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Landsat Satellite Multi-Spectral Classification of Land Cover Change for GIS-Based Urbanization Analysis in Irrigation Districts: Evaluation in the Lower Rio Grande Valley

By:
Yanbo Huang, Extension Associate and Guy Fipps, Professor and Extension Agricultural Engineer, Department of Biological and Agricultural Engineering, Texas A&M University, College Station, TX.

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LANDSAT SATELLITE MULTI-SPECTRAL CLASSIFICATION OF LAND COVER CHANGE FOR GIS-BASED URBANIZATION ANALYSIS IN IRRIGATION DISTRICTS: EVALUATION IN THE LOWER RIO GRANDE VALLEY

Rio Grande Basin Initiative
Irrigation Technology Center
Texas Water Resources Institute
Texas AgriLife Extension Service

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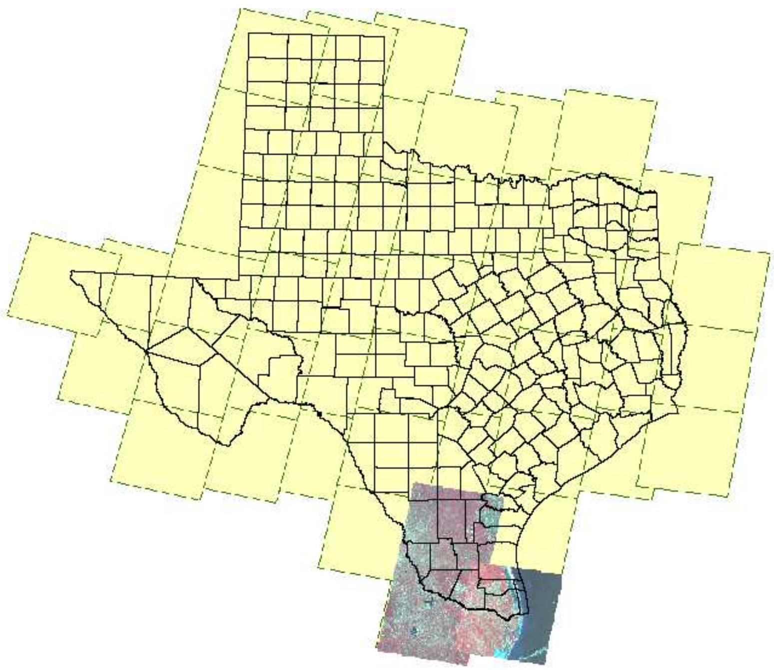

by

Yanbo Huang and Guy Fipps, P.E.[2]

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[2] Extension Associate, and Professor and Extension Agricultural Engineer, respectively, Biological and Agricultural Engineering, 2117 Texas A&M University, College Station, TX 77843-2117

Landsat Satellite Multi-Spectral Image Classification of Land Cover Change for GIS-Based Urbanization Analysis in Irrigation Districts: Evaluation in Low Rio Grande Valley

Summary and Conclusion

This report summarizes our evaluation of the potential of Landsat satellite multi-spectral land cover imagery for GIS-based urbanization analysis in irrigation districts. Three image scenes of ETM+ (2003) and TM (1993) multi-spectral image data were purchased from USGS through TexasView Remote Sensing Consortium. The three scenes cover the Hidalgo, Cameron, and Willacy Counties in the Lower Rio Grande Valley. The images were classified in terms of land cover categories, and the classified data were overlaid on GIS layout to visualize urbanization in irrigation districts.

The images covering the three counties were classified. Based on the classification, the land cover changes in the three counties were estimated. The urbanization in the five most urbanized irrigation districts was derived. On average, over the ten years, in the three counties of the Lower Rio Grande Valley, the urbanization increased drastically at 46% while the irrigation land decreased moderately at 7.6%. Specifically in Hidalgo County the urbanization increased 59.7% and irrigated land decreased 10.2%, in Cameron County the urbanization increased 52.8% and irrigated land decreased 6.7%, and in Willacy County the urbanization increased 25.7% and the irrigated land decreased 5.9%. Therefore, in overall, with the increase of urbanization the irrigated land decreases in the valley (figure 1).

This report provides an analysis of land cover changes in Hidalgo County, Cameron County, and Willacy County between 1993 (non-drought period) and 2003 (drought period). Based on the land cover analysis, GIS visualizations of urbanization in the heavily urbanized United, Edinburg, McAllen 3, San Juan, and Harlingen Irrigation Districts are generated.

Our conclusion and recommendations are as the following:

1. Landsat satellite multi-spectral remote sensing land cover imaging is a promising technique for urbanization analysis in irrigation districts;
2. GIS has a great potential to help generate more detailed analysis on the basis of Landsat image processing;
3. Further development is needed to establish a method to verify the image classification; and
4. The districts should consider the results of the urbanization analysis based on the Landsat image processing and GIS visualizations in project planning.

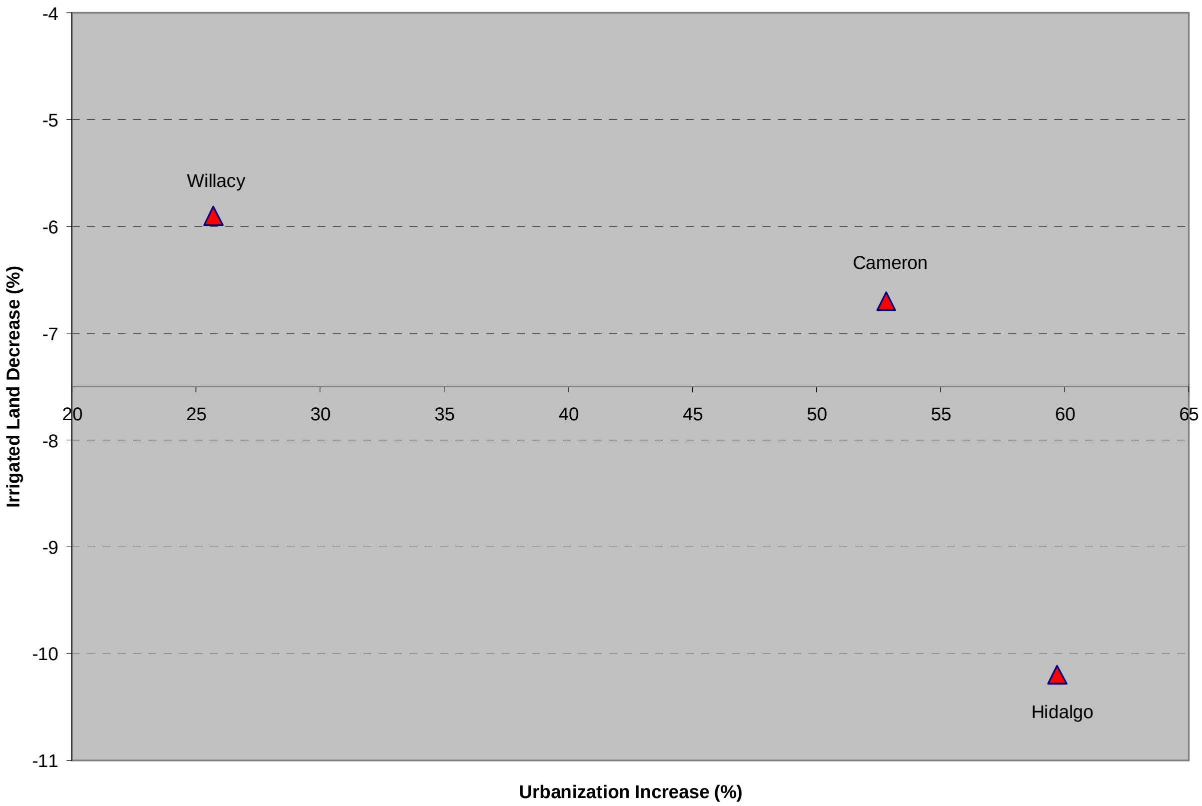

Figure 1. Irrigated land decreased with the increase of urbanization in the valley

