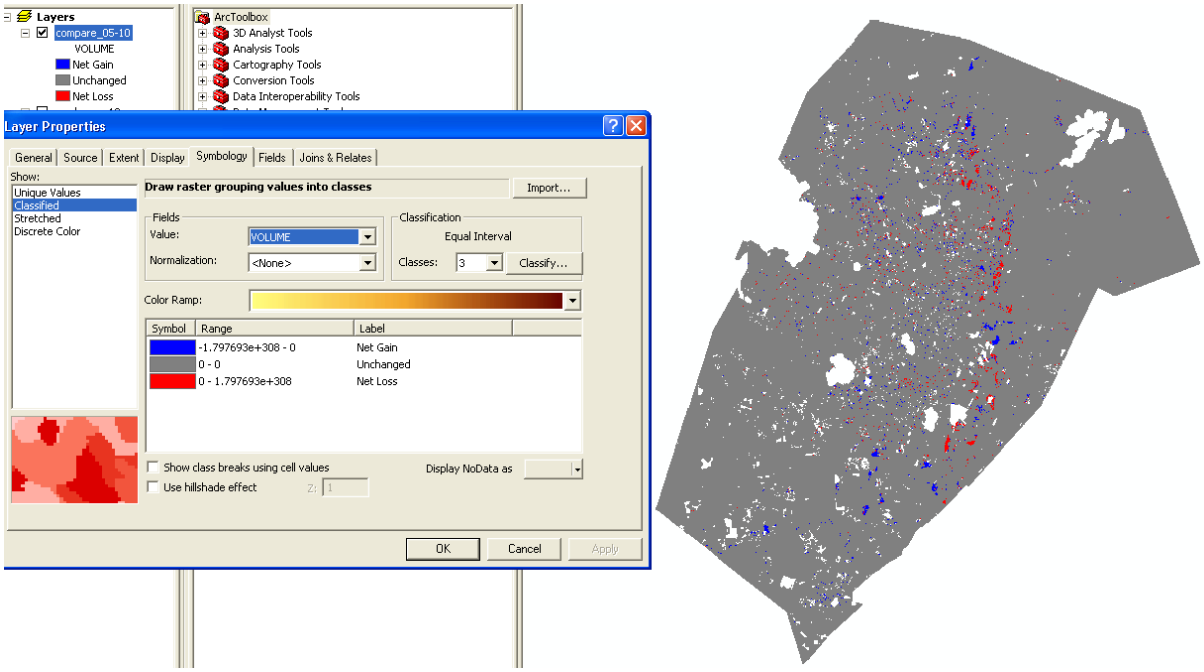

Figure 4.14: Net Gain/Loss of Development due to Scenario Change

4.1.9 TAZ

The *TAZ* Tool uses zonal statistical analysis to calculate the area of land allocated for each land use in each TAZ.

Steps:
SA Model ⟶ Allocation ⟶ TAZ

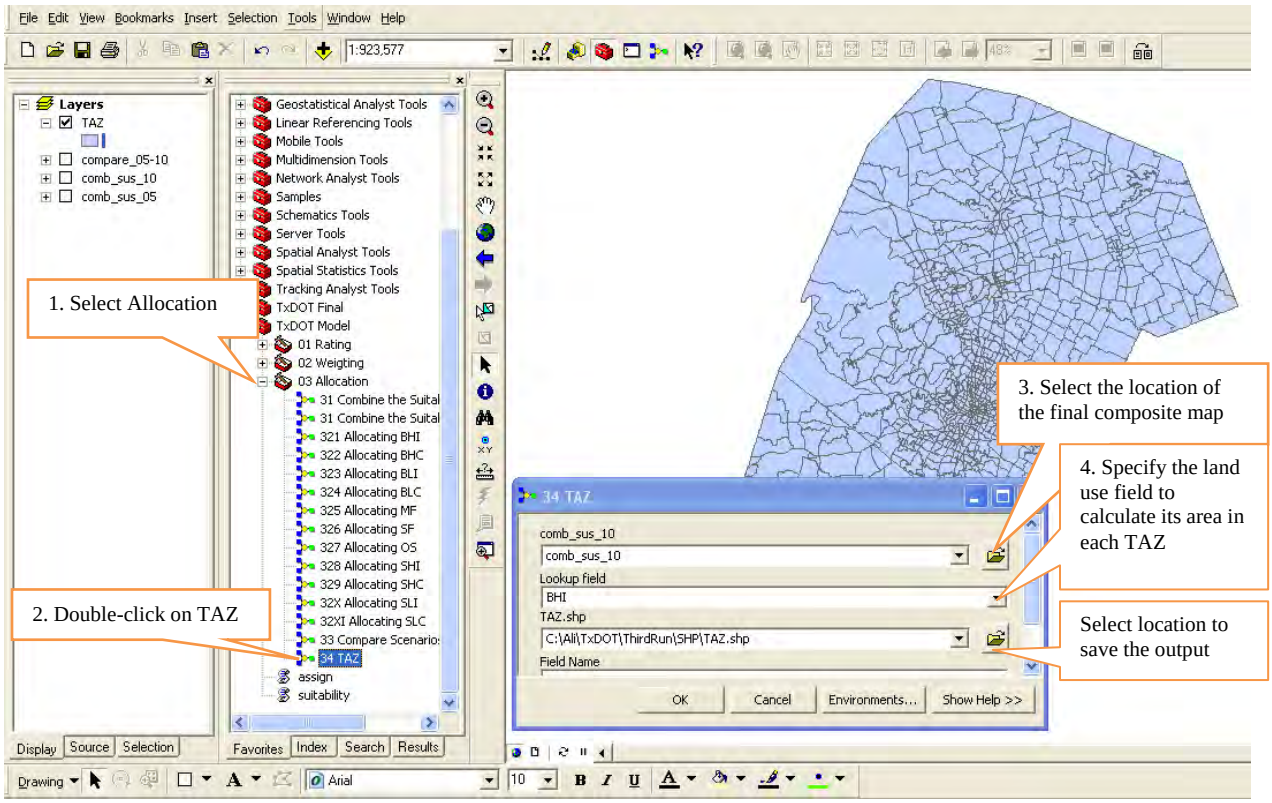

Figure 4.15: TAZ Tool

This step should be repeated for each land use. The result is a TAZ shapefile that contains allocated land for all the land uses. To obtain employment and household density in TAZ, follow the steps below:

1) Open the attribute table of TAZ shape file and copy it to Excel.

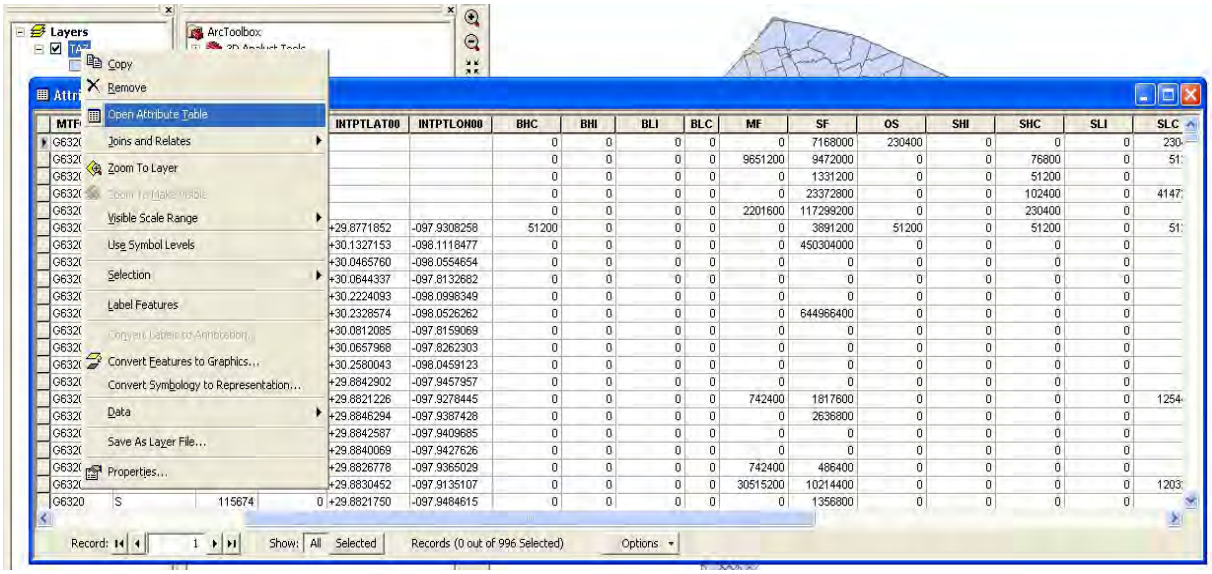

Figure 4.16: TAZ Attribute Field

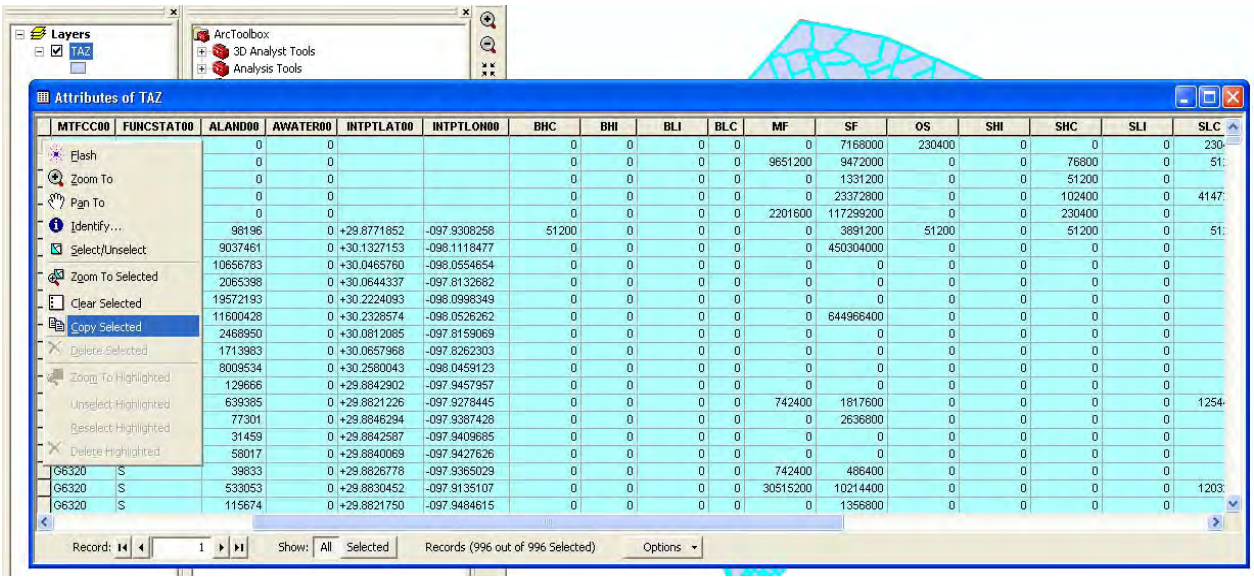

Figure 4.17: Select all the Fields in the Attribute Table and Copy to Microsoft Excel

2) Get the average square feet of land per employment and the average square feet of land per single family and multifamily household (this can be obtained from the existing average square feet per employment under the assumption that the region will continue to grow the same way. There are also other resources that may provide standard calculation of average area per employee.)
3) In Microsoft Excel, calculate total number of employment. For basic employment, divide the sum of the allocated land for basic employment by the average square feet of land per employment. For service employment, divide the sum of the allocated land for service employment by the average feet of land per employment.
4) Calculate the total number of households. For single family household, divide the total allocated land for single family by the average square feet of land per single family household. Similarly, for multifamily, divide the total allocated land for multifamily by the average square feet of land per multifamily.
5) Join the newly created Excel spreadsheet with the TAZ shape file.

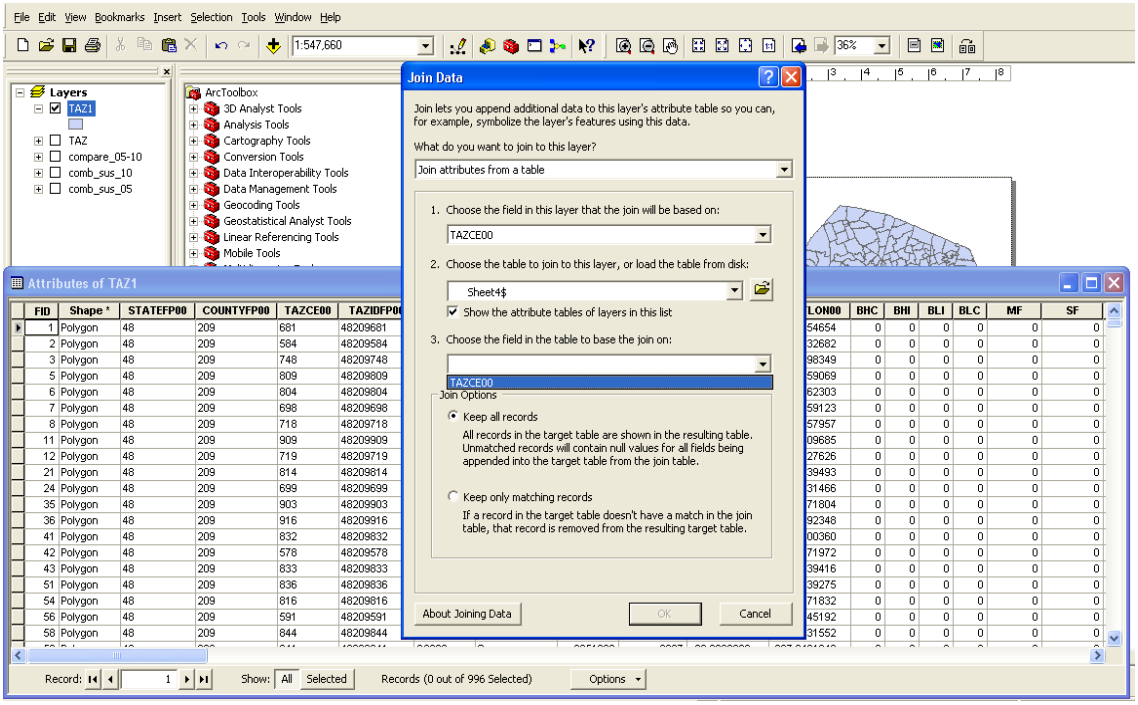

Figure 4.18: Join the Excel Sheet with TAZ Shapefile

6) Add 3 new fields in the attribute table: a) field to calculate area in acre; b) field to calculate employment density per acre; c) field to calculate household density per acre.

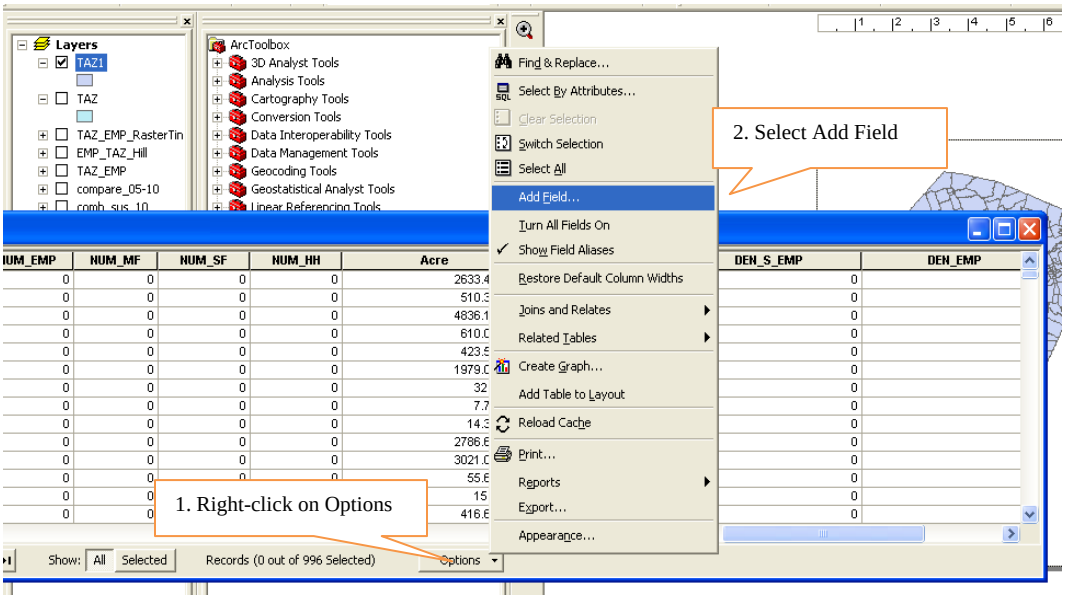

Figure 4.19: Add New Field to the TAZ Attribute Table

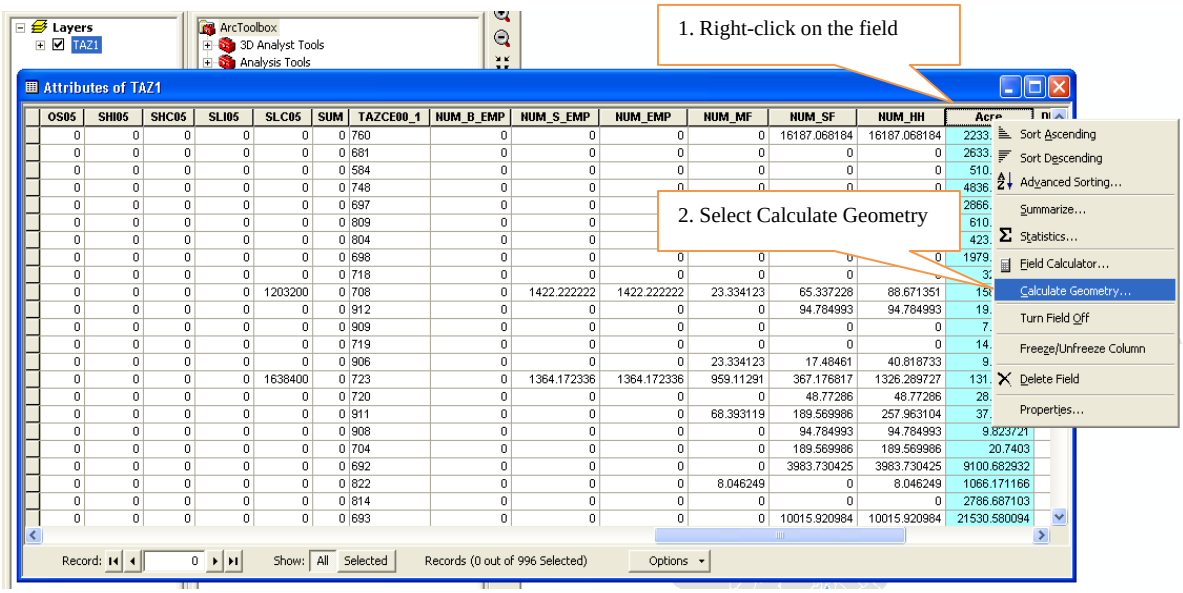

Figure 4.20: Calculate Area in Acre

Figure 4.21: Calculate Employment Density in Field Calculator

Appendix A: Proximity Tool

Proximity in urban and transportation planning usually refers to the distance to facilities and services that affect allocation suitability and attractiveness. A popular research method to study the impact of proximity on land use is determining the *radial distance* or traditional circular buffer. The rating of attractiveness of locations within the buffer areas are determined by the environment and other locational effects these actors have on the site within a particular buffer distance.

