Applications of Remote Sensing Technology for Irrigation System Analysis

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Airborne Multi-Spectral Remote Sensing for Canal Leak detection

Water leaks from canal channels need to be monitored in such a large area of irrigated lands in the Valley. A rapid and effective method is necessary to detect water leaks over the irrigation distribution networks.

Data Acquisition

An airborne multi-spectral (Red, Near InfraRed, and Thermal) imager was operated over 24 canal sections (14 lined and 10 unlined) of 11 districts.

Image Processing

1. Imagery preview

The imager flyover generated over 400 image triplets (Red, NIR, and Thermal). By previewing the imagery, about ¼ of them were left for point leak and seepage study.

2. Image Processing

- Image registration to line up the three images for the same scene in the pixel scale
- Image stack to pack the three registered images in layers
- Image geo-reference to refer the composite imagery to the ground control points

Image processing is a routine and laborious process. Batch procedures were developed to automate the process.

3. Image analysis

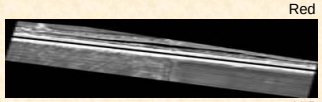
- Geo-referenced imagery can be overlaid on GIS map to help analysis by overall or band by band
- NDVI (Normalized Difference Vegetation Index) can be used to detect the degree of vegetation on the surface

Field Reconnaissance

Fourteen canal sections (9 lined and 5 unlined) of 9 districts were visited. The majors foundings are:

1. Three major leaks in concrete sections matches with image analysis

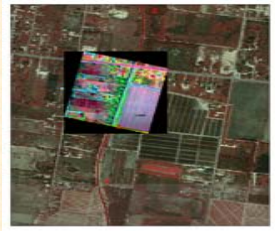

Red


NIR


Thermal

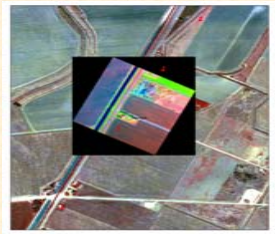
The GIS map on the left above shows an airborne composite image on a spot of a canal section in Delta Lake. On the right above the images in red and NIR bands indicate that along the levees of the section present strong vegetation and the general condition of the canal section looks fairly good. However, the circled area in the thermal image presents a much cooler signature than adjacent area. The following two pictures were taken during filed inspection in the circled area of the thermal image. A big piece of concrete is missing in the spot. This is a significant point of leak, which matches with the observation in the thermal image. Other than this leak point, the canal section looks in fairly good condition in general. The grass on the levees presents the potential seepage from canal and/or ditch side.

2. Other than the major leaks, a number of other defects along the concrete channels, mostly cracks or lining layer off , were determined as potentials of leak sources.



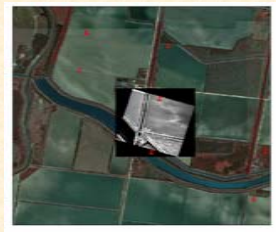
The GIS map on the left above shows an airborne composite image on a spot of a canal section in United. On the above the picture shows a n open lining layer, which is a potential leak source.

3. Wet areas in earth sections are more difficult to determine because image analysis is easily misled by the mixed signatures of vegetation and moistened spots with less vegetation although a lot of spots, such as strong vegetation, holes, lateral turnout, pump and stand pipes, were identified as potential leak sources.



The GIS map on the left above is an airborne composite image on a spot of an earth canal section in Harlingen. This section is the Harlingen main that is a wide earth canal shown as the picture on the lower right above. The spot was determined as a potential leak source located at a pump station with a stand pipe. However, along the channel the grass is uniformly distributed, which is hard to determine as a result of leak or seepage.

4. Visual field inspection is limited. An objective field inspection method, such as EC (electric conductivity), may be needed in addition to visual inspection.



The GIS map on the left above shows an airborne NIR image on a spot of a canal section in San Benito. The picture on the top right indicates a hole on the side of the canal and the picture on the bottom right presents some water on the drainage side. Are they the leak sources? Merely with visual inspection it is hard to determine.

Conclusion

This application provides an effective method to rapidly detect water leaks over the irrigation distribution networks in the large scale. The next task should be integrating it with an effective field inspection method in addition to visual inspection.

Satellite Remote Sensing for Urbanization Analysis

Urbanization rapidly increases in the Lower Rio Grande Valley as the population grows. Urbanization should have a strong impact on the management and development of irrigation districts. An effective analysis method is necessary to characterize the impact.

Landsat satellite 7 ETM+ and 5 TM imagery of NASA have been processed and classified by developing remote sensing and GIS technologies to quantify the land cover change over the ten-year period in the valley.

With the classification of the imagery, the land cover changes over ten years (between 1993 and 2003) are estimated and the urbanization is quantified over the Lower Rio Grande Valley.

Land Cover Change Estimation of Hidalgo County between 1993 and 2003

Land Cover Category	1993 Area (km²)	2003 Area (km²)	Net Change (%)
Water	59	39	-33
Woodland	2000	1928	-4
Irrigated Land	959	1023	7
Grassland	831	682	-18
Urban	260	438	68

Land Cover Change Estimation of Cameron County between 1993 and 2003

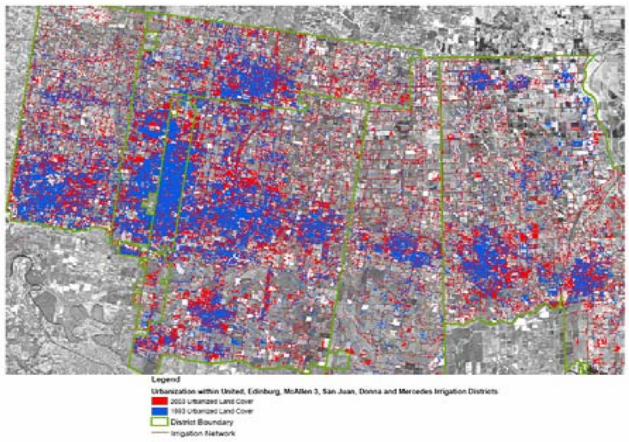
Land Cover Category	1993 Area (km²)	2003 Area (km²)	Net Change (%)
Water	693	579	-16
Woodland	801	800	-0
Irrigated Land	937	1029	10
Grassland	492	470	-5
Urban	105	150	43

Land Cover Change Estimation of Willacy County between 1993 and 2003

Land Cover Category	1993 Area (km²)	2003 Area (km²)	Net Change (%)
Water	363	230	-37
Woodland	653	715	9
Irrigated Land	360	322	-11
Grassland	524	632	21
Urban	8	10	19

The results show that Hidalgo county has the highest urbanization over the ten years (68%) with a moderate increase of irrigated land (7%). Cameron County also has a strong urbanization over the ten years (43%) and a moderate irrigated land increase (10%). Even in Willacy county the urbanization increased 19% but the irrigated land may decrease (11%).

The map below scales down to show the urbanization within the irrigation districts, United, Edinburg, McAllen 3, San Juan, Donna and Mercedes in Hidalgo county. In this area, the urbanization was estimated as an increase of 62% with an increase of irrigated land of 20%.



This application establishes a method to characterize the impact of urbanization on irrigation districts through scalable land cover change analysis. It has a great potential in providing information for districts' management and development and higher level decision making.