Materials and Methods

<u>Landsat Satellite Imagery</u>

Landsat satellites have been collecting images of the Earth's surface for more than thirty years. NASA launched the first Landsat satellite in 1972, and the most recent one, Landsat 7, in 1999. Currently, only the Landsat 5 and 7 are still able to be operated. Landsat 7 carries the Enhanced Thematic Mapper Plus (ETM+) sensor with 30m visible and IR bands, a 60m spatial resolution thermal band, and a 15m panchromatic band. The Thematic Mapper (TM) sensors onboard Landsats 4 and 5 included 30m visible and IR bands, several additional bands in the shortwave infrared (SWIR), and an spatial resolution of 120m for the thermal-IR band.

On May 31, 2003, unusual artifacts began to appear in the image data collected by the ETM+ instrument onboard Landsat 7. The problem was caused by failure of the Scan Line Corrector (SLC), which compensates for the forward motion of the satellite. This caused a problem in using ETM+ image data after May 31, 2003. Therefore, the ETM+ image data in early 2003 has been collected to represent the land cover in the 2000s. Correspondingly, the TM image data in 1993 has been collected to represent the land cover in the 1990s.

<u>Data description</u>

Our project goal is to study the urbanization over the Lower Rio Grande Valley by estimating land cover change in the last ten years. During the last ten years, the Lower Rio Grande Valley has experienced a transition from non-drought (1990s) to drought (2000s) periods. Landsat satellite imagery was used as the data source for the estimation.

Figure 2 shows the Landsat satellite footprints over Texas. To cover the Lower Rio Grande Valley, three image scenes are needed. The scene of path 26, row 42 covers the Cameron, Willacy, and eastern Hidalgo Counties. The scene of path 27, row 41 covers north Hidalgo County. The scene of path 27, row 42 covers south Hidalgo County, the most urbanized area in the valley.

The Landsat ETM+ and TM multi-spectral image data were purchased from USGS through the TexasView Remote Sensing Consortium, an AmericaView member consortium representing Texas. Figure 3 shows the ETM+ images in 2003. The TM images in 1993 have the same coverage.

The ETM+ and TM image data purchased through TexasView are terrain corrected (similar to orthorectification). They can be directly used for classification and are reliable for GIS analysis.

<u>Methods</u>

With the image data, the work was conducted as follows:

1. Convert the image data in visible and IR bands from the original NLAP format to the IMG format compatible to ERDAS Imagine (Leica Geosystems Geospatial Imaging, Atlanta, Georgia), a software package for remote sensing image processing;
2. Clip the image pieces covering the Hidalgo, Cameron, and Willacy Counties from the original images using ERDAS AOI Tool with GIS shapefile;
3. Perform ISODATA unsupervised classification on all the clipped image pieces with 50 clusters (more clusters translates to more accuracy but also causes more computing time and post-processing work);
4. Categorize the clusters into five land cover classes: water, barren land, irrigated land, vegetated land, and urban. These classes were adapted from the USGS' Anderson classification system (Anderson et al., 1976);
5. Convert the classified image pieces into GRID format;
6. Reclassify the classified image piece grids with Spatial Analyst in ArcGIS;
7. Merge the reclassified image pieces to produce complete maps for the three counties;
8. Perform GIS analysis in the scale of the county, irrigation districts, and even smaller areas.