Factors: Highway, Endangered Species, Water Bodies, Wetlands

Figures A1 through A9 and Tables A1 through A4 present information on these four factors.

Highway

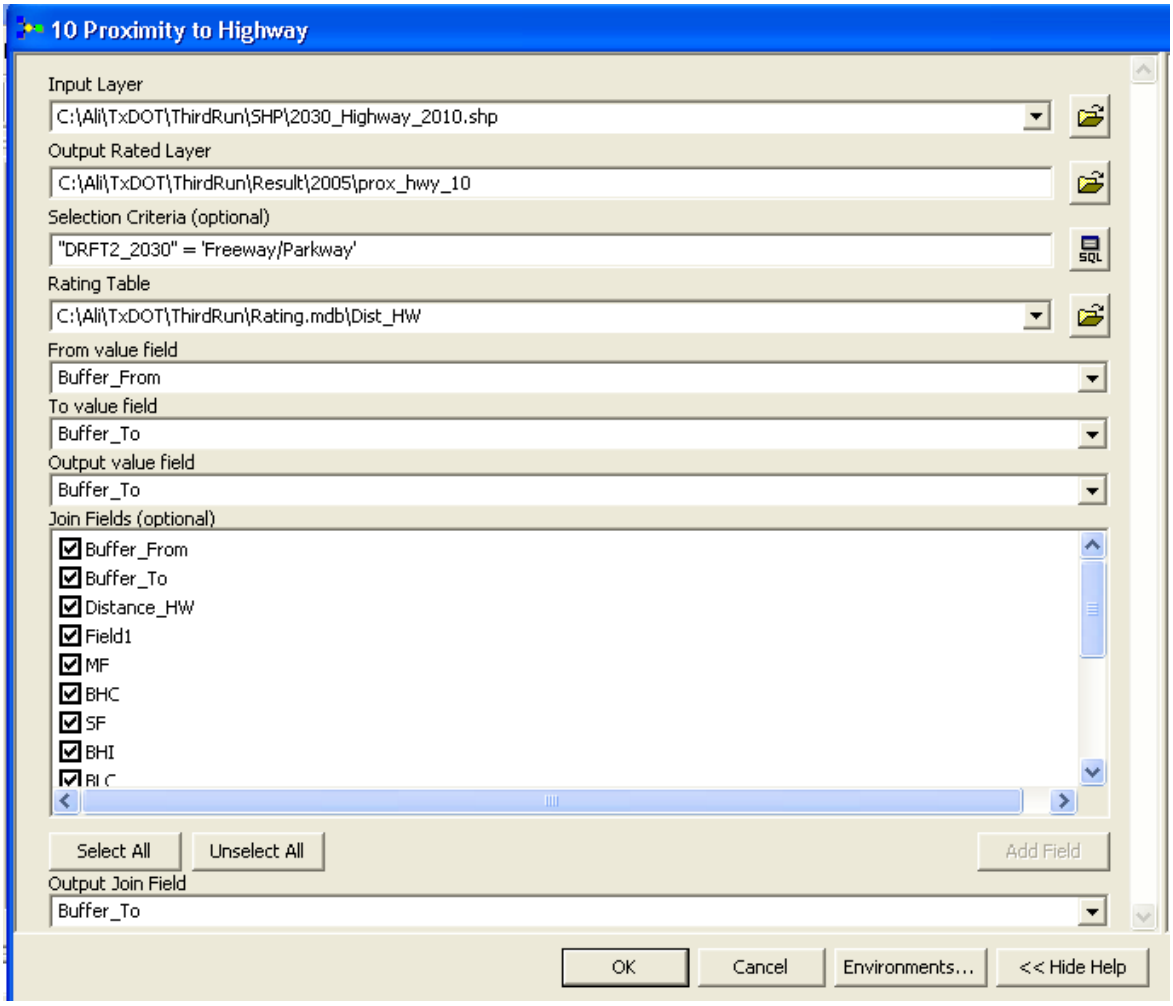

Figure A1: Proximity to Highway Tool

Input Layer: Select the highway shape file (2030_Highway_2010.shp)
Output Rated Layer: Choose the location and name of the output file
Selection Criteria: "DRFT2_2030" = 'Freeway/Parkway' OR "DRFT2_2030" = 'Major Arterial' (these are the major highways and roads in the study area)
Rating Table: A rating table for highway in mdb format
From Value Field: It is the minimum value for buffer, so select "Buffer From." For Example, the model would consider 0 as the minimum value for highway distance of 0 to 50 feet from the land use type.
To Value Field: It is the maximum value for buffer, so select "Buffer To." For example, the model would consider 50 as the maximum value for highway distance of 0 to 50 feet from the land use type.
Output value field: Select "Buffer_to"
Join Fields (optional): It is optional but if needed you can select all or some of the fields to show them in the attribute table.
Output Join Field: Join the rating table with the result of the analysis to get the output. Here "Distance_HW" is a common field to join the rating table and the result of the analysis.

Table A1: Rating Table for Proximity to Highway

ID	Buffer_From	Buffer_To	Distance_HW	Field1	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	0	50	50	50	-10	10	-10	-5	10	-4	10	-5	10	-4	2
2	50	200	200	200	-5	10	-7	0	10	0	10	0	10	0	4
3	200	500	500	500	0	7	-3	2	5	3	8	4	5	3	1
4	500	1000	1000	1000	1	3	0	6	0	5	3	6	0	5	0
5	1000	2000	2000	2000	2	0	1	8	-2	-1	0	8	-5	-1	0
6	2000	10000	10000	10000	5	-4	3	-2	-3	-5	-4	-3	-3	-5	-10

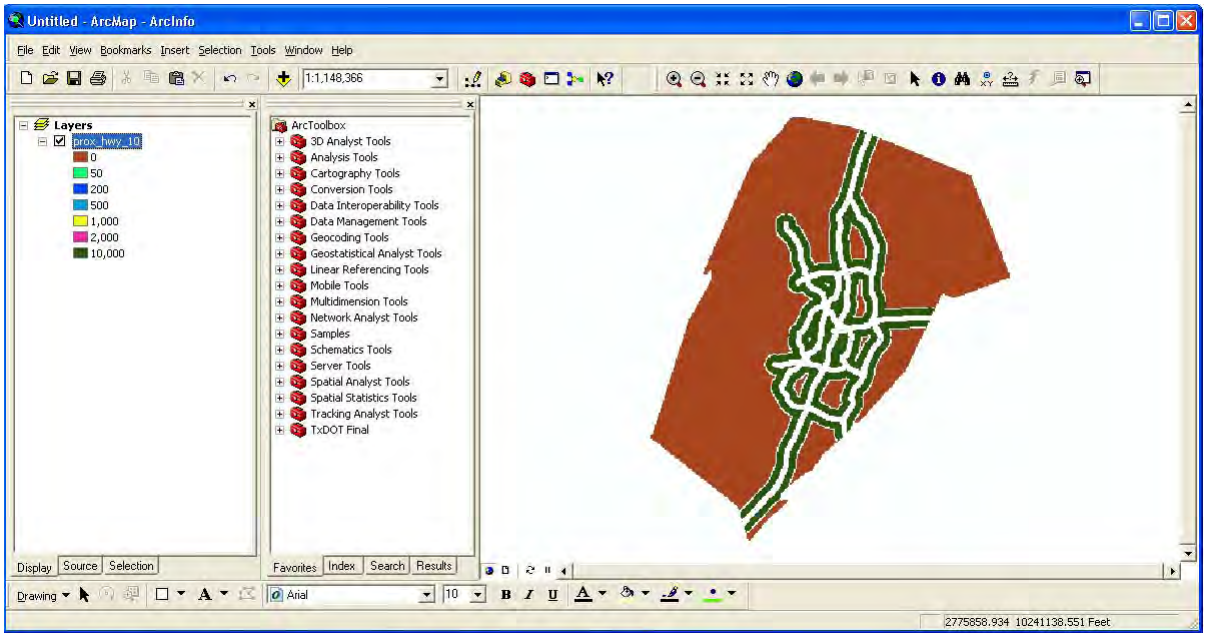

Figure A2: Result of Proximity to Highway Tool

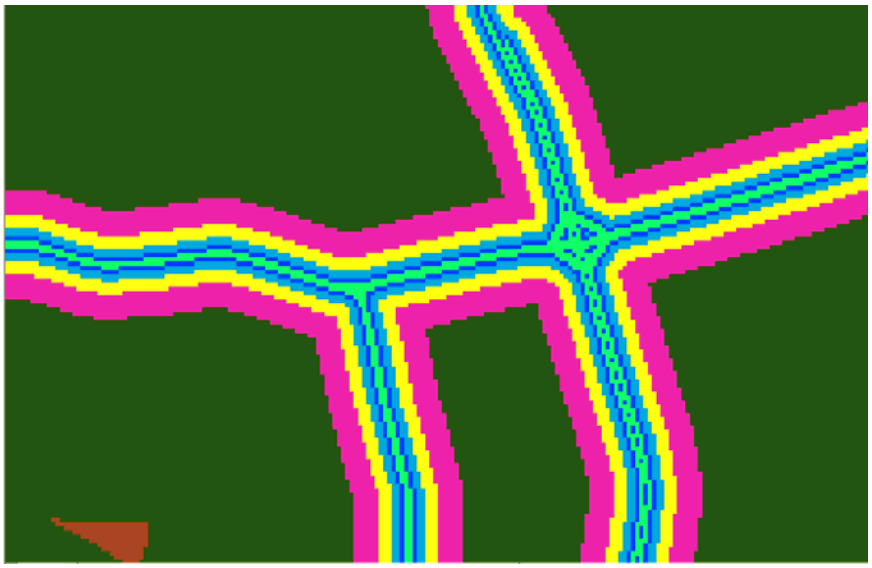

Figure A3: Result (Zoomed In) of Proximity to Highway Tool

Endangered Species

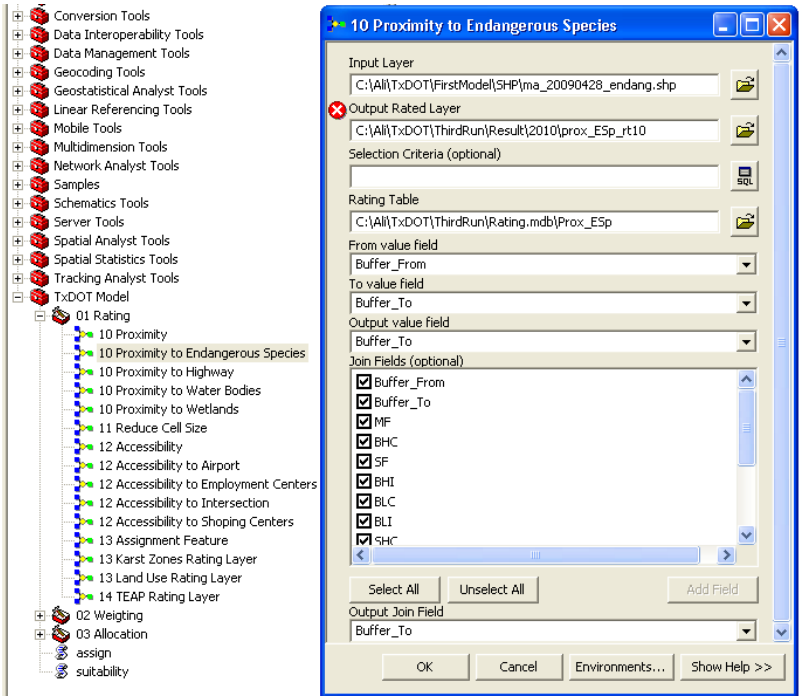

Figure A4: Proximity to Endangered Species Tool

Input Layer: Shape file for endangered species (33nding.shp)
Output Rated Layer: Choose the location and name of the output file
Selection Criteria: Not required
Rating Table: A rating table for endangered species in mdb format (Rating.mdb\Prox_Esp)

From Value Field: It is the minimum value for buffer, so select "Buffer From." For Example, the model would consider 0 as the minimum value for Endangered Species from 0 to 100 meters.
To Value Field: It is the maximum value for buffer, so select "Buffer To." For example, the model would consider 100 as the maximum value for Endangered Species from 0 to 100 meters.
Output value field: Select "Buffer_to"
Join Fields (optional): It is optional but if needed you can select all or some of the fields to show them in the attribute table.
Output Join Field: Join the rating table with the result of the analysis to get the output. Here "Buffer_To" is the common field to join the rating table and the result of the proximity analysis.

Table A2: Rating Table for Endangered Species

ID	Buffer_From	Buffer_To	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	0	100	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	5
2	100	300	-5	-8	-1	-11	-7	-8	-8	-11	-7	-8	10
3	300	700	2	-5	5	-11	-3	-6	-5	-11	-3	-6	4
4	700	1500	5	1	7	-11	3	-1	1	-11	3	-1	2

