SAFETY FROM THE SKY

CHIARA SOLIMINI AND ANA ISABEL MARTÍNEZ EXPLAIN HOW MULTITEMPORAL ANALYSIS OF EARTH OBSERVATION IMAGING HELPED TO IDENTIFY POTENTIALLY DANGEROUS CHANGES IN LAND-USE IN HYDERABAD

With the world's second largest population and its enormous urban growth, India is facing a great number of challenges, such as overcrowding, environmental pollution and depletion of resources. The engineering, architecture and urban planning sectors are growing in importance to foster sustainable development and, as a result, mapping technologies are also playing a crucial role.

Geospatial information is a valuable source of data to develop rigorous and cost-effective topographic mapping and 3D modelling of buildings and cities, for urban development applications. Better mapping results in better urban management by helping to detect infractions, improving accountability and streamlining planning processes. Digital elevation models (DEMs) and 3D models are important tools for hydrological modelling, topographic mapping and terrain stability assessment, allowing the monitoring of urban growth and surface movements and changes and supporting the prevention and quick detection of undesired effects from construction. DEMs are also very useful for assessing risk and vulnerability to extreme weather events, and for the identification of the most appropriated locations for new buildings and infrastructures.

Flood risk in Hyderabad

Spread over 650 square kilometres along the Musi River banks, Hyderabad grew from about one million inhabitants in 1951 to about 10.2 million in 2016, becoming India's fourth most crowded city. As population continues rising, the shortage of planned affordable housing has forced thousands of people to live in unauthorised housing. Moreover, rapid urbanisation has altered the natural drainage patterns, leading to flooding and waterlogging even after mild showers.

My company, Deimos Imaging, carried out a multi-scale and multi-temporal urban analysis of Hyderabad's metropolitan area, to evaluate its urban structure and environment and to identify trends and patterns that would assist in developing new strategies for sustainable urban development.

In particular, a multitemporal analysis of Deimos-1 and Landsat-5 data ranging from 1988 to 2017 enabled us to monitor the entire metropolitan area and its extension, detecting where the main changes occurred. Then, we used the very high resolution (VHR) satellite Deimos-2 to provide highly detailed information about the structural characteristics of the urban morphology. Last, but not least, our DEM