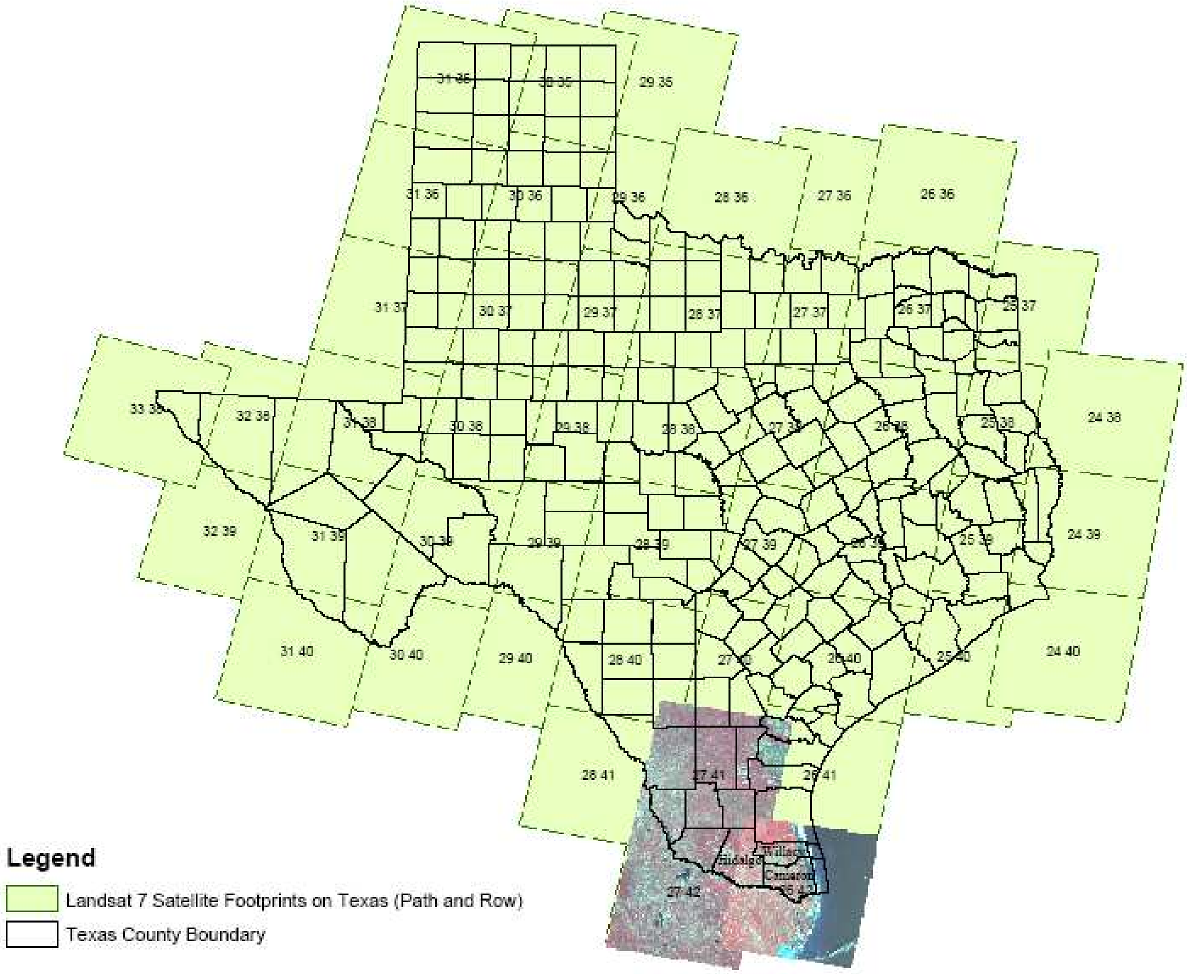

Figure 2. Landsat 7 footprints over Texas

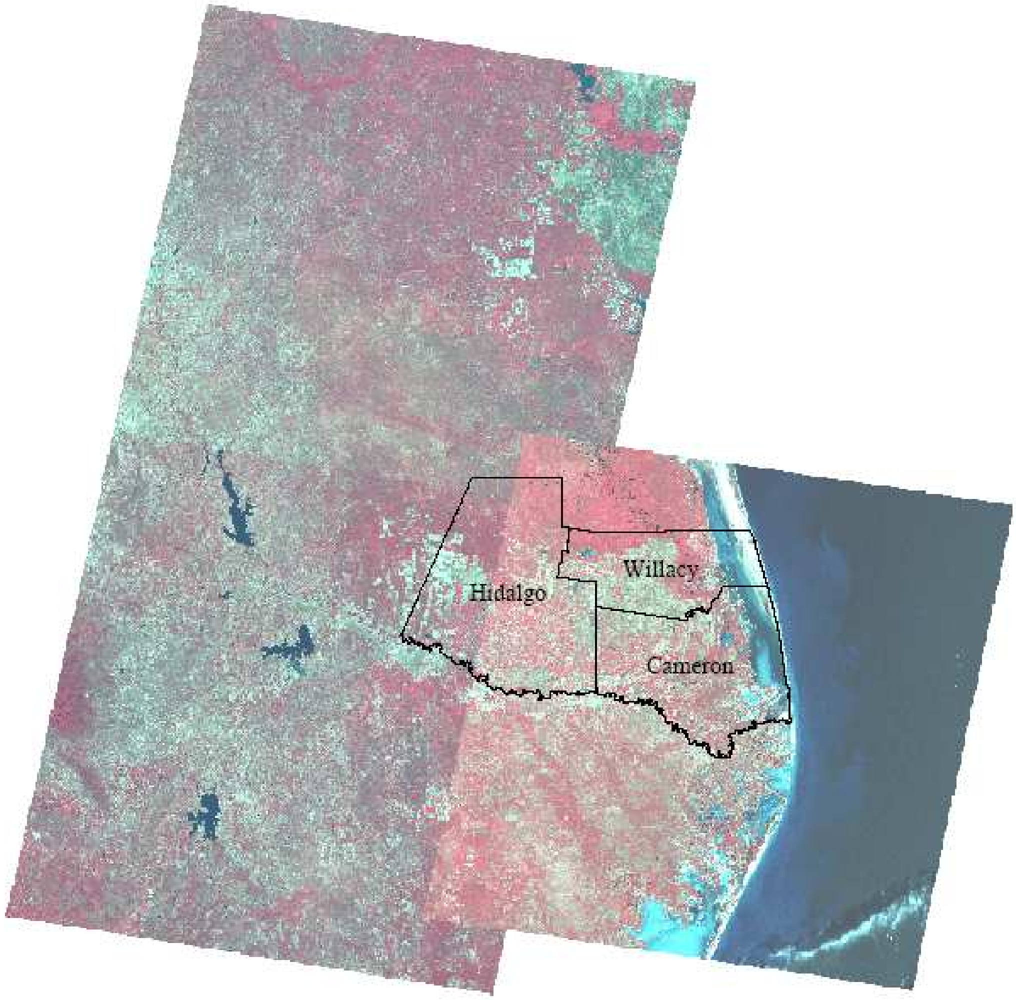

Figure 3. Three ETM+ 2003 image scenes covering the Hidalgo, Cameron, and Willacy Counties in the Lower Rio Grande Valley

Results

Tables 1, 2, and 3 estimate the land cover changes in a ten- year interval from 1993 to 2003 in the Hidalgo, Cameron, and Willacy Counties, respectively. Based on the estimation, over the ten years, Hidalgo County had a significant urbanization increase of 59.7%, but the county still had a moderate decrease of irrigated land at 10.2%. Similarly, Cameron County had a significant urbanization increase of 52.8% but a moderate decrease of irrigated land at 6.7% in ten years. Willacy County also had an increase of urbanization at 25.7% while the irrigated land decreased 5.9%. Therefore, the three counties, on the average, had a drastic urbanization increase of 46% and a moderate irrigated land decrease of 7.6%,

Table 1. Land Cover Change Estimation in Hidalgo County

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	71.62	57.34	-19.89
Barren Land	1149.23	1254.27	9.14
Irrigated Land	2155.08	1934.24	-10.25
Vegetated Land	550.94	571.93	3.8
Urban	182.75	291.83	59.69

- decrease

Table 2. Land Cover Change Estimation in Cameron County

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	547.06	562.68	2.85
Barren Land	894.92	881.09	-1.55
Irrigated Land	1118.27	1043.11	-6.72
Vegetated Land	337.55	343.20	1.67
Urban	130.00	198.63	52.80

- decrease

Table 3. Land Cover Change Estimation in Willacy County

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	208.18	309.86	48.84
Barren Land	901.24	767.28	-14.86
Irrigated Land	432.28	406.53	-5.96
Vegetated Land	352.77	407.38	15.48
Urban	13.64	17.15	25.68

- decrease

Figures 4, 5, and 6 show the derived urbanization GIS maps of Hidalgo, Cameron, and Willacy Counties, respectively. In order to reveal the impact of urbanization to the irrigation districts, the analysis needs to be scaled down.