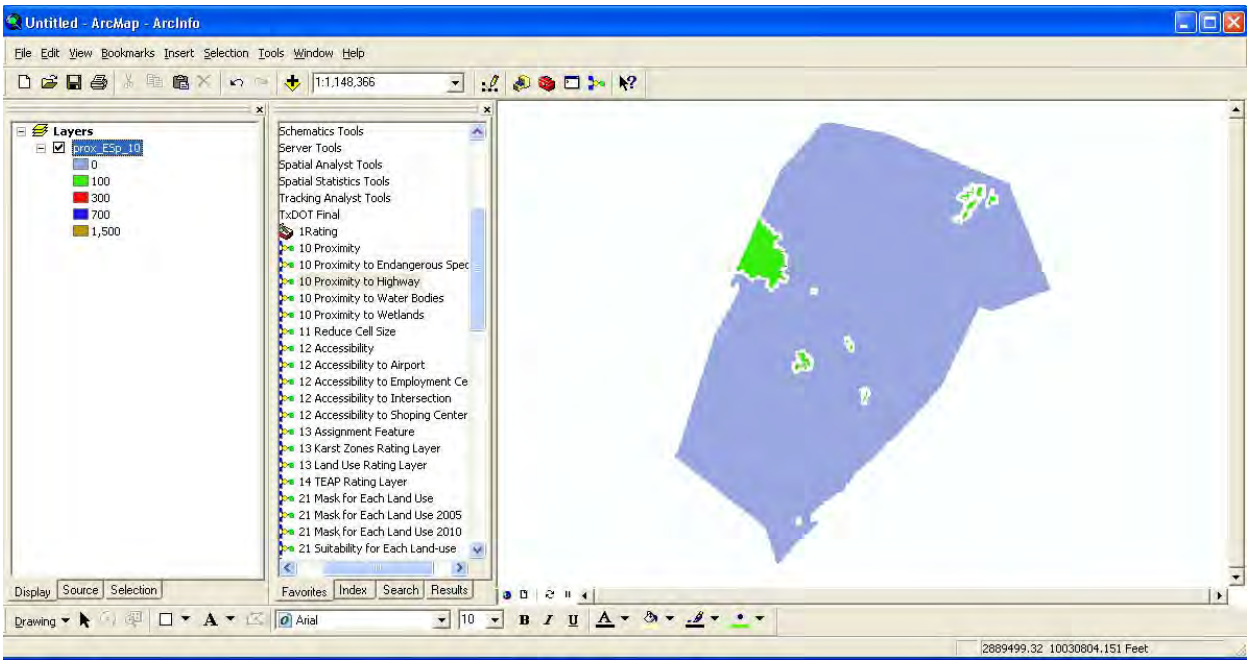

Figure A5: Result of Proximity to Endangered Species Tool

Water Bodies

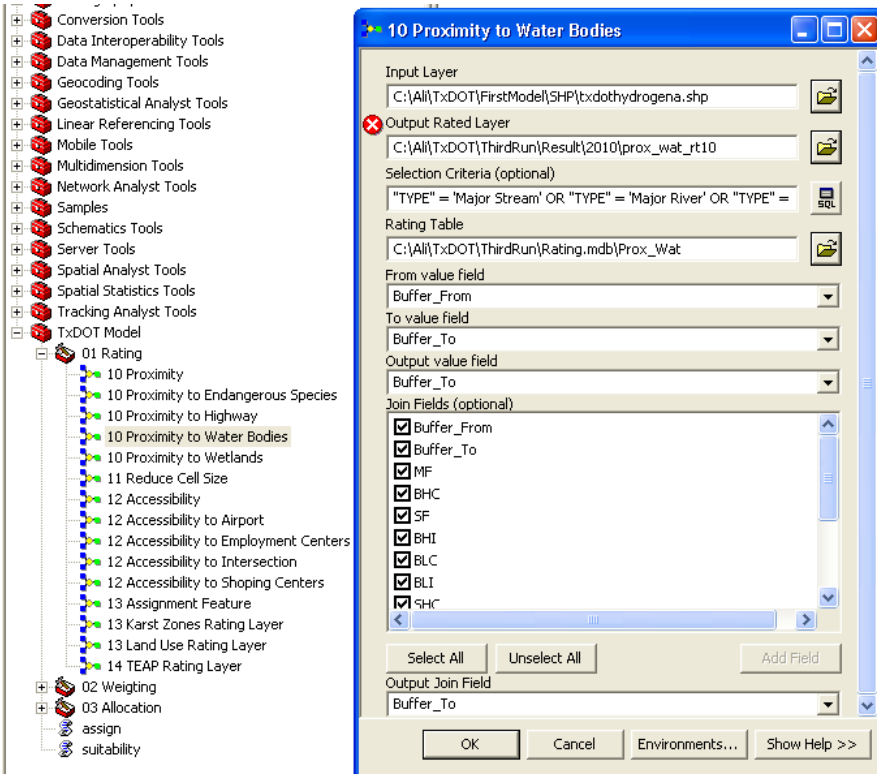

Figure A6: Proximity to Water Bodies Tool

Input Layer: Select the shape file for water bodies (SAhydrogena.shp)
Output Rated Layer: Choose the location and name of the output file
Selection Criteria: "TYPE" = 'Major Stream' OR "TYPE" = 'Major River' OR "TYPE" = 'Stream, Water Body' OR "TYPE" = 'Water Body'
Rating Table: A rating table for water bodies in mdb format (Rating.mdb\Prox_Wat)
From Value Field: It is the minimum value for buffer, so select "Buffer From." For Example, the model would consider 0 as the minimum value for water bodies from 0 to 30 meters.
To Value Field: It is the maximum value for buffer, so select "Buffer To." For example, the model would consider 30 as the maximum value for water bodies from 0 to 30 meters.
Output value field: Select "Buffer_to"
Join Fields (optional): It is optional but if needed you can select all or some of the fields to show them in the attribute table.
Output Join Field: Join the rating table with the result of the analysis to get the output. Here "Buffer_To" is the common field to join the rating table and the result of the analysis.

Table A3: Rating Table for Water Bodies

ID	Buffer_From	Buffer_To	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	0	30	-10	-11	-10	-11	-11	-11	-11	-11	-10	-11	2
2	30	100	-5	-7	5	-11	-5	-11	-5	-11	-3	-11	5
3	100	200	2	0	7	-7	1	-5	2	-5	3	-3	7
4	200	1000	9	5	8	0	7	1	7	2	8	5	8

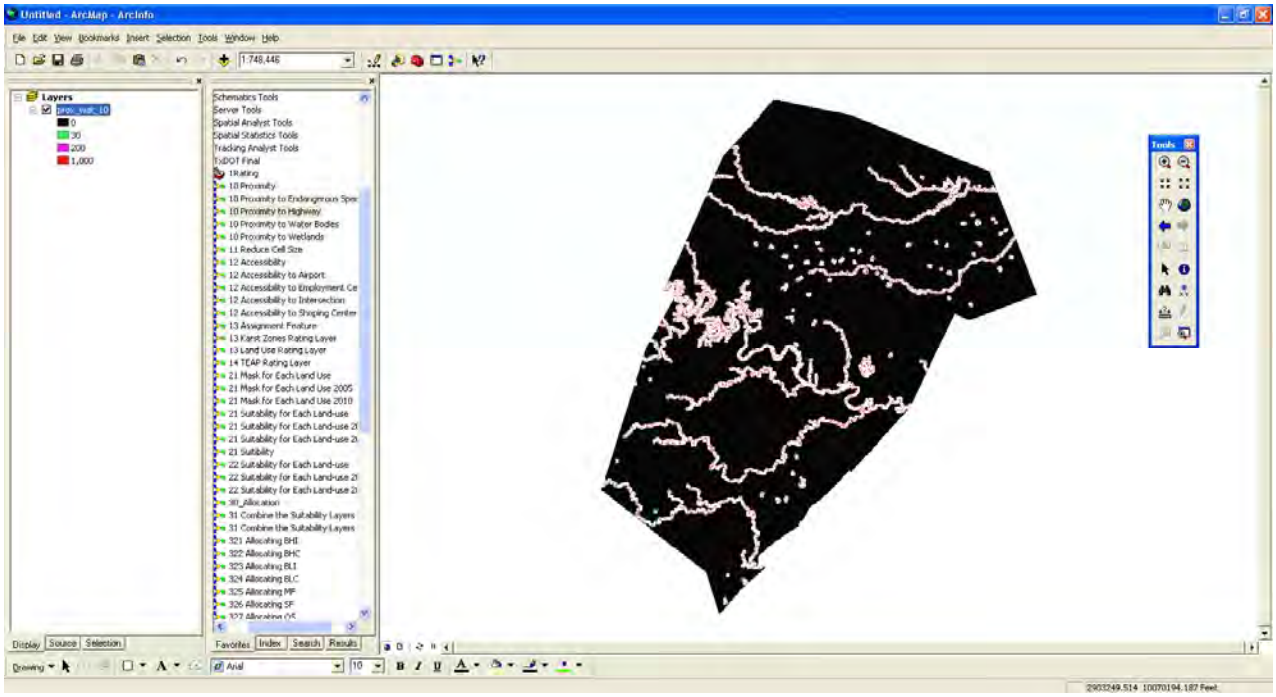

Figure A7: Result of Proximity to Water Bodies Tool

Wetlands

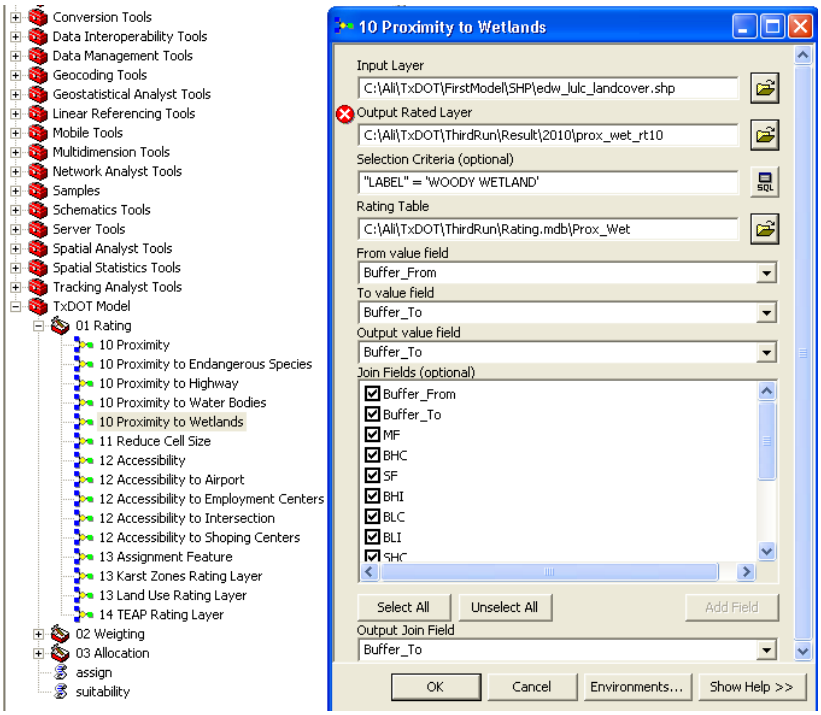

Figure A8: Proximity to Wetlands Tool

Input Layer: Select the shape file for wetlands (edw_lulc_landcover.shp)
Output Rated Layer: Choose the location and name of the output file
Selection Criteria: "LABEL" = 'WOODY WETLAND'
Rating Table: A rating table for water bodies in mdb format (Rating.mdb\Prox_Wet)
From Value Field: It is the minimum value for buffer, so select "Buffer From." For Example, the model would consider 0 as the minimum value for wetlands from 0 to 30 meters.
To Value Field: It is the maximum value for buffer, so select "Buffer To." For example, the model would consider 30 as the maximum value for wetlands from 0 to 30 meters.
Output value field: Select "Buffer_to"
Join Fields (optional): It is optional but if needed you can select all or some of the fields to show them in the attribute table.
Output Join Field: Join the rating table with the result of the analysis to get the output. Here "Buffer_To" is the common field to join the rating table and the result of the analysis.

Table A4: Rating Table for Wetlands

ID	Buffer_From	Buffer_To	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	0	30	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	2
2	30	100	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	7
3	100	280	1	-3	5	-5	-1	-2	-3	-5	-1	-2	6
4	280	1000	8	3	10	-1	7	0	3	-1	7	0	3

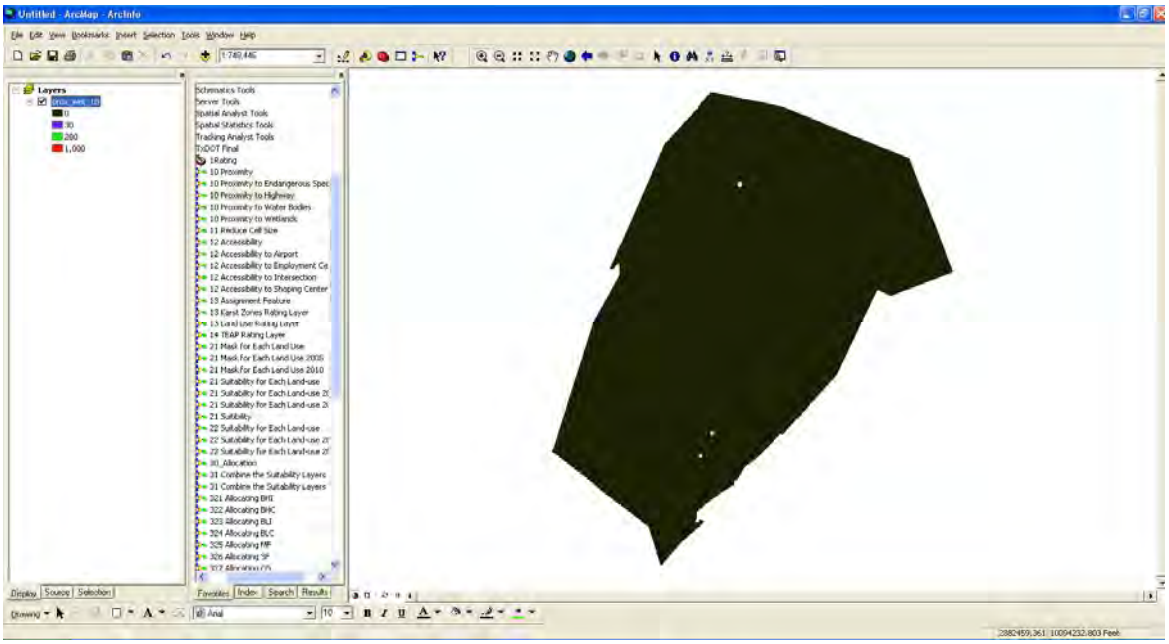

Figure A9: Result of Proximity to Wetland Tool

Appendix B: Accessibility Tool

Factors: Airport, Employment Centers, Intersection, Shopping Centers

Figures B1 through B8 and Tables B1 through B4 present information about these four factors.

Airport

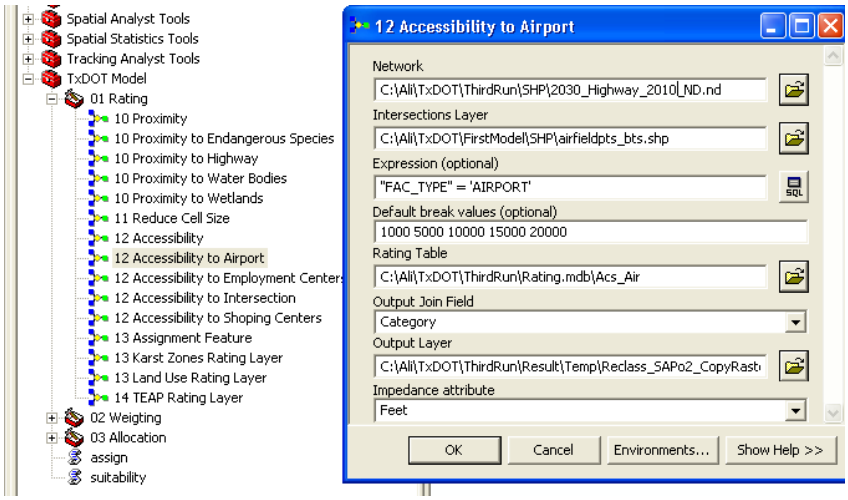

Figure B1: Accessibility to Airport Tool

Network: It is the network of roads and highways for the study area. Select the existing transportation (roads, highways) network from the geodatabase (2030_Highway_2010_ND.nd)
Intersection Layer: Shape file for airports (airfields_bts.shp)
Expression (optional): To specify the input layer if needed, here it is "FAC_TYPE" = 'AIRPORT'
Default break values (Measurement Units): Here the distance category is 1000, 5000, 10,000, 15,000, and 20,000 feet.
Rating Table: A rating table for intersection layer in .mdb format from the geodatabase (Rating.mdb\Acs_Air)
Output Join Field: Join the rating table with the result of the analysis to get the output. Here select “Category” because it is the common field to join the rating table and the result of the analysis.
Output Layer: Name and specify the location of the output. A raster file will be produced.
Impedance Attribute: Unit of measurement (feet, miles, etc).

Table B1: Rating Table for Airport

ID	Category	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	1000	-10	-5	-10	-3	-4	-5	-5	-10	-5	-10	0
2	5000	-5	-3	-7	-1	-2	-4	-3	-9	-2	-9	1
3	10000	0	0	0	1	2	-3	0	-8	0	-8	4
4	15000	2	1	1	2	4	0	1	0	4	0	5
5	20000	3	2	5	-1	6	3	2	0	6	2	7

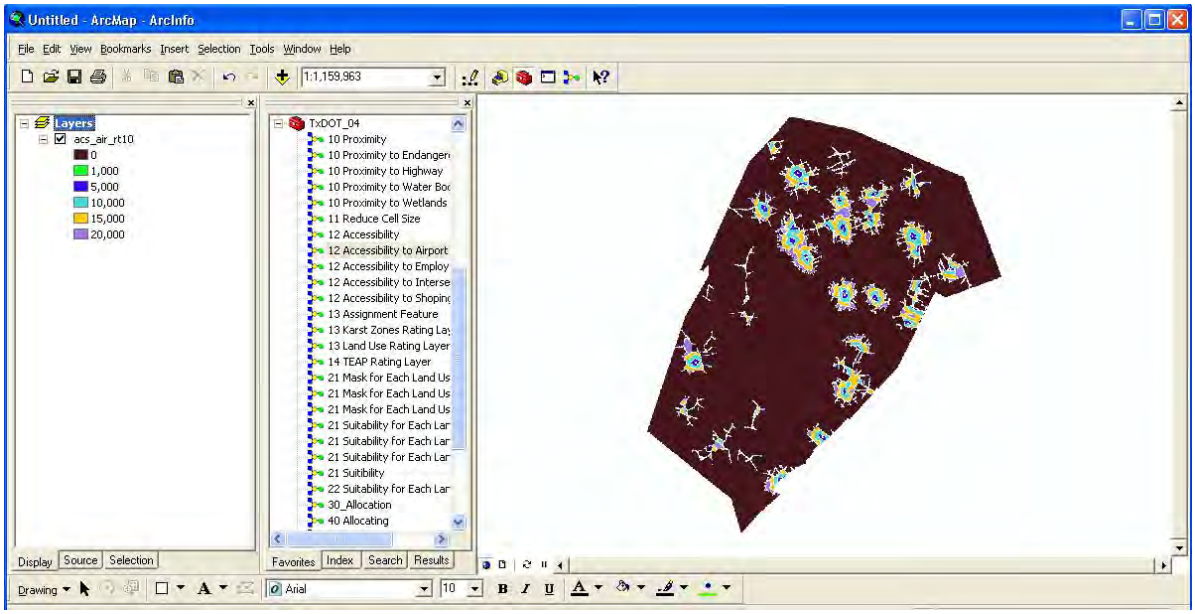

Figure B2: Result of Accessibility to Airport Tool

Employment Centers

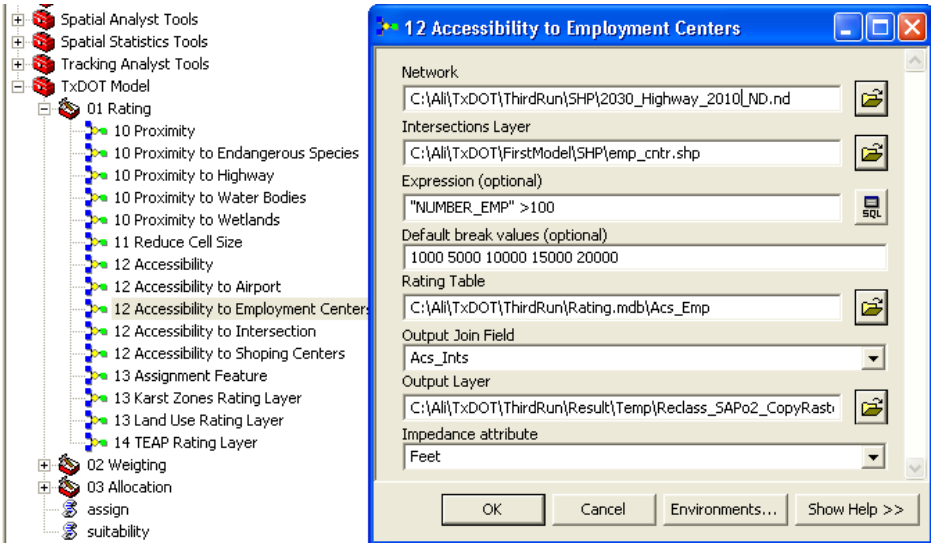

Figure B3: Accessibility to Employment Centers Tool

Network: Select the existing transportation (roads, highways) network from the geodatabase (2030_Highway_2010_ND.nd)
Intersection Layer: Shape file for employment centers (emp_cntr.shp)
Expression (optional): To specify the input layer if needed, here it is "NUMBER_EMP" >100
Default break values (Measurement Units): Here the distance category is 1000, 5000, 10,000, 15,000, and 20,000 feet.
Rating Table: Rating table for intersection layer in .mdb format from the geodatabase (Rating.mdb\Acs_Emp)
Output Join Field: Join the rating table with the result of the analysis to get the output. Here select "Category" is the common field to join the rating table and the result of the analysis.
Output Layer: Specify the location and name of the output. A raster file will be produced.
Impedance Attribute: Unit of measurement (feet, miles, etc).

