Image courtesy of William Cho

L3HARRIS™
FAST. FORWARD.

TAIWAN USES ENVI DEEP LEARNING TO CALCULATE ARABLE LANDS LOST TO DEVELOPMENT

The island of Taiwan grows a remarkable volume and variety of agricultural products each year. Although rice is a well-known staple food for the island’s 24 million people, Taiwan also produces more than 30 types of tropical fruits that are consumed locally and exported throughout Asia.

But Taiwan faces a crisis familiar to many rapidly developing locales – too much arable land is being lost every year to the construction of new homes, parking lots, and commercial buildings. The loss of agricultural lands is considered a major threat because once fertile ground is converted to steel and concrete, it is lost to crop production for the foreseeable future.

“Conserving arable land is an important aspect of ensuring food security in Taiwan,” said Professor Chi-Kuei Wang, a remote sensing scientist in the Geomatics Department at the National Cheng Kung University (NCKU) in Tainan, Taiwan.

The Taiwanese government understands the delicate balance that must be struck between industrial development and farmland conservation. Today, roughly one quarter of the island’s 35,800 square kilometers of land is used for growing crops. Many hectares, of course, will never be arable, such as the high mountains and sprawling metropolitan areas, including the capital city of Taipei.

Several government agencies have attempted to determine how much arable land remains undeveloped on the island and, equally as important, how much fertile ground has already been lost to construction of homes and buildings. Government offices have used several techniques to make these calculations, but the results are considered to be inaccurate.

> **“Conserving arable land is an important aspect of ensuring food security in Taiwan,” said Professor Chi-Kuei Wang.**

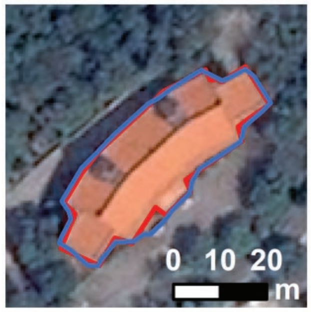
Determined to complete an authoritative assessment of arable land area, the Taiwan Agriculture Research Institute (TARI), which was established in 1895 and currently resides under the Council of Agriculture, has turned to advanced remote sensing and Artificial Intelligence (AI) technologies.

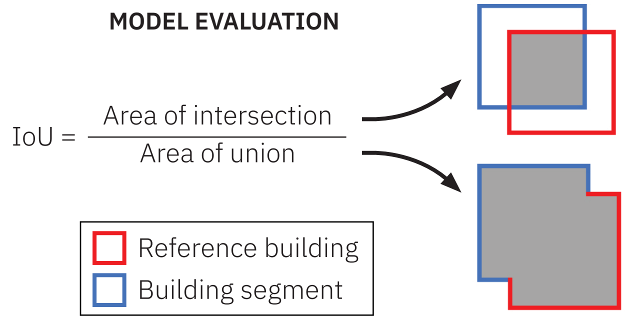
TARI contacted Prof. Wang at NCKU to bring his remote sensing expertise to bear on the project. Although much of his previous research utilizes LiDAR data, the TARI project would use very high-resolution satellite imagery from the Airbus Pleiades constellation, processed and analyzed with ENVI® software and the ENVI Deep Learning module. In classroom instruction and research, Wang relies heavily on these software packages.

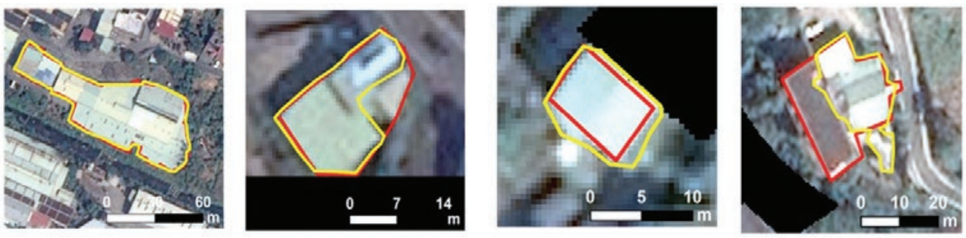
FINDING BUILDINGS

TARI obtained 76 images acquired by the Pleiades satellites covering most of the island. These data sets included 50-centimeter panchromatic and 2-meter multispectral (red, green, blue, near infrared) data. The first step in processing the data in ENVI was to merge the pan and multispectral bands to create pansharpened imagery with both high spatial resolution and spectral content. After completing this simple process in ENVI, Wang’s team masked out urban areas and regions with extreme terrain deemed non-arable.

With the image data ready for analysis, the researchers turned to the ENVI® Deep Learning module to find building structures in agricultural areas. To do this, 500 training patches – each 2500x2500 pixels – were randomly chosen. Wang brought a dozen graduate and undergraduate students into the project to manually delineate houses, buildings, and other structures they found.







IoU:0.96 IoU:0.77 IoU:0.68 IoU:0.48

The red polygons are building boundaries digitized by humans. The yellow polygons are those extracted by AI (with post-processing in ArcGIS). Higher IoU (Intersection-over-Union) value means the AI result has better resemblance with human result. The above figures show typical results in this study.

The process that Professor Wang and his students used for digitizing building boundaries with AI was the following.

1. For AI results with high IoUs (such as 0.96), they simply accepted the AI result.
2. For other AI results with lower IoUs (such as 0.77, 0.68, and 0.48), they used the AI result as a visual cue to help manually find the building and then to digitize its boundary.

The ENVI Deep Learning module then used the training patches to learn how to recognize building structures in the rest of the images. It is important to note that the deep learning algorithms analyze the geometry, dimensions, and spectral signatures of the delineated features to learn that they are building structures. The algorithms look for these same spatial and spectral characteristics in other features throughout the images to find buildings.

The project was a success. Wang and his team identified more than 168,000 structures in the eastern part of Taiwan and calculated the surface area they occupy. The western part of Taiwan will be finished at a later time. This area was subtracted from the overall agriculture land area. The researchers converted the structure features to vectors for inclusion and further examination.

REFINING THE PROCESS

Throughout the project, Wang tested the results of the deep learning analysis and noted two important trends. First, there were inconsistencies in the ways the students delineated buildings in the training sites, which introduced some variations in the identification of features by the software. If this project were to be repeated, Wang would reduce the number of people helping to prepare the training data to as small a number as possible to decrease the variability in interpretation.

Second, Wang compared the deep learning algorithms' ability to identify building features against those of the human assistants. As expected, the human eye was better at finding the structures and delineating their edges more sharply, but the manual method was significantly more time consuming. Wang concluded the slightly lower deep learning accuracy was well worth the tradeoff in time. If the project had been performed entirely with manual observations, it would have taken 3,400 hours to complete.

Prof. Wang will send the results to TARI along with explicit instructions on how to repeat the study in the future with the ENVI Deep Learning module. By obtaining new satellite imagery periodically in the future, TARI will have the ability to calculate the rate of arable land loss over time. This information will be used by TARI to advise other Taiwan government agencies in creating policies that minimize destruction of agricultural lands.

L3HARRIS™
FAST FORWARD

385 Interlocken Crescent, Ste 300
Broomfield, CO 80021
t 303 786 9900
GeospatialInfo@L3Harris.com