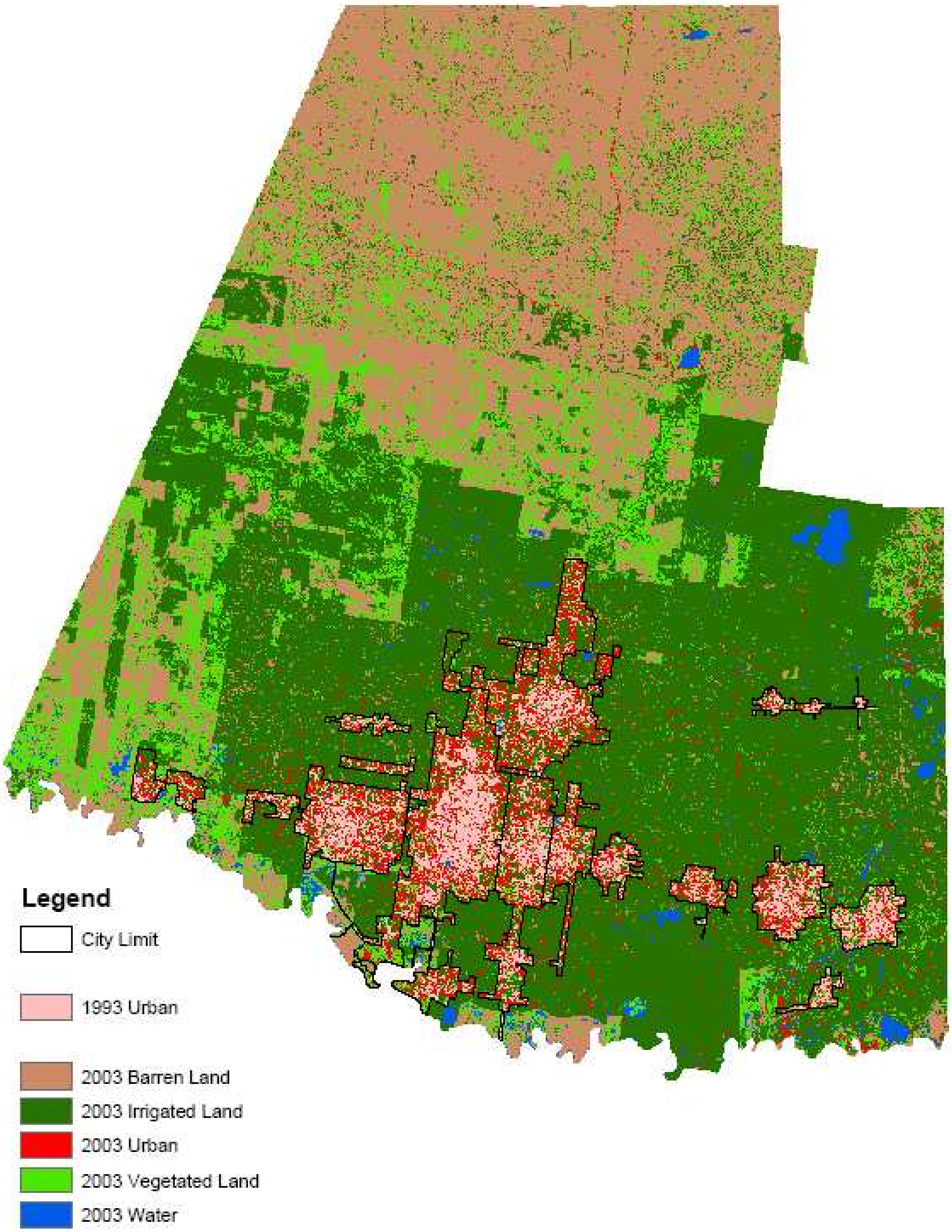

Figure 4. GIS map of land cover and urbanization in Hidalgo County

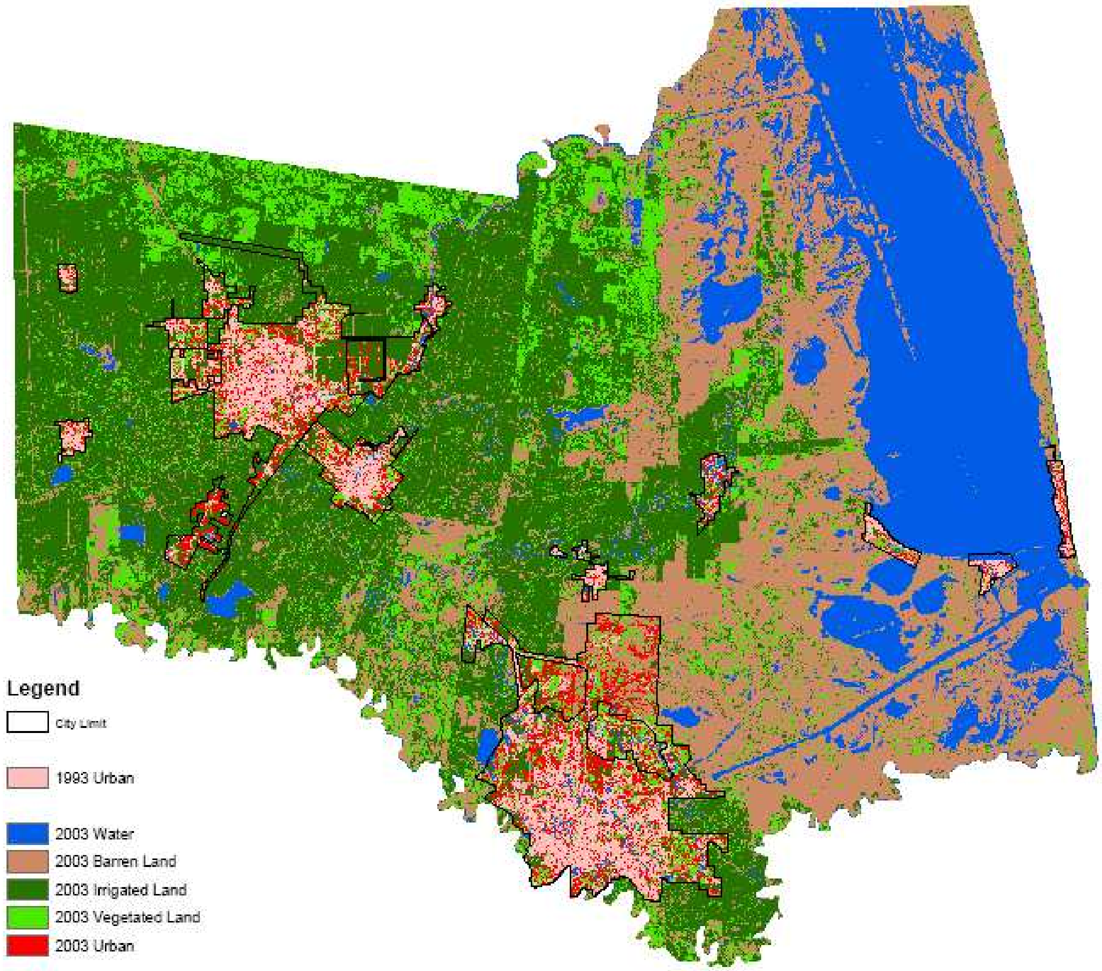

Figure 5. GIS map of land cover and urbanization in Cameron County

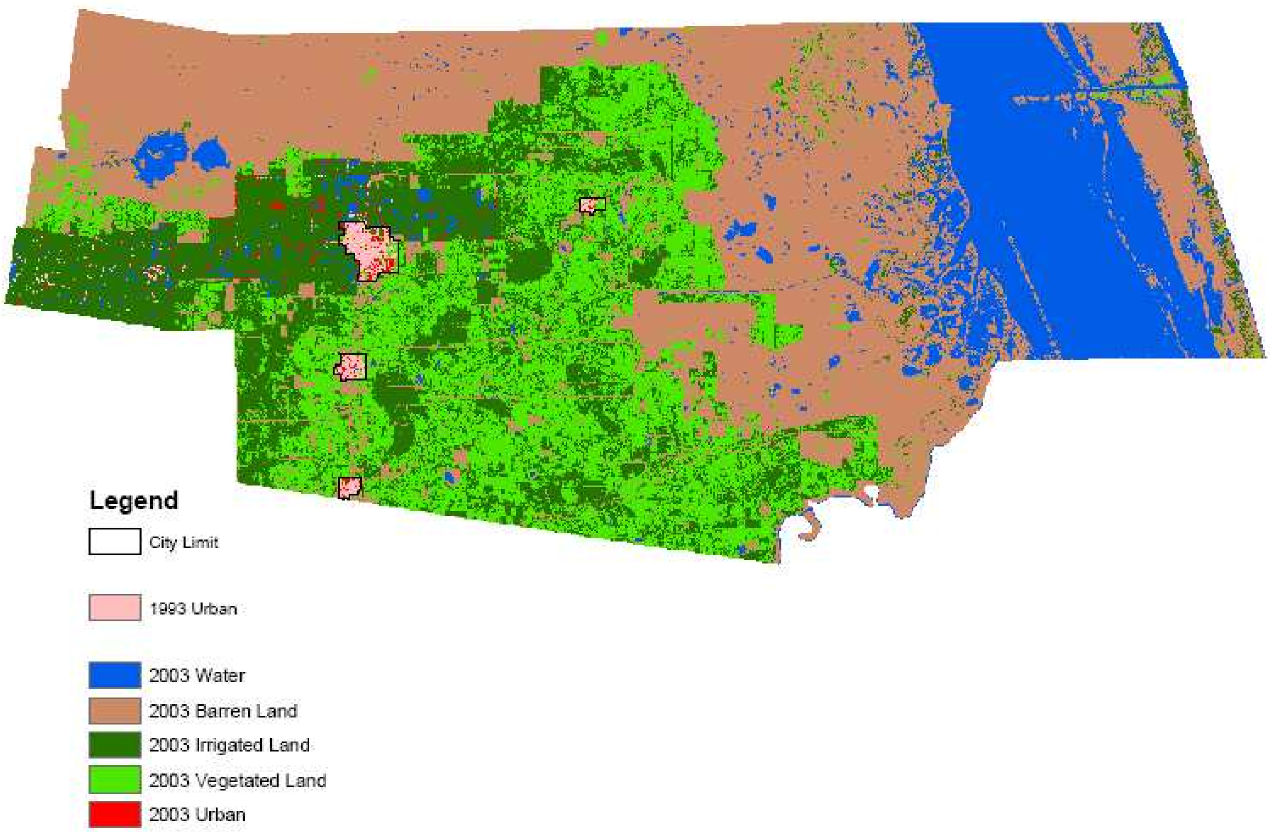

Figure 6. GIS map of land cover and urbanization in Willacy County

Tables 4, 5, 6, 7, and 8 are the estimations of land cover changes in the United, Edinburg, McAllen 3, San Juan, and Harlingen Irrigation Districts over the ten years. These districts are the most urbanized in the valley. The estimation indicates that in these districts the irrigated lands consistently decreased with the increase of urbanization. Figure 7 plots the relationship between the rate of irrigated land decrease and the rate of urbanization increase in these districts.

Table 4. Land Cover Change Estimation in United Irrigation District

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	0.77	0.84	9.23
Barren Land	2.24	3.59	60.43
Irrigated Land	123.47	107.31	-13.10
Vegetated Land	3.98	5.96	49.75
Urban	23.33	36.08	54.65

- decrease

Table 5. Land Cover Change Estimation in Edinburg Irrigation District

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	1.01	1.11	10.38
Barren Land	2.56	2.22	-4.68