Table B2: Rating Table for Employment Centers

ID	Category	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	1000	-10	7	-10	-10	10	-10	7	-10	10	-10	0
2	5000	0	8	-2	-7	8	-5	8	-7	8	-5	2
3	10000	3	6	1	-3	5	-1	6	-3	5	-1	4
4	15000	2	1	3	-1	0	0	1	-1	0	0	-1
5	20000	-1	0	-5	0	-1	1	0	0	-1	1	-5

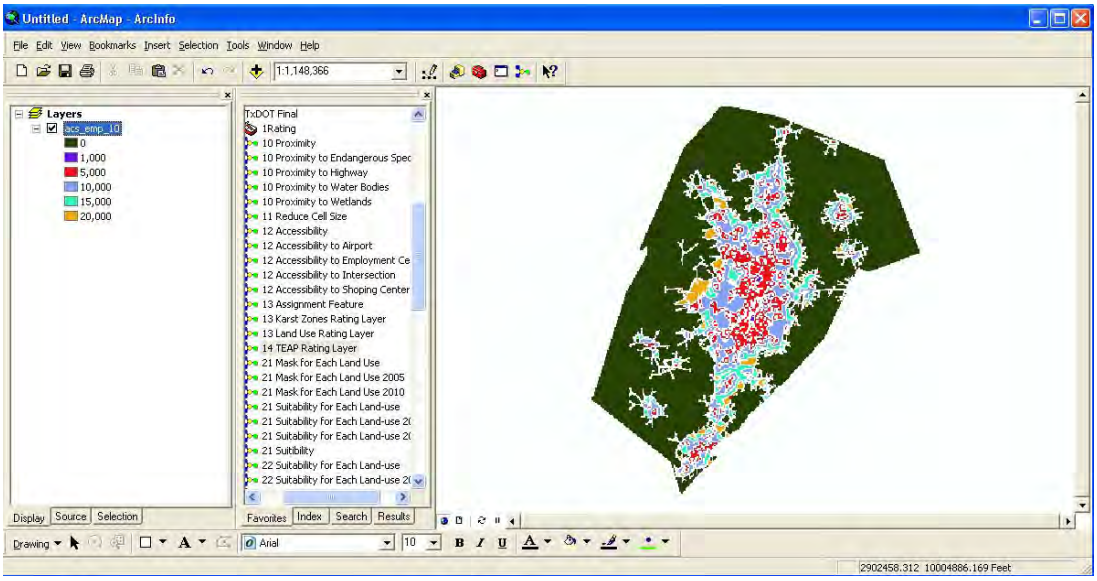

Figure B4: Result of Accessibility to Employment Centers Tool

Intersection

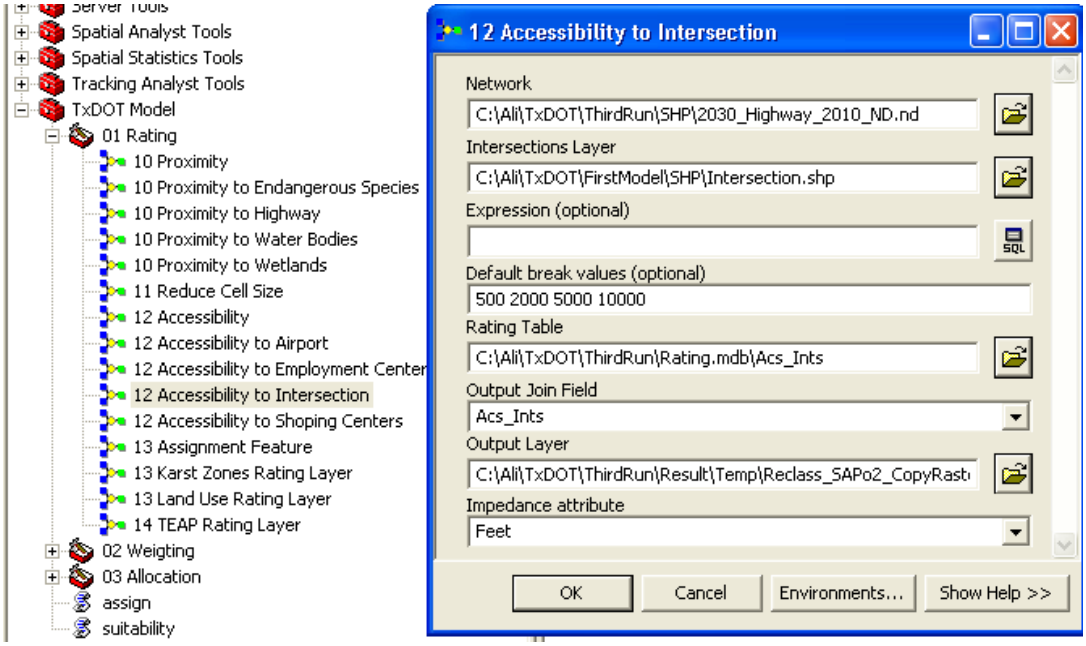

Figure B5: Accessibility to Intersection Tool

Network: Select the existing transportation (roads, highways) network from the geodatabase (2030_Highway_2010_ND.nd)
Intersection Layer: Shape file for intersection (Intersection.shp)
Expression (optional): To specify the input layer if needed, here not needed.
Default break values (Measurement Units): mile for Intersection. Here the distance category is 0.5, 1, 2, and 3 miles
Rating Table: Rating table for intersection layer in .mdb format from the geodatabase (Rating.mdb\Acs_Ints)
Output Join Field: Join the rating table with the result of the analysis to get the output. Here select "Category" because it is the common field to join the rating table and the result of the analysis.
Output Layer: Specify the location and name of the output. A raster file will be produced.
Impedance Attribute: Unit of measurement (feet, miles, etc).

Table B3: Rating Table for Intersection

ID	Category	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	500	-3	-3	-5	-10	-1	-10	-1	-10	-1	-10	-1
2	2000	1	0	0	-6	5	-5	0	-6	5	-5	1
3	5000	3	7	2	-3	2	-1	7	-3	2	-1	4
4	10000	2	-1	5	1	-7	1	-2	1	-7	1	0

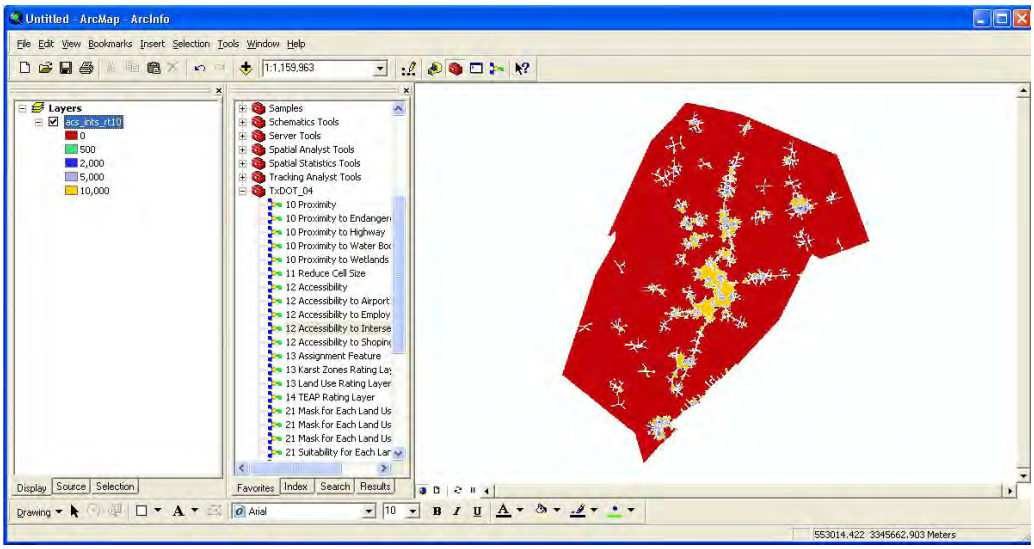

Figure B6: Result of Accessibility to Intersection Tool

Shopping Centers

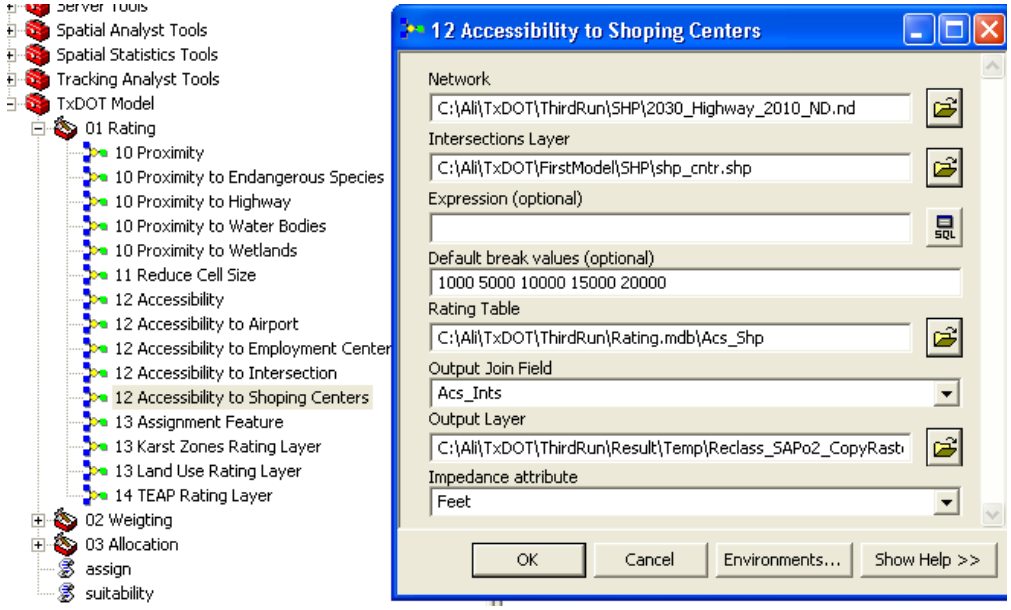

Figure B7: Accessibility to Shopping Centers Tool

Network: Select the existing transportation (roads, highways) network from the geodatabase (2030_Highway_2010_ND.nd)
Intersection Layer: Shape file for shopping centers (shp_cntr.shp)
Expression (optional): To specify the input layer if needed, here it is not needed.
Default break values (Measurement Units): Here the distance category is 1000, 5000, 10,000, 15,000, and 20,000 feet.
Rating Table: Rating table for intersection layer in .mdb format from the geodatabase (Rating.mdb\Acs_Shp)

Output Join Field: Join the rating table with the result of the analysis to get the output. Here select "Category" t is the common field to join the rating table and the result of the analysis.
Output Layer: Specify the location and name of the output. A raster file will be produced.
Impedance Attribute: Unit of measurement (feet, miles, etc).

Table B4: Rating Table for Shopping Centers

ID	Category	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
1	1000	-10	7	-10	-10	10	-10	7	-10	10	-10	0
2	5000	0	8	0	-7	8	-5	8	-7	8	-5	3
3	10000	3	6	1	-3	7	-1	6	-3	5	-1	5
4	15000	0	1	0	-1	0	0	1	-1	0	0	0
5	20000	-6	0	-5	0	-1	1	0	0	-2	1	-3

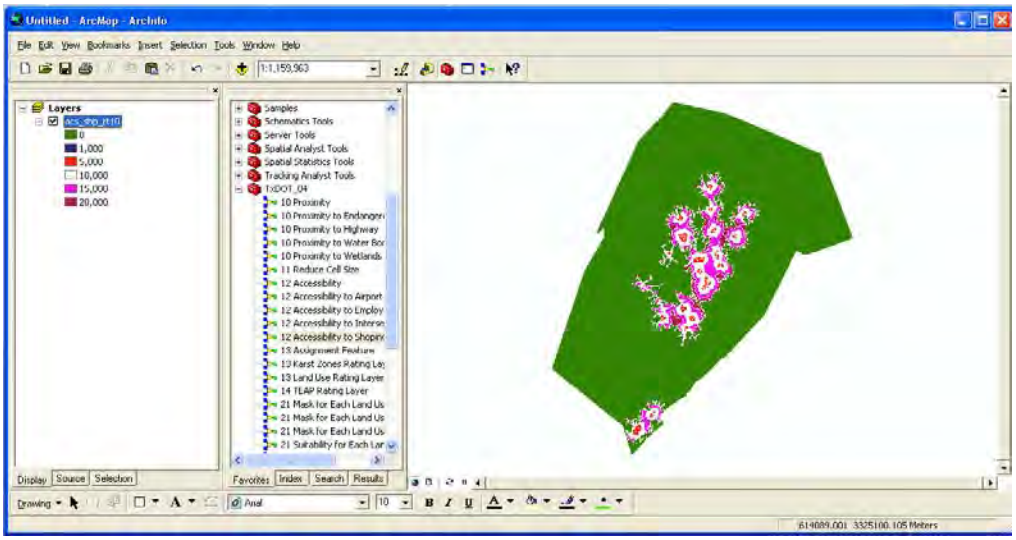

Figure B8: Result of Accessibility to Shopping Centers Tool

Appendix C: Assignment Tool

Factors: Land Use, Karst, Texas Ecological Assessment Protocol (TEAP)

Figures C1 through C6 and Tables C1 through C3 present information about these three factors.

Land Use

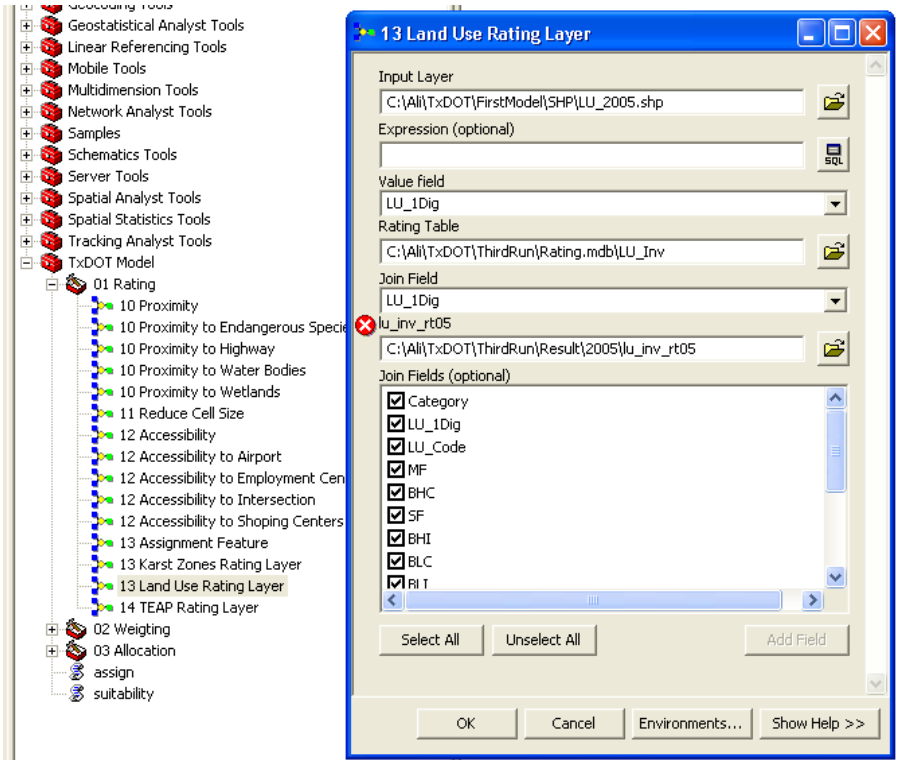

Figure C1: Assignment Tool for Land Use

Input Layer: Select the shape file for land use (LU_2005.shp)
Expression (optional): Not required
Value Field: Specify the value field, here it is "LU_1Dig"
Rating Table: Rating table of land use in mdb format (Rating.mdb\LU_Inv)
Join Field: Join the rating table with the result of the analysis to get the output. Here the common join field is "LU_1Dig"
lu_Inv_rt05: lu_inv_rt05
Join Fields (optional): It is optional but if needed you can select all or some of the fields to show them in the attribute table.

Table C1: Rating Table for Existing Land Use

ID	LU_Code	Category	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	LU_1Dig	OS
1	A	Single Family Residential	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	1	-11
2	B	Multifamily Residential	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	2	-11
3	C	Vacant Lots and Tracts	10	10	10	10	10	10	10	10	10	10	3	10
4	D	Qualified Agricultural Land	0	-5	5	-5	-5	-5	-5	-7	-2	-5	4	10
5	E	Farm and Ranch Improvements	0	-5	5	-5	-5	-5	-5	-7	-2	-5	5	10
6	F	Commercial	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	6	-11
7	G	Oil, Gas, and Other Minerals	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	7	-11
8	H	Non business vehicles _tangible personal property	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	8	-11
9	J	Utilities	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	9	-11
10	M	Mobile Homes	0	0	1	0	0	0	0	0	0	0	10	0

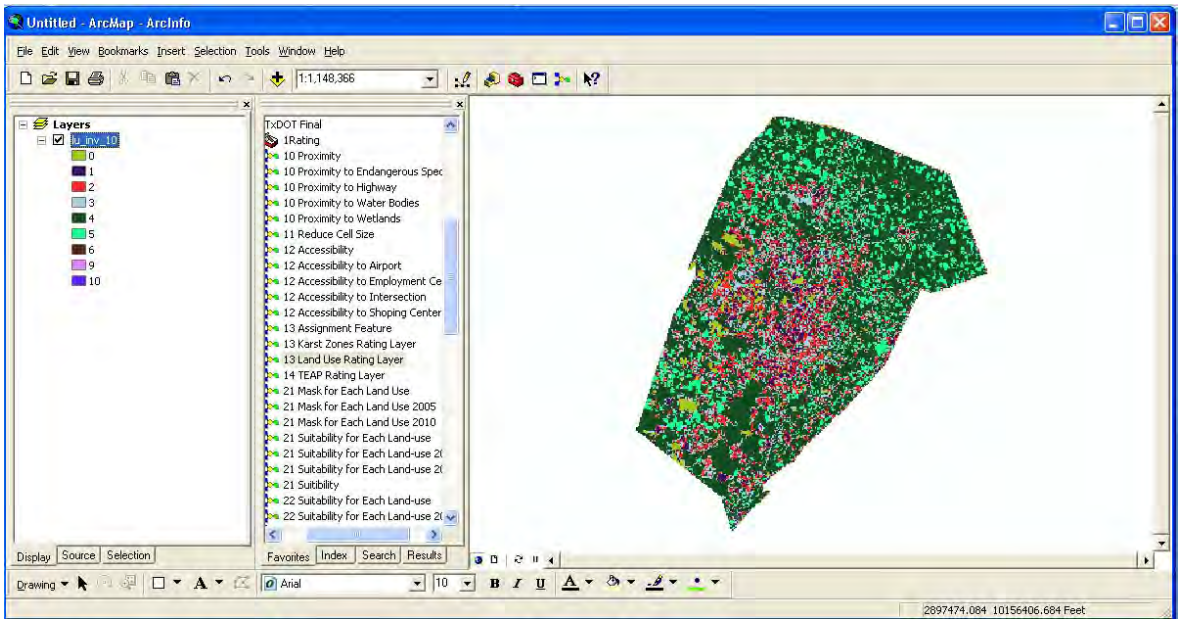

Figure C2: Result of Assignment of Land Use Tool

Karst

Input Layer: Select the shape file for Karst (KarstZones.shp)
Value Field: Specify the value field; here it is "Zone_"
Rating Table: Rating table of Karst in mdb format (Rating.mdb\Karst)
Join Field: Join the rating table with the result of the analysis to get the output. Here the common join field is "Code"
Karst_rt05: karst_rt05
Join Fields (optional): It is optional but if needed you can select all or some of the fields to show them in the attribute table.

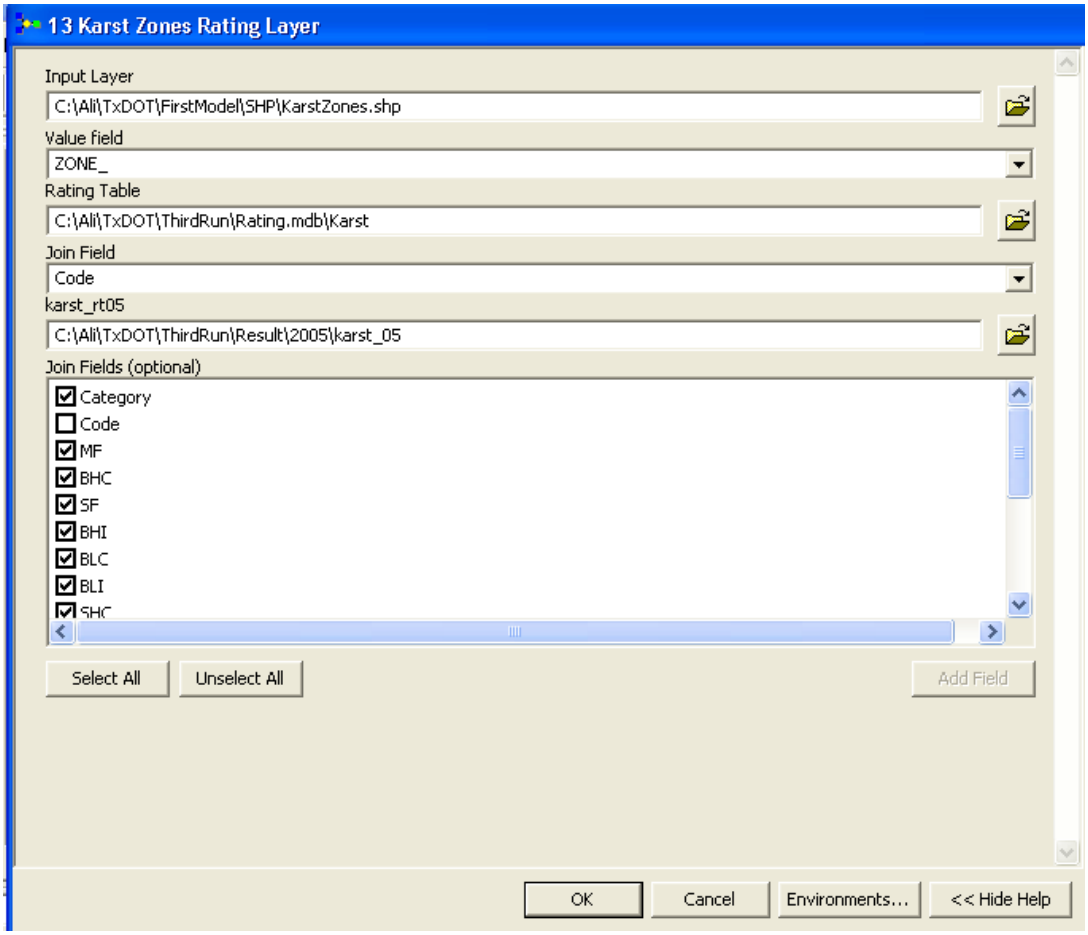

Figure C3: Assignment Tool for Karst

Table C2: Rating Table for Karst

Karst														
ID	**Category**	**Code**	**MF**	**BHC**	**SF**	**BHI**	**BLC**	**BLI**	**SHC**	**SHI**	**SLC**	**SLI**	**ID1**	**OS**
1	Zone 1	1	-8	-10	-3	-10	-10	-10	-10	-10	-10	-10	1	8
2	Zone 2	2	-6	-10	-1	-10	-8	-10	-10	-10	-8	-10	2	10
3	Zone 3	3	-2	-7	2	-10	-4	-7	-7	-10	-4	-7	3	6
4	Zone 4	4	0	-3	4	-8	-2	-8	-3	-8	-2	-7	4	0

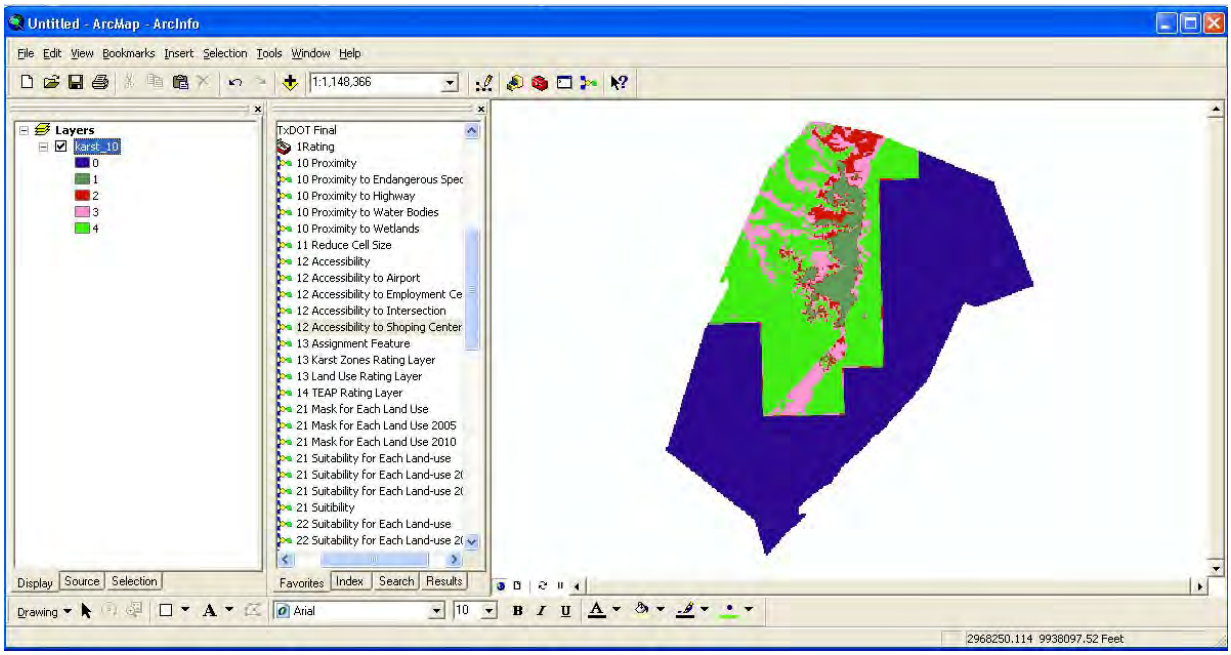

Figure C4: Result of Assignment of Karst Tool

TEAP

Composite: Select the composite layer for TEAP. It is one of the layers in TEAP dataset that includes the mean value of other of TEAP factors, which are diversity, rarity, and sustainability.

Teap_rt05: Specify the output raster layer, which include the rating for different land uses.

TEAP: A rating table of TEAP (Rating.mdb\TEAP)

From value field: "Category_From"

To value field: "Category_To"

Output value field: Specify the common field for joining the rating table to TEAP layer.

Output Join Field: Specify the common field for joining the rating table to TEAP layer

Join Fields (optional): Specify the field that needs to be included in final output layer, which are the rating for all the land uses.

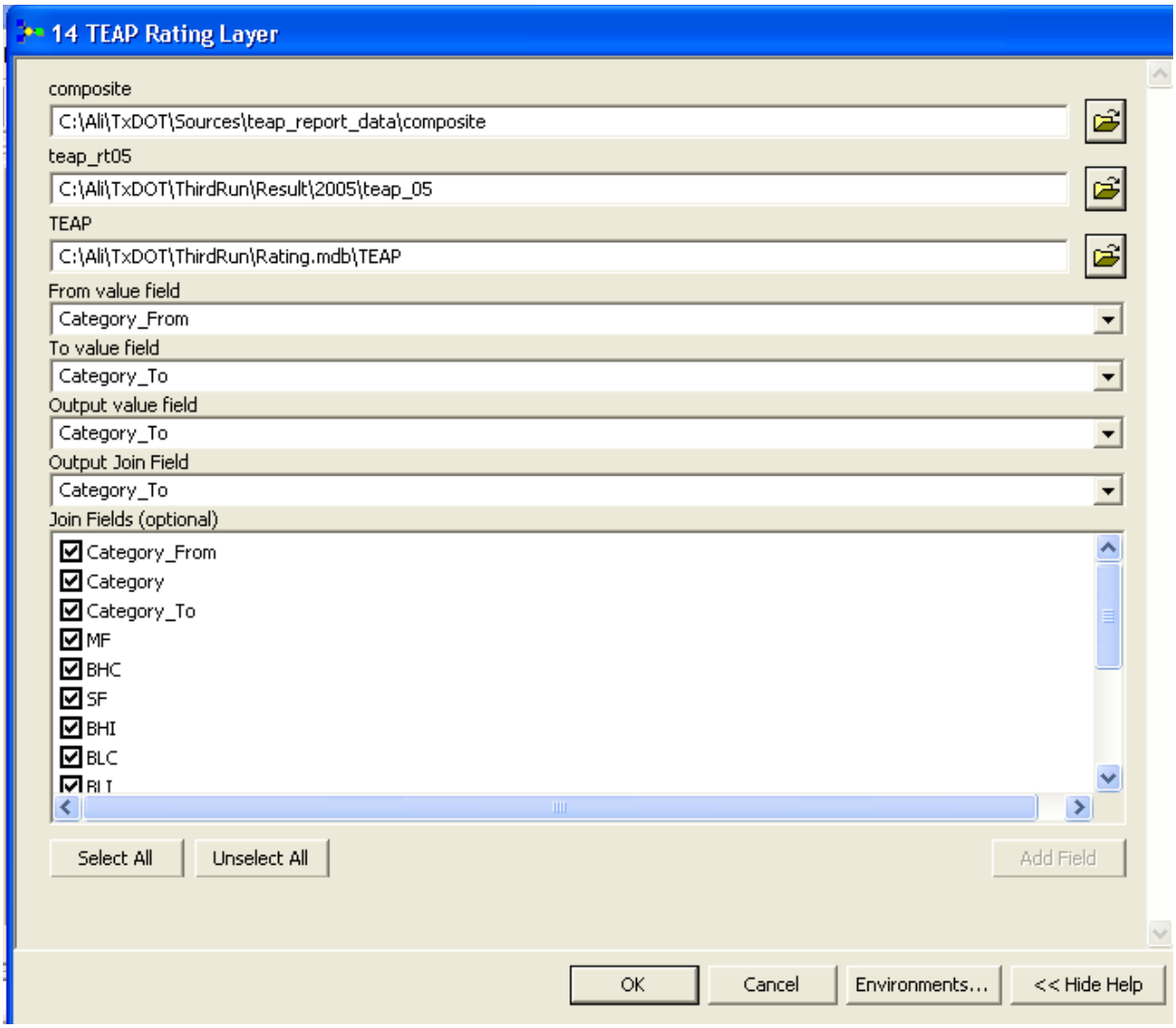

Figure C5: Assignment Tool for TEAP

Table C3: Rating Table for TEAP

Category_From	ID	Category	Category_To	MF	BHC	SF	BHI	BLC	BLI	SHC	SHI	SLC	SLI	OS
0	1	1	1	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	10
1	2	10	10	-2	-6	-1	-8	-4	-6	-6	-8	-4	-6	10
10	3	25	25	4	-1	8	-6	0	-2	-1	-6	0	-2	8
25	4	50	50	9	3	10	-2	5	0	4	-2	7	0	4
50	5	100	100	0	0	0	4	0	5	0	6	0	7	1

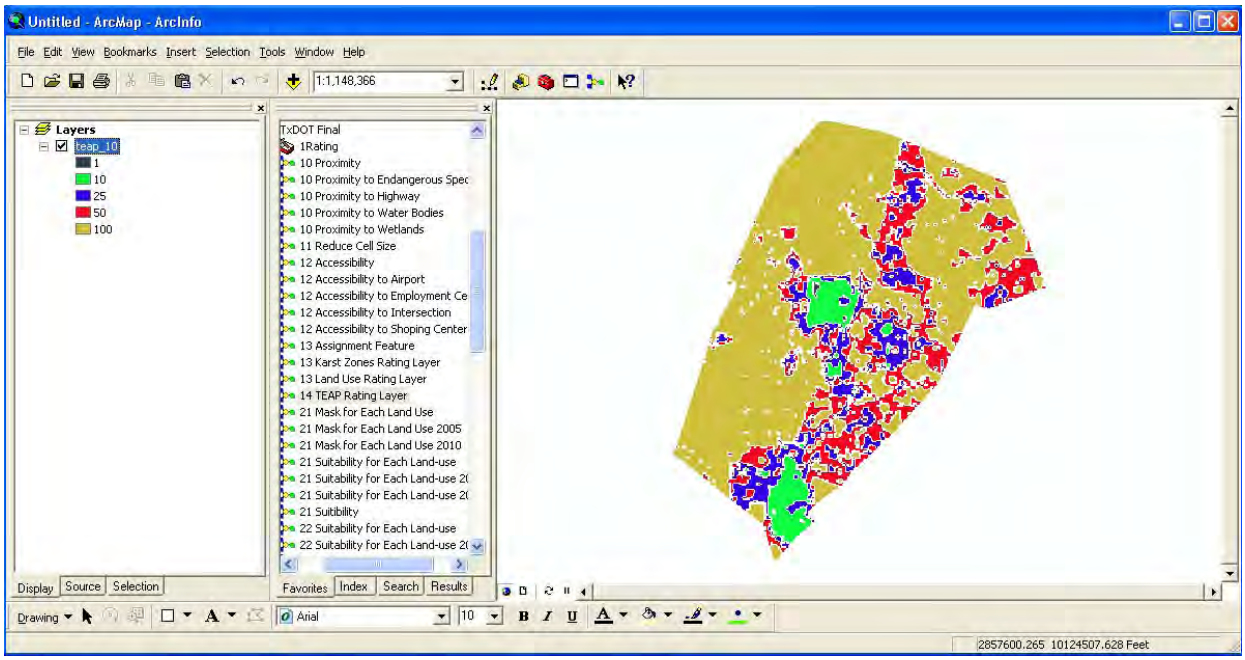

Figure C6: Result of Assignment of TEAP Tool

Appendix D: Allocation Toolset

Combination of all the rated and weighted maps is shown in Figures D1 through D24.