Irrigated Land	116.78	92.83	-20.52
Vegetated Land	5.97	8.05	34.74
Urban	31.16	53.05	70.26

- decrease

Table 6. Land Cover Change Estimation in McAllen 3 Irrigation District

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	0.14	0.14	-1.96
Barren Land	0.71	0.43	-38.85
Irrigated Land	19.47	15.34	-21.20
Vegetated Land	0.98	1.59	62.56
Urban	16.34	20.13	23.20

- decrease

Table 7. Land Cover Change Estimation in San Juan Irrigation District

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	2.17	2.22	2.28
Barren Land	5.28	3.65	-30.88
Irrigated Land	232.79	200.47	-13.89
Vegetated Land	8.21	12.46	51.84
Urban	46.76	76.40	63.39

- decrease

Table 8. Land Cover Change Estimation in Harlingen Irrigation District

Land Cover Category	1993 Area (km^2)	2003 Area (km^2)	Net Change (%)
Water	1.77	2.30	30.05
Barren Land	14.47	15.88	9.71
Irrigated Land	156.45	138.42	-11.52
Vegetated Land	23.38	21.04	-10.01
Urban	33.95	52.38	54.28

- decrease

Figures 8, 9, 10, 11, and 12 show the derived urbanization over the ten year overlay on irrigation networks in the five above-mentioned irrigation districts. With the maps, more detailed study should be able to discover the conflicts between urbanization and irrigation network development.