Combination for 2010

This process involves combining all the suitability layers of each land use for year 2010 and generating a composite suitability map.

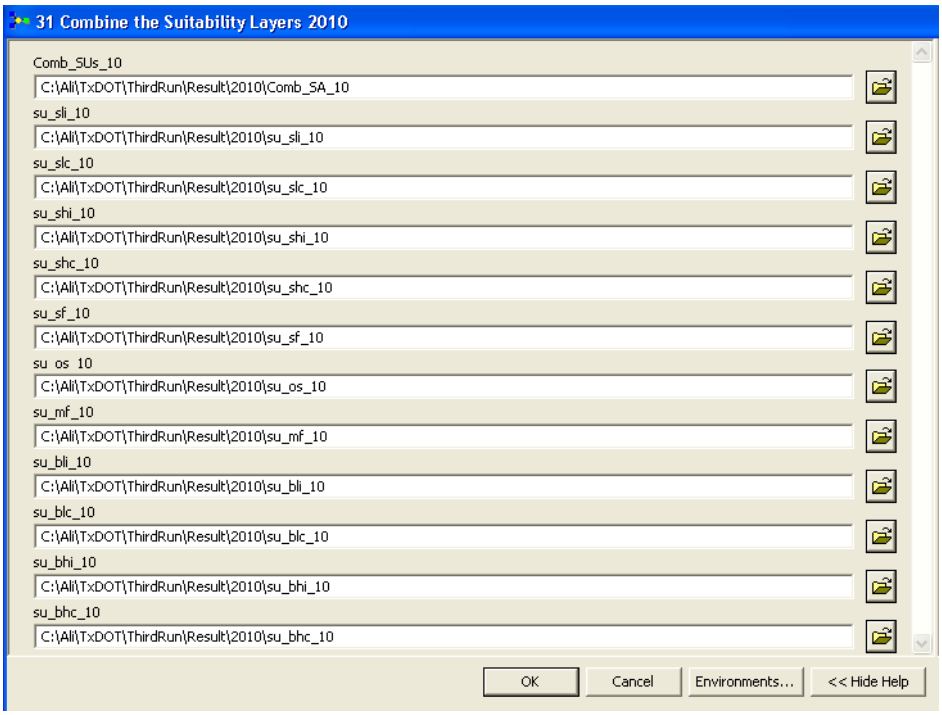

Figure D1: Allocation Tool to Combine Suitability Layers

Result

Darker area represents available land for development.

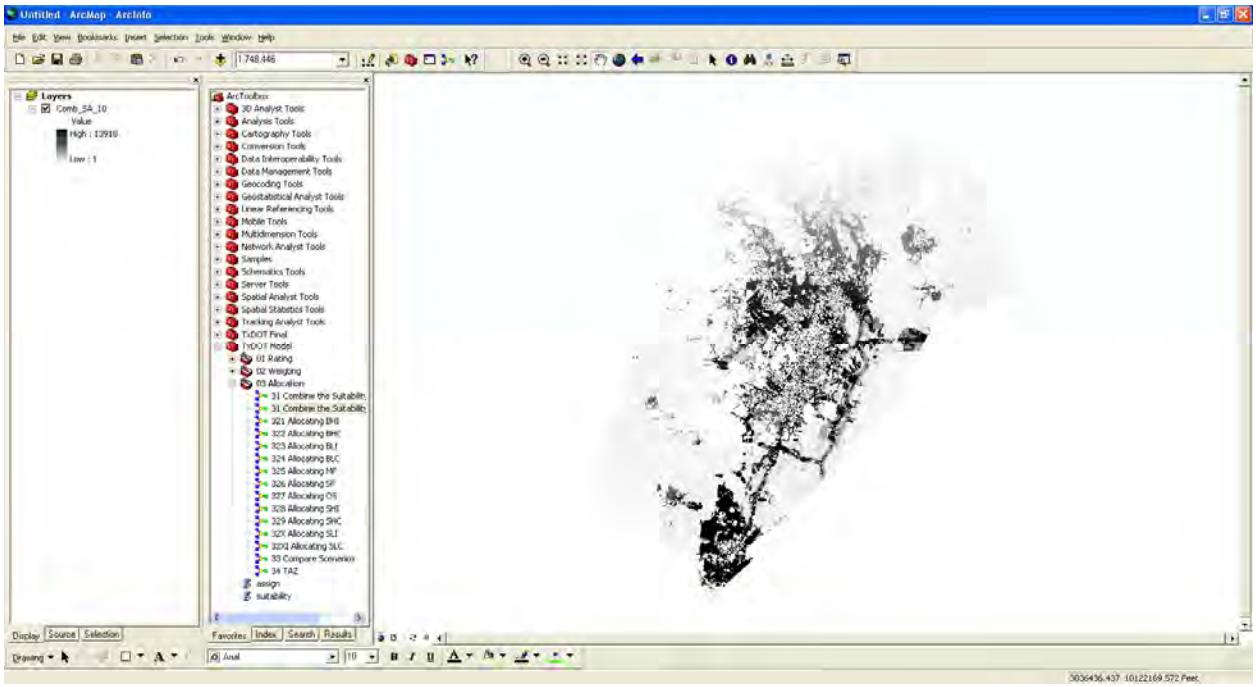

Figure D2: Result of Allocation Tool Showing Available Land for Development

Open Space

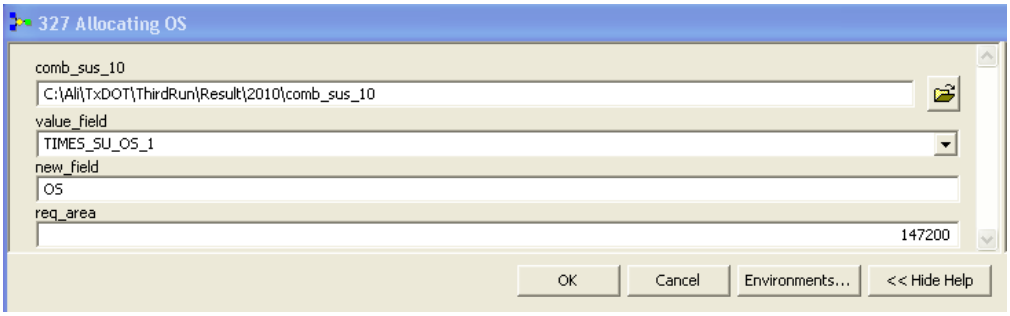

Figure D3: Allocation Tool for Open Space

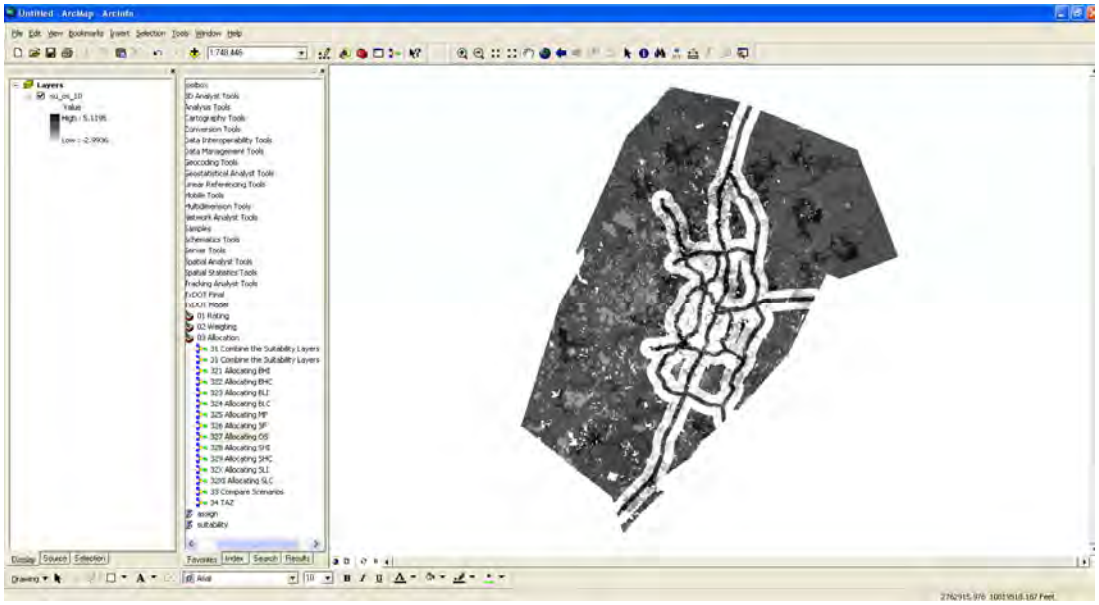

Figure D4: Allocated Open Space

Single Family (SF) 2010

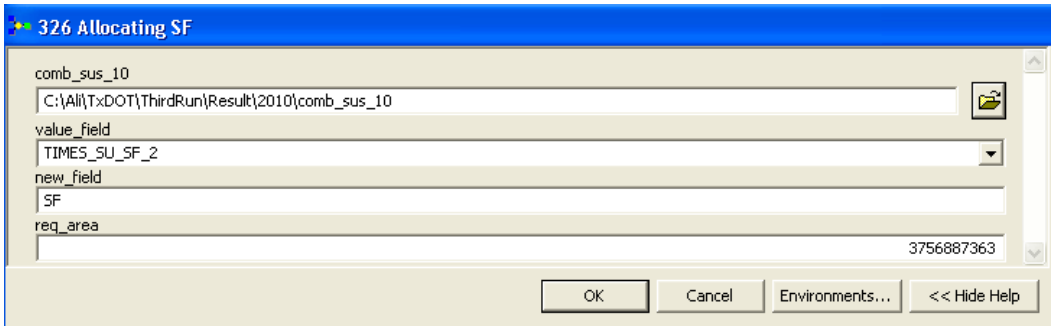

Figure D5: Allocation Tool for Single Family

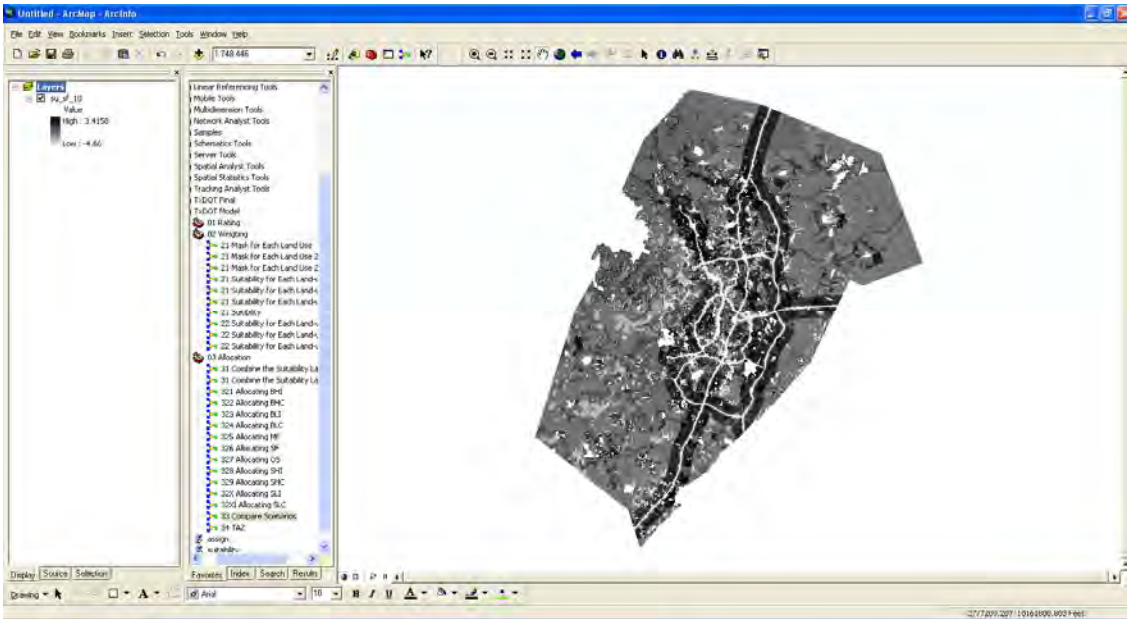

Figure D6: Allocated Single Family

Multi Family (MF)

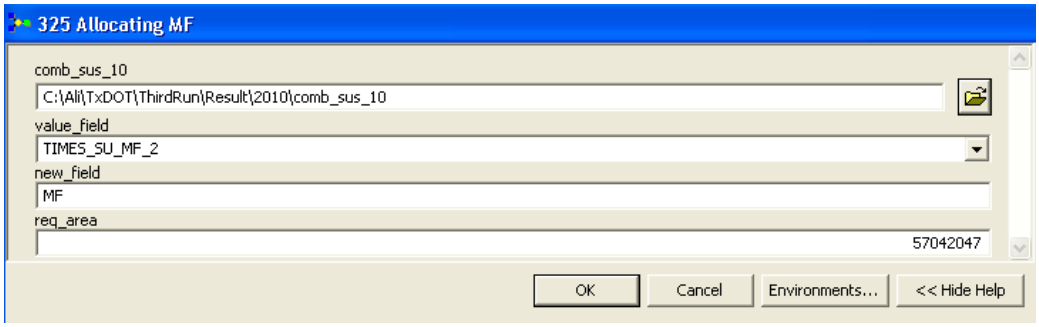

Figure D7: Allocation Tool for Multi Family

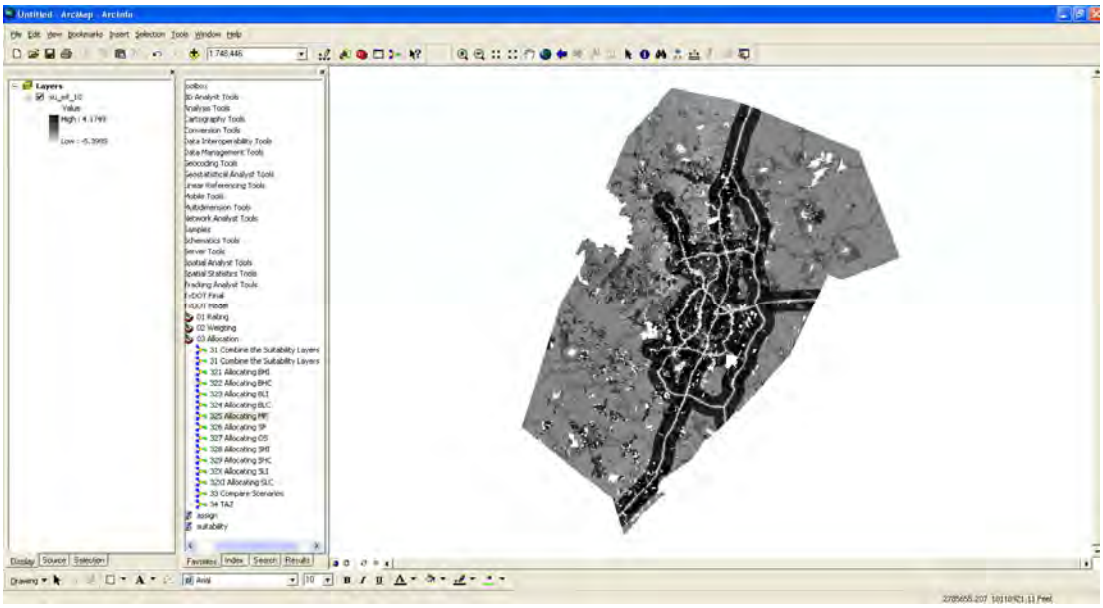

Figure D8: Allocated Multi Family

Basic Heavy Industrial (BHI)

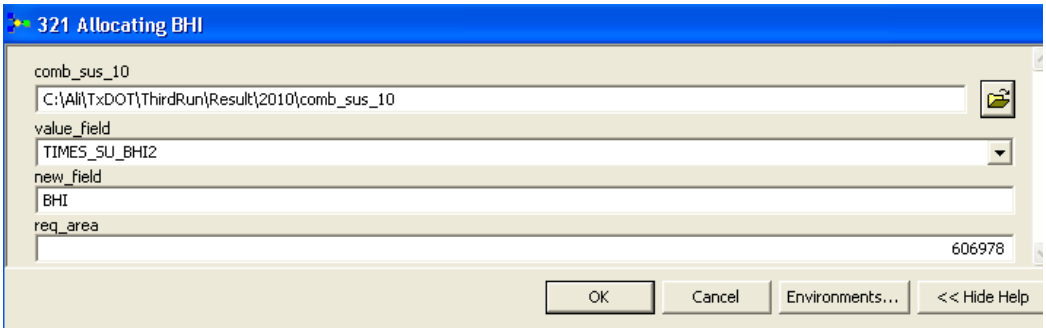

Figure D9: Allocation Tool for Basic Heavy Industrial

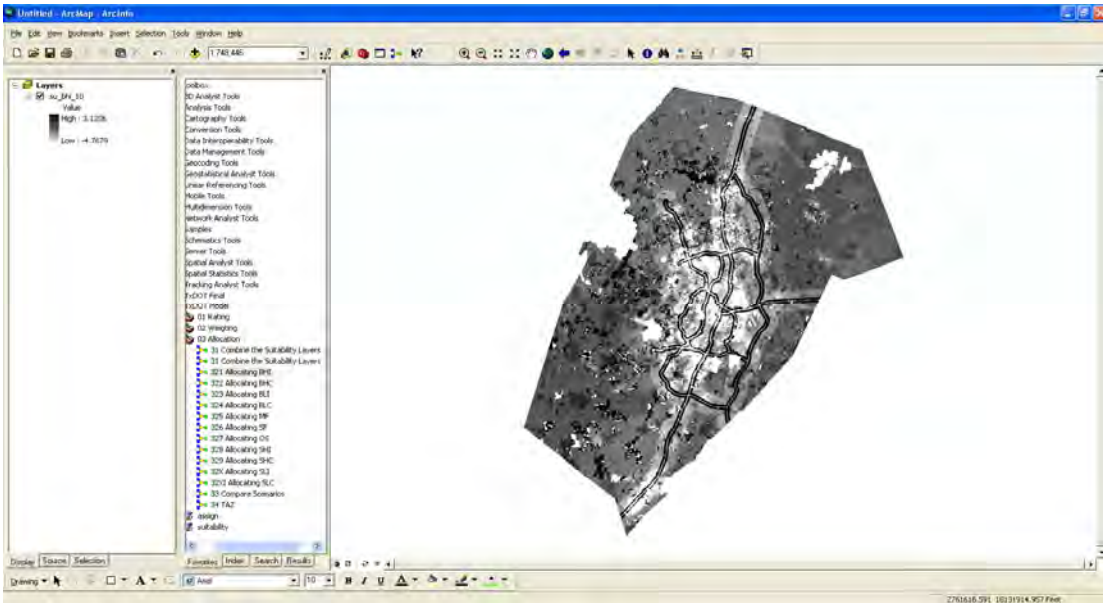

Figure D10: Allocated Basic Heavy Industrial

Basic Light Industrial (BLI)

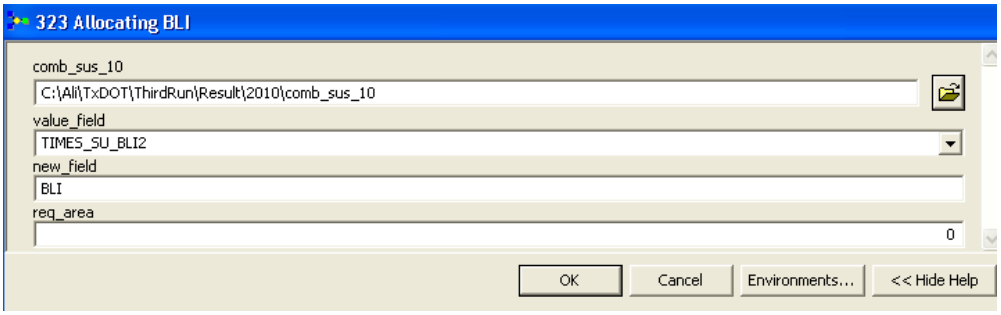

Figure D11: Allocation Tool for Basic Light Industrial

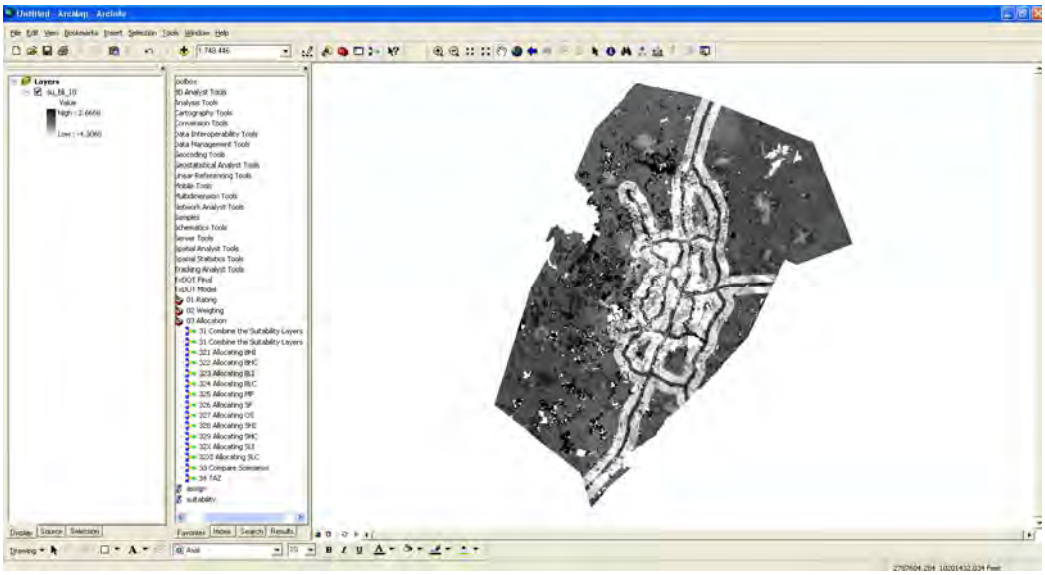

Figure D12: Allocated Basic Light Industrial

Service Heavy Industrial (SHI)

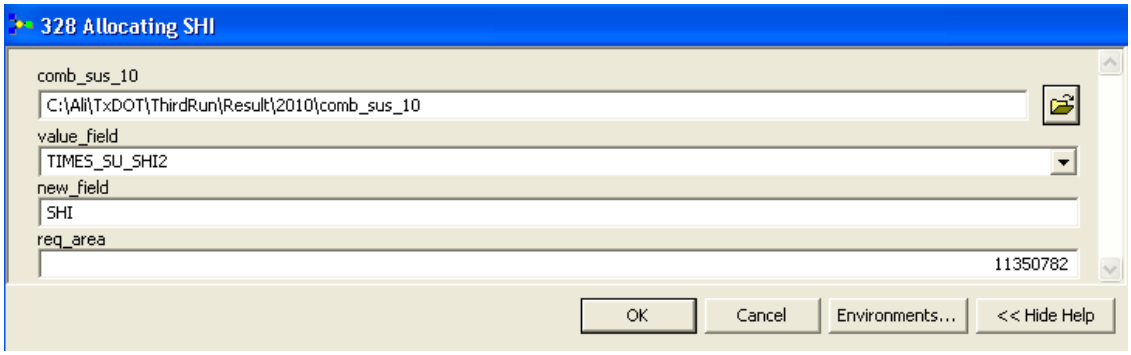

Figure D13: Allocation Tool for Service Heavy Industrial

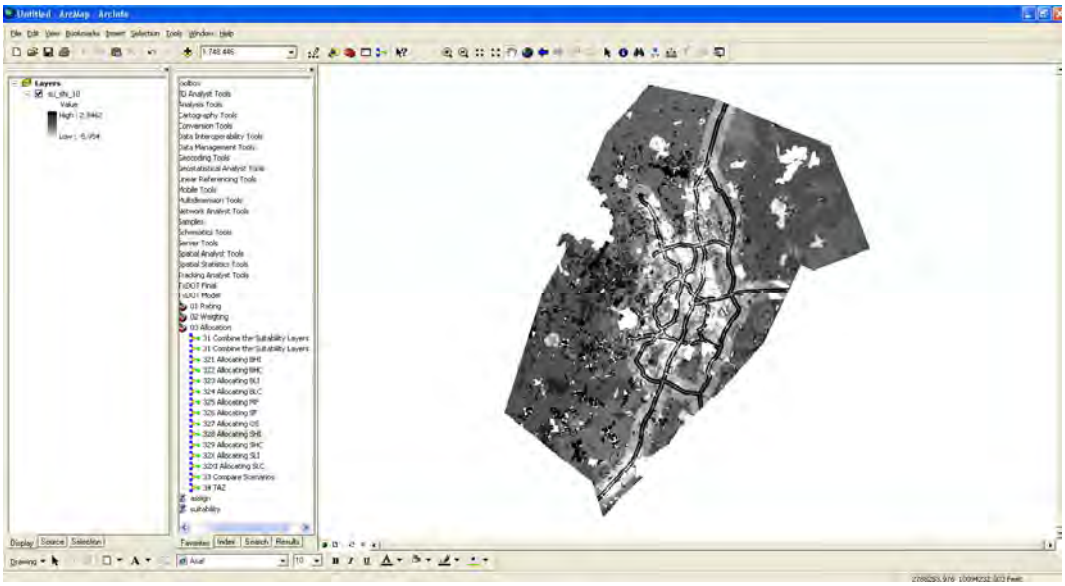

Figure D14: Allocated Service Heavy Industrial

Service Light Industrial (SLI)

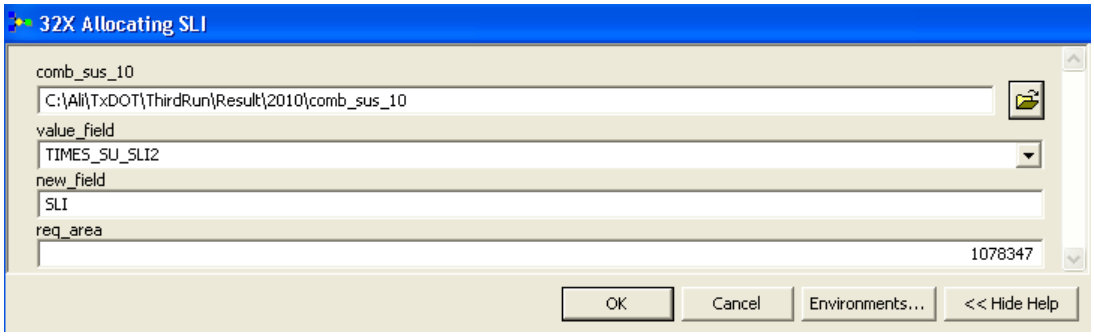

Figure D15: Allocation Tool for Service Light Industrial

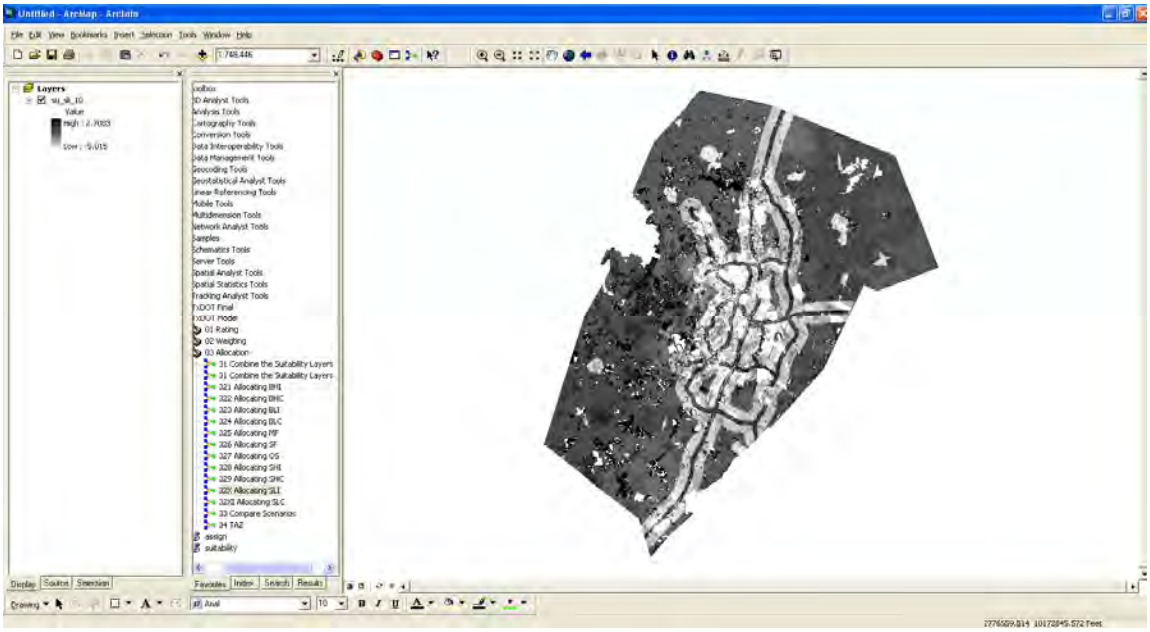

Figure D16: Allocated Service Light Industrial

Basic High Commercial (BHC)

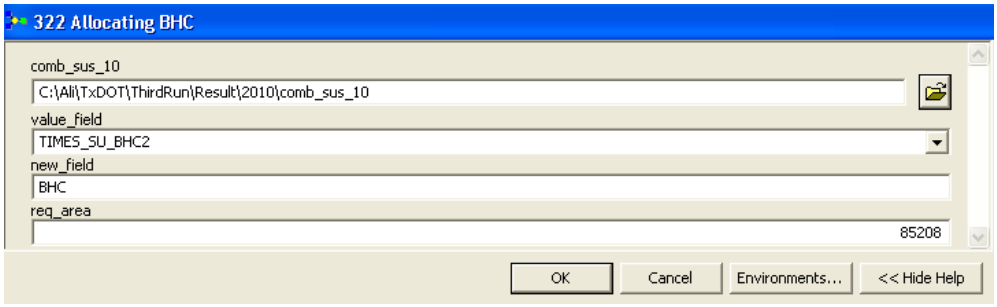

Figure D17: Allocation Tool for Basic High Commercial

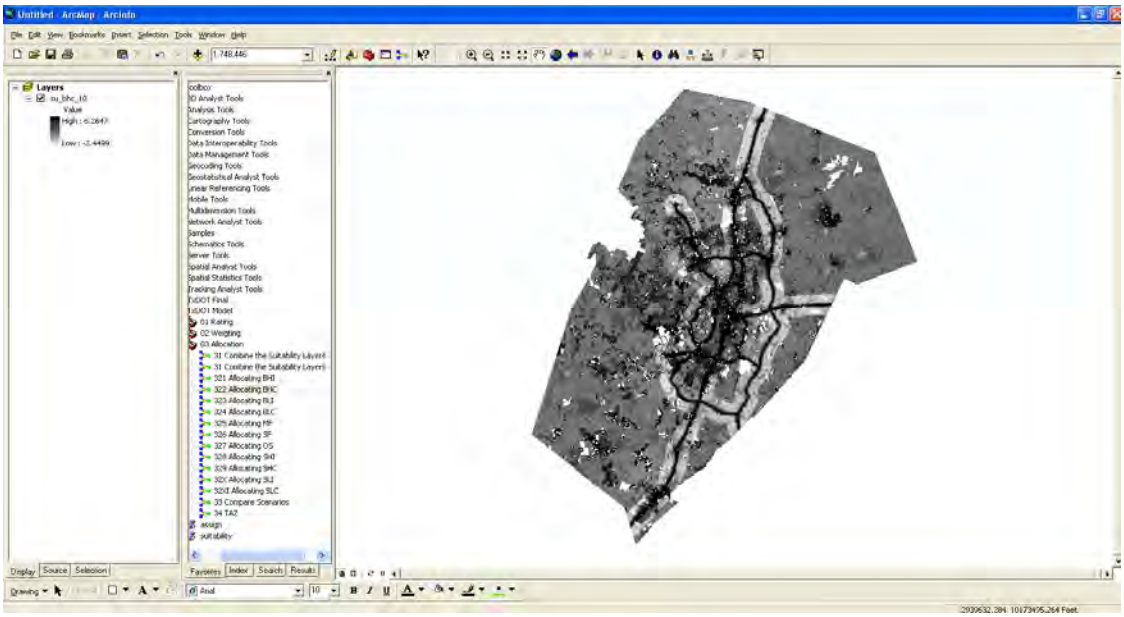

Figure D18: Allocated Basic High Commercial

Basic Low Commercial (BLC)

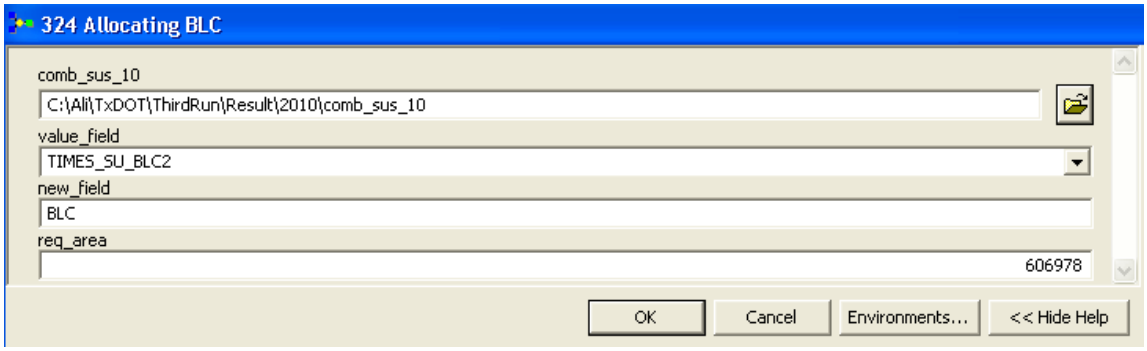

Figure D19: Allocation Tool for Basic Low Commercial

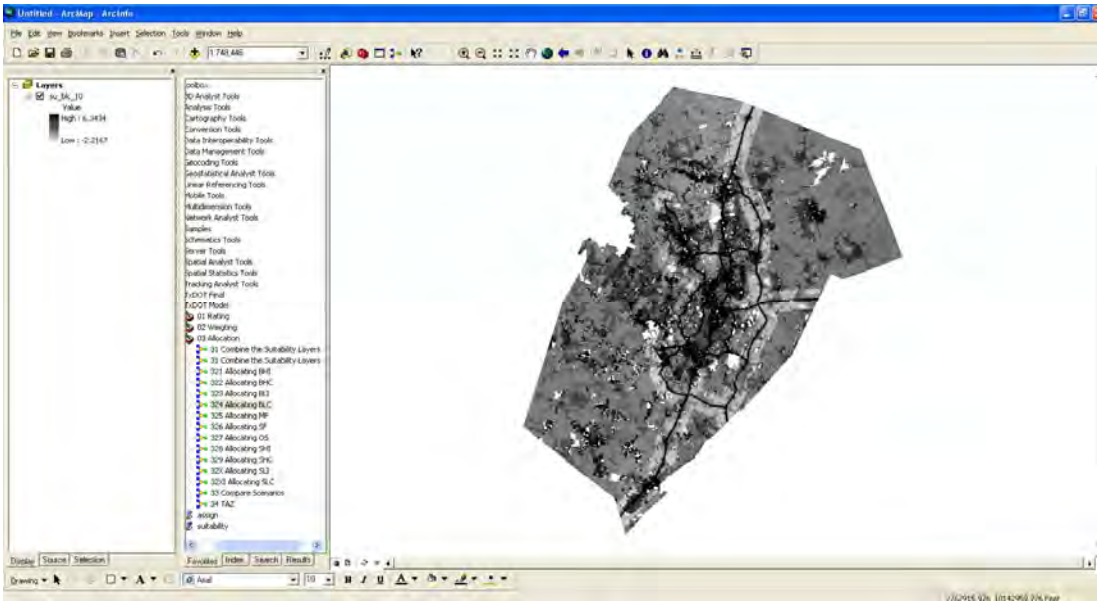

Figure D20: Allocated Basic Low Commercial

Service High Commercial (SHC)