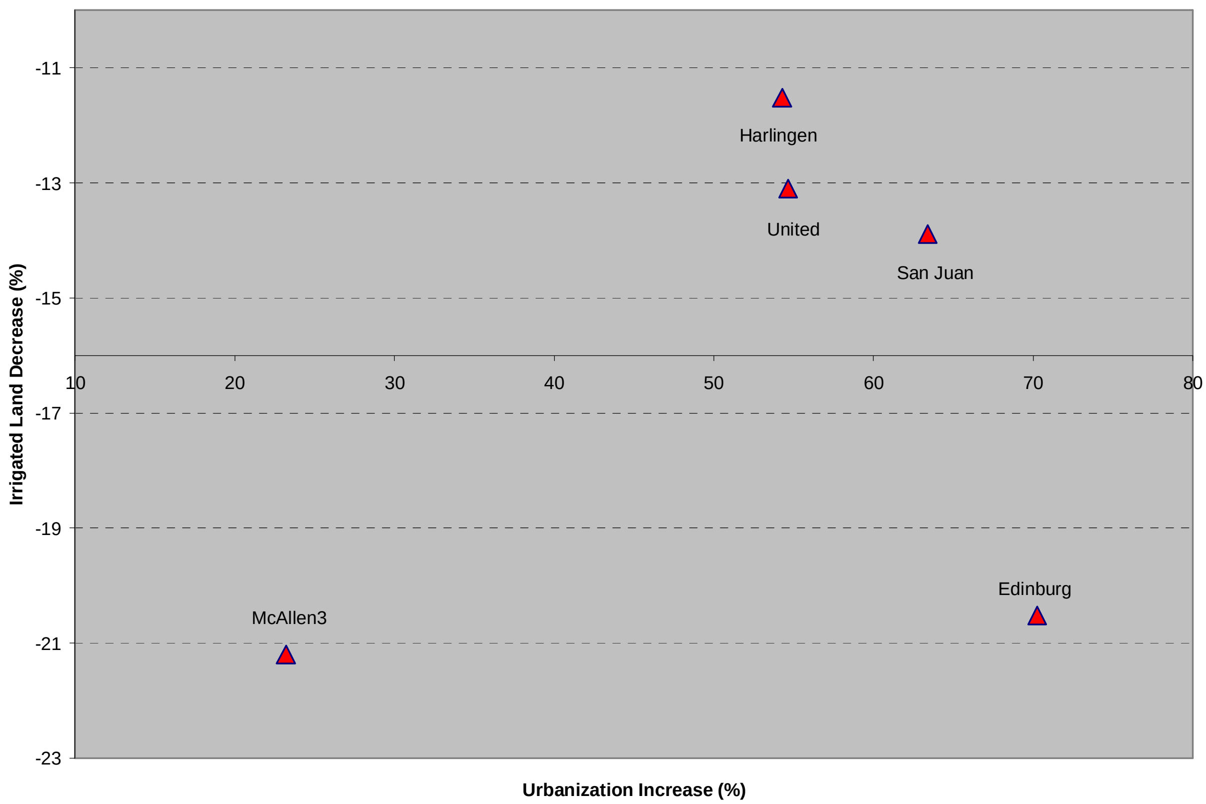

Figure 7. Irrigated land decreased with the increase of urbanization in the districts

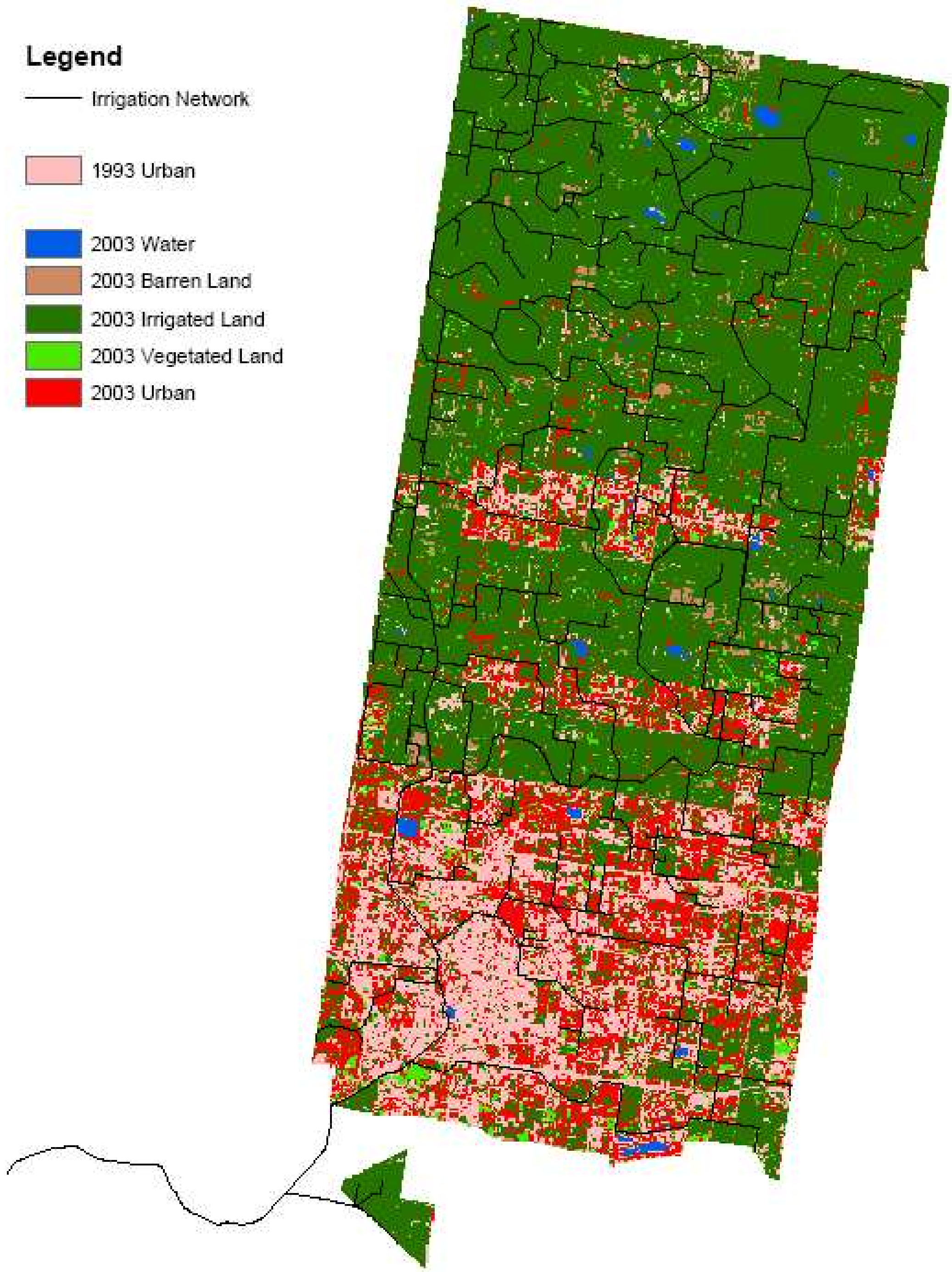

Figure 8. GIS map of land cover and urbanization in the United Irrigation District