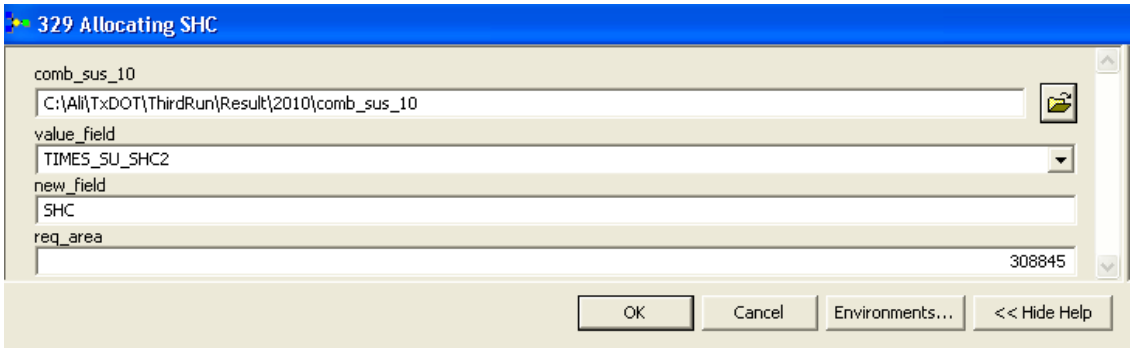

Figure D21: Allocation Tool for Service High Commercial

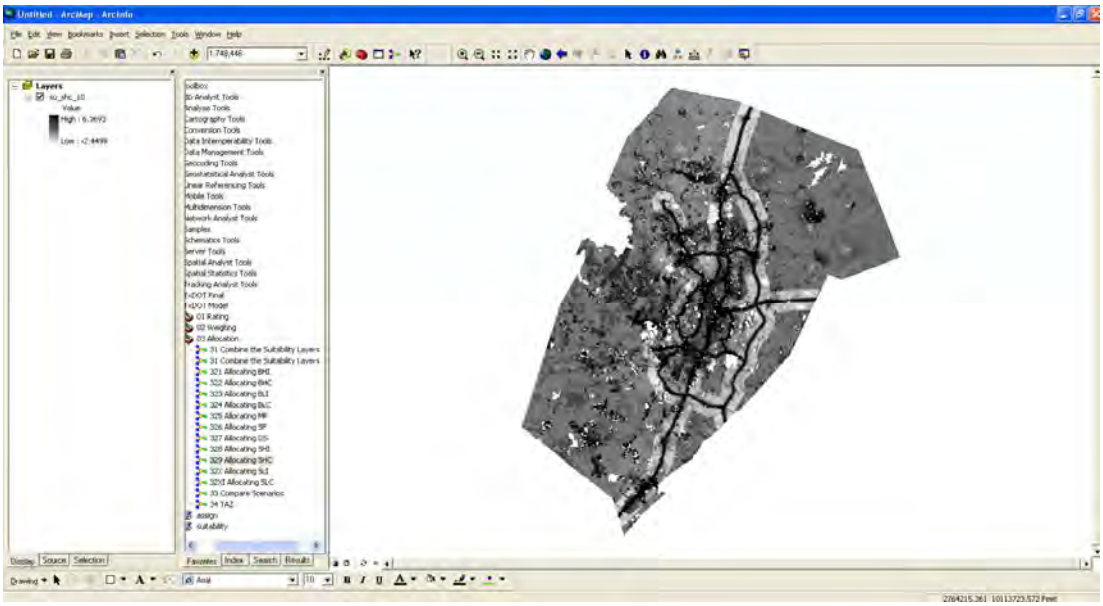

Figure D22: Allocated Service High Commercial

Service Low Commercial

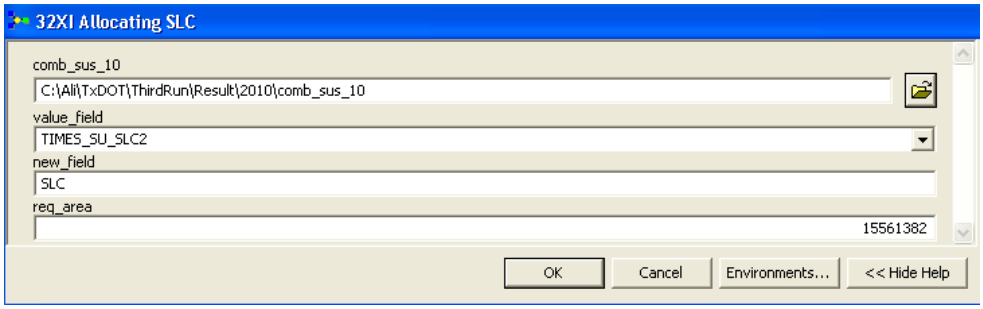

Figure D23: Allocation Tool for Service Low Commercial

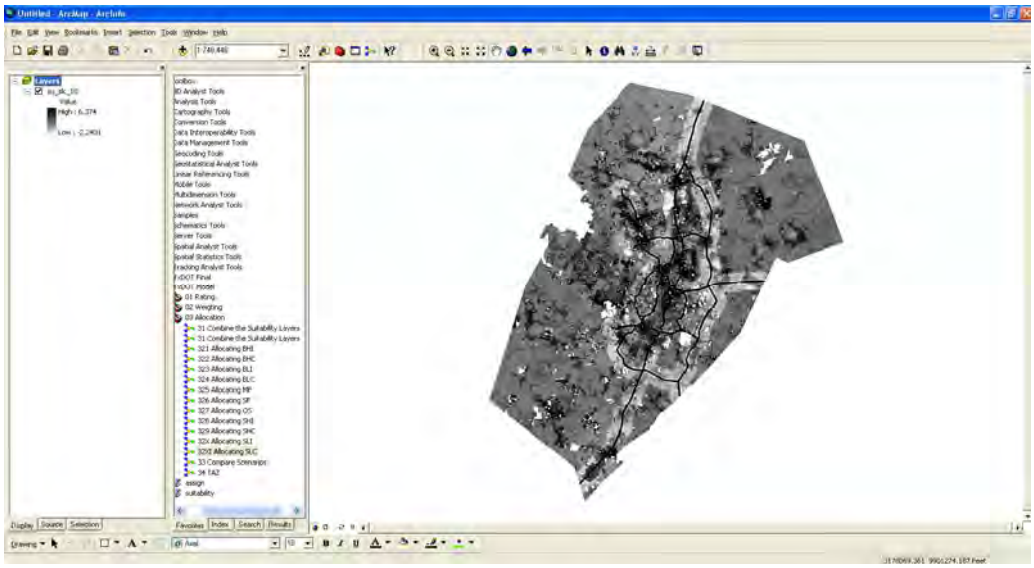

Figure D24: Allocated Service Low Commercial

Appendix E: Suitability Tool

After we get total land available for development, we perform suitability analysis for each land use based on the weight. See Figures E1 through E5.

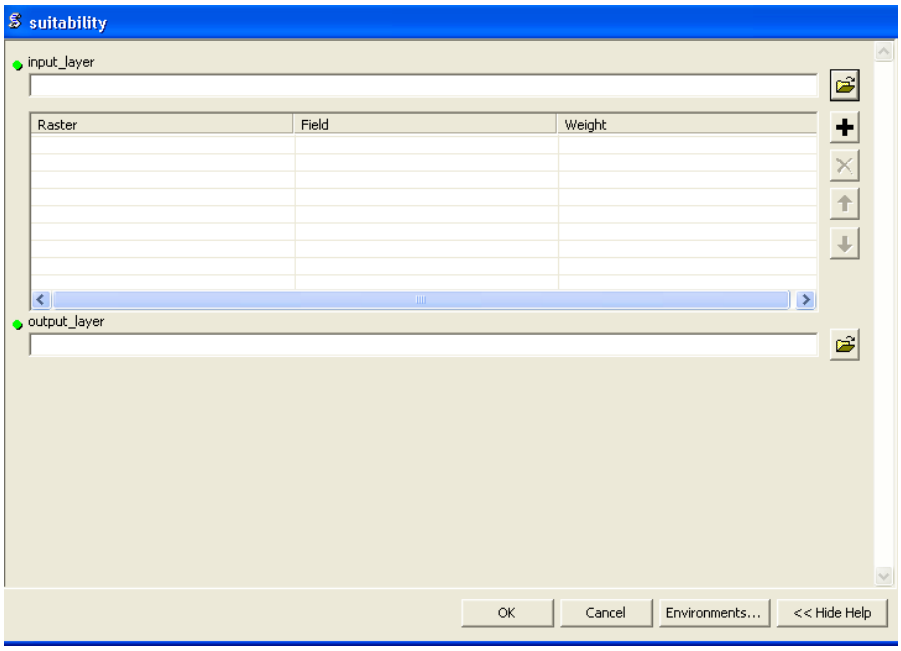

Figure E1: Suitability Tool

Suitability for 2005

Here, a raster file of each suitability factor for Single Family (SF) land use with assigned weight is entered.

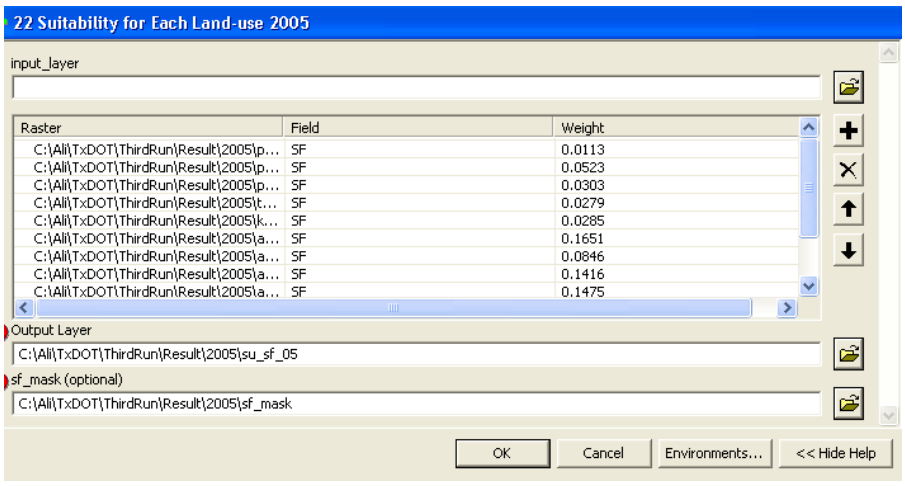

Figure E2: Suitability Tool for 2005

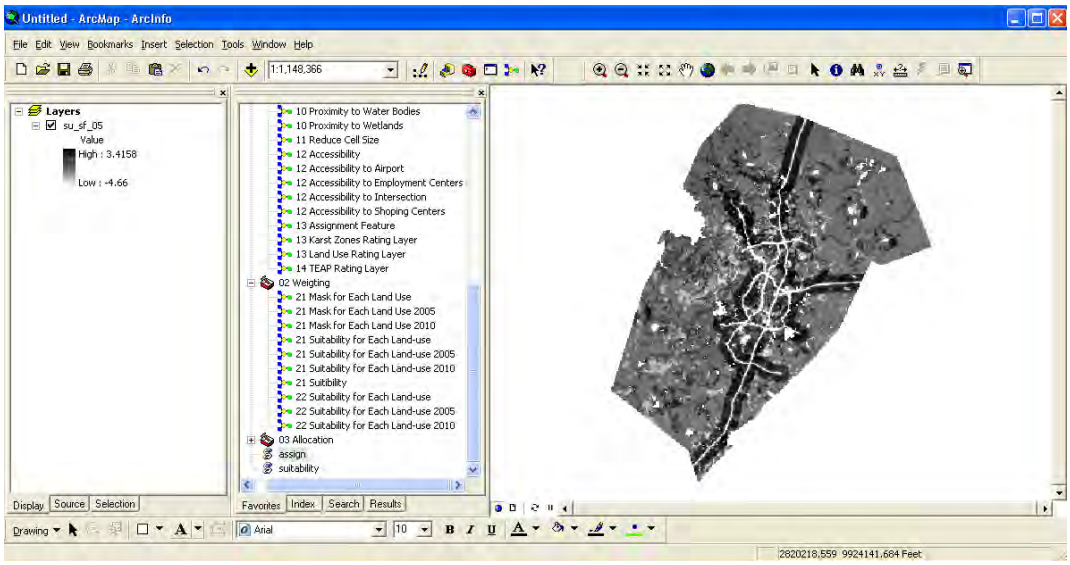

Figure E3: Result Suitability 2005

Suitability for 2010

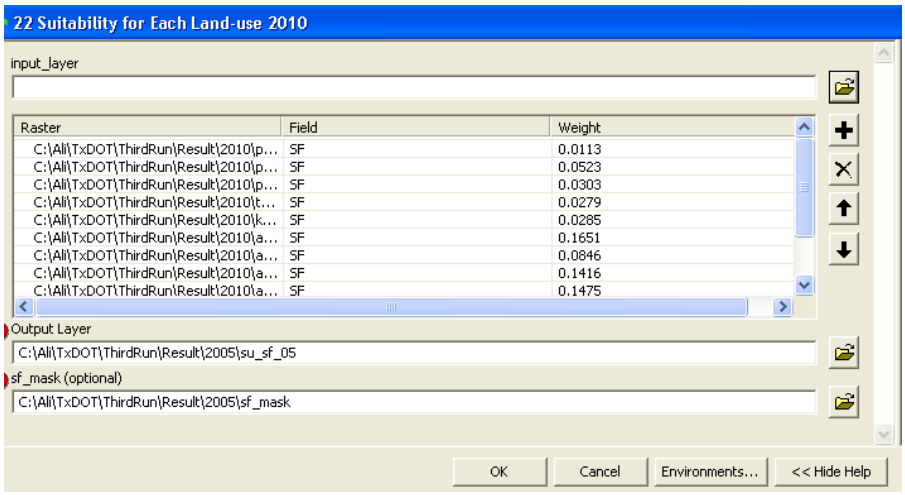

Figure E4: Result Suitability 2010

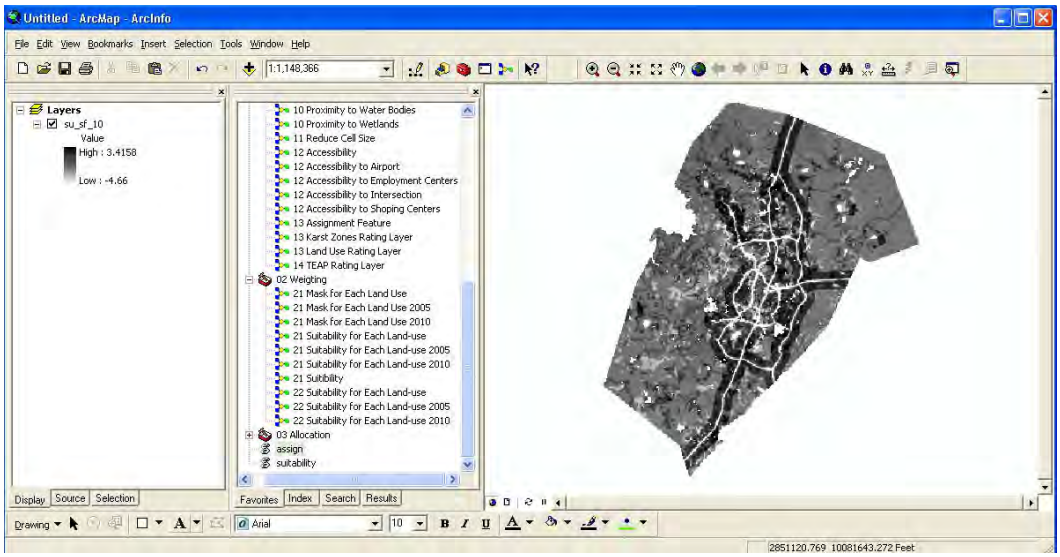

Figure E5: Result Suitability Single Family 2010