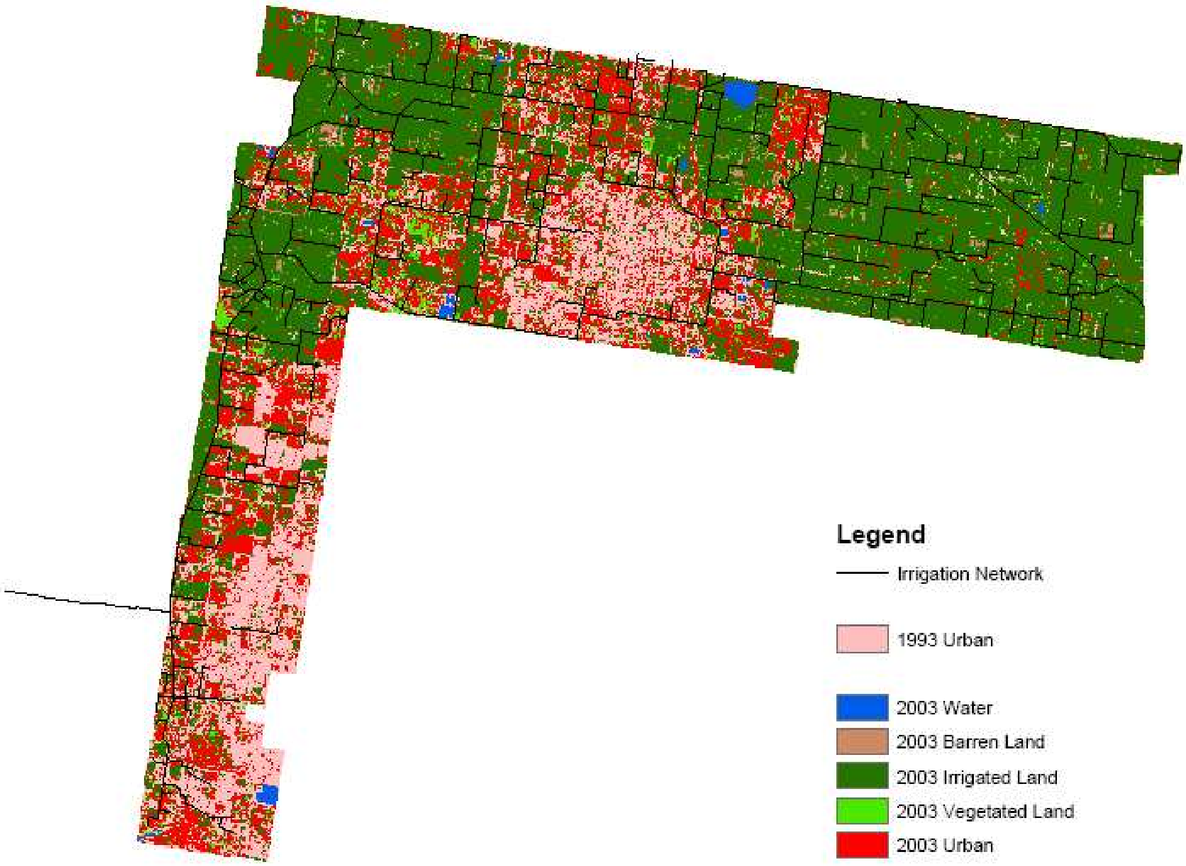

Figure 9. GIS map of land cover and urbanization in the Edinburg Irrigation District

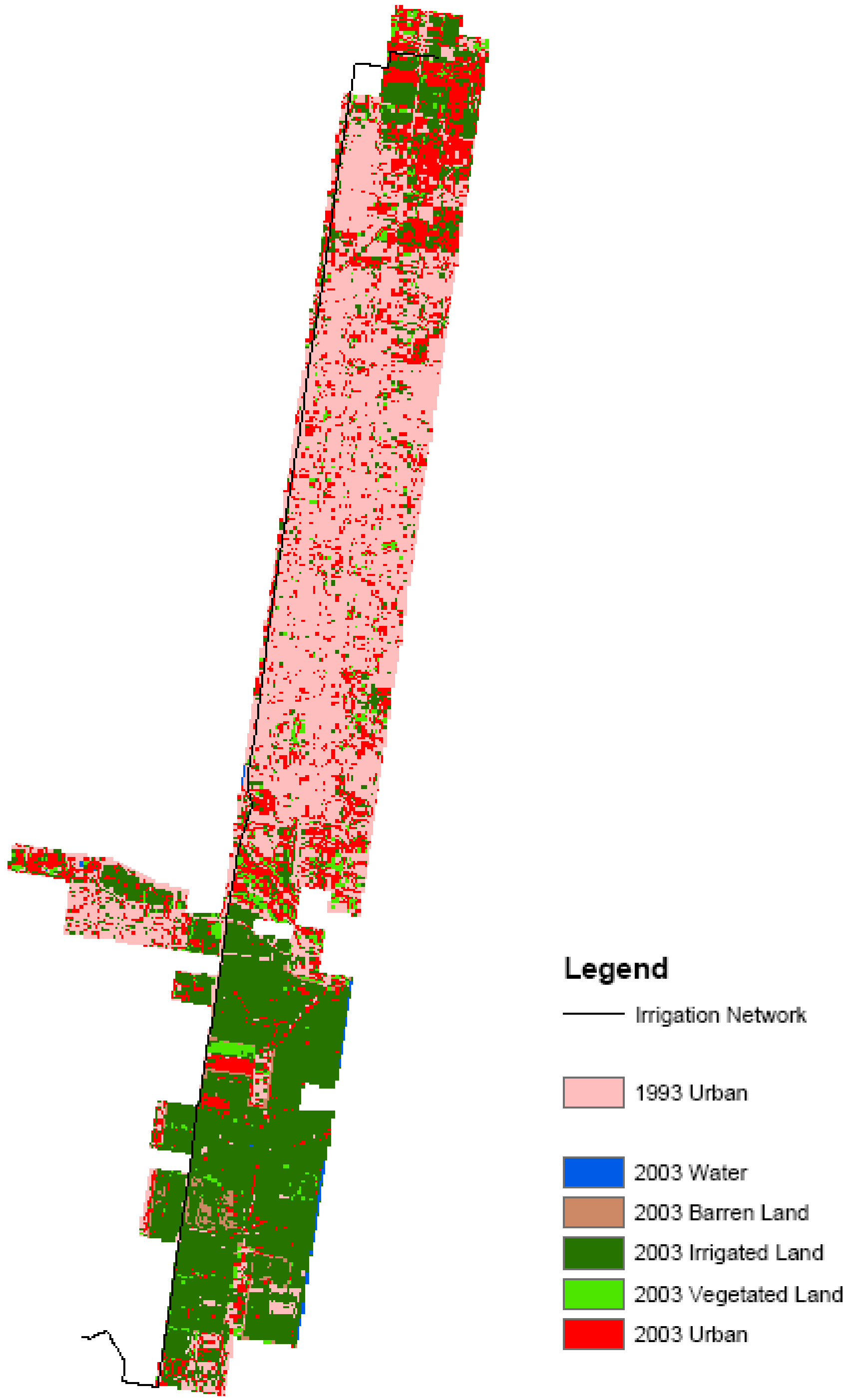

Figure 10. GIS map of land cover and urbanization in the McAllen 3 Irrigation District

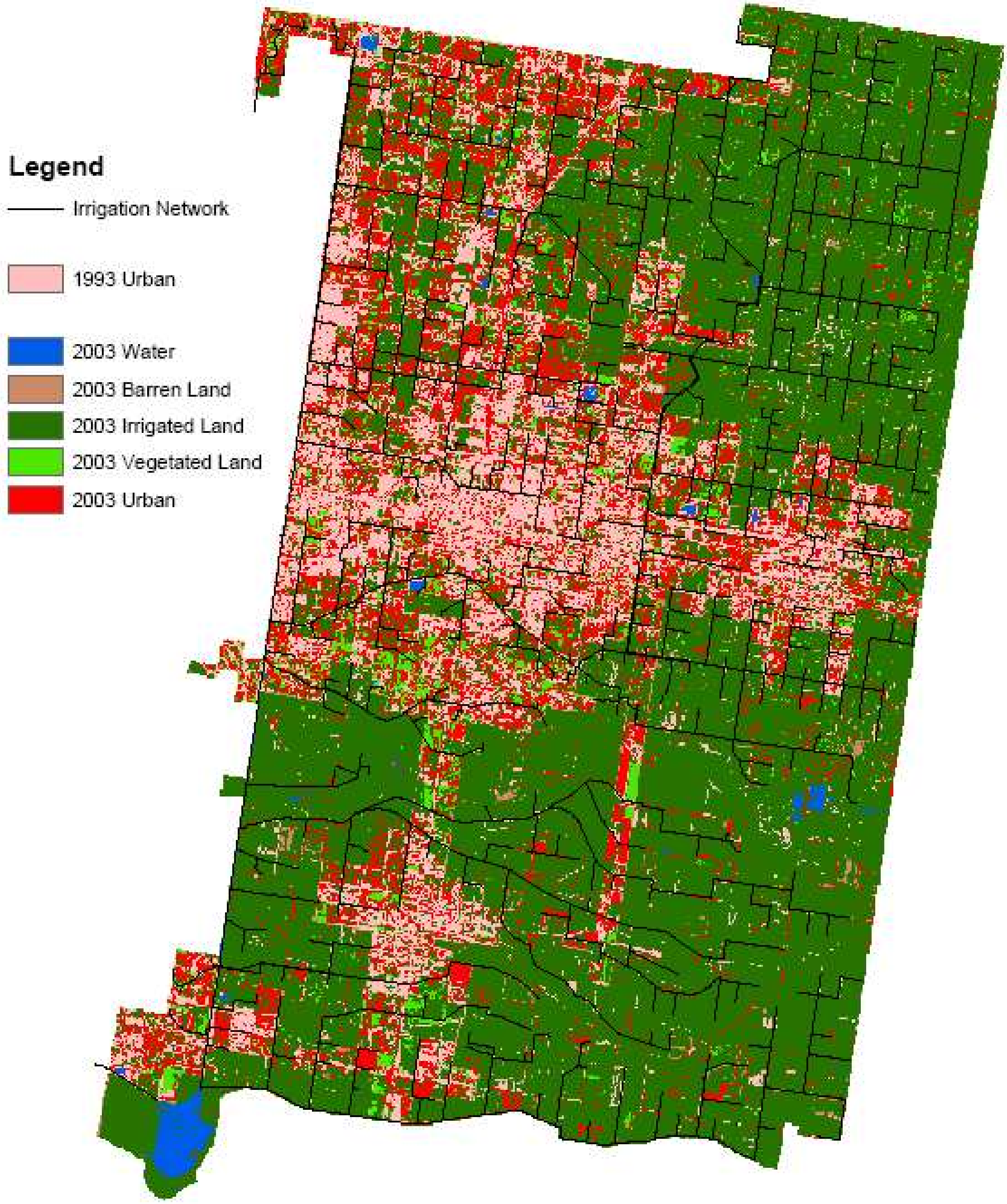

Figure 11. GIS map of land cover and urbanization in the San Juan Irrigation District

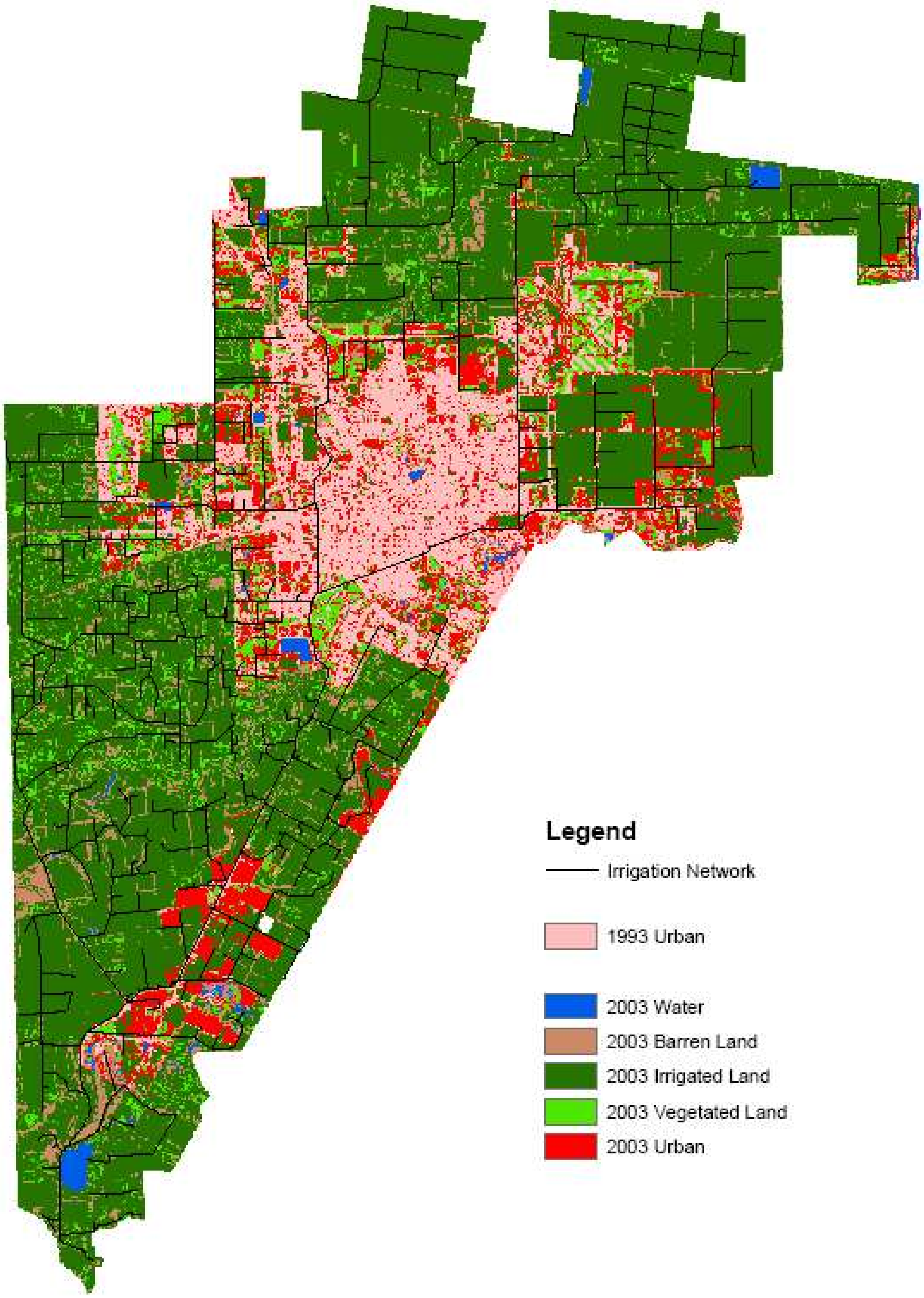

Figure 12. GIS map of land cover and urbanization in the Harlingen Irrigation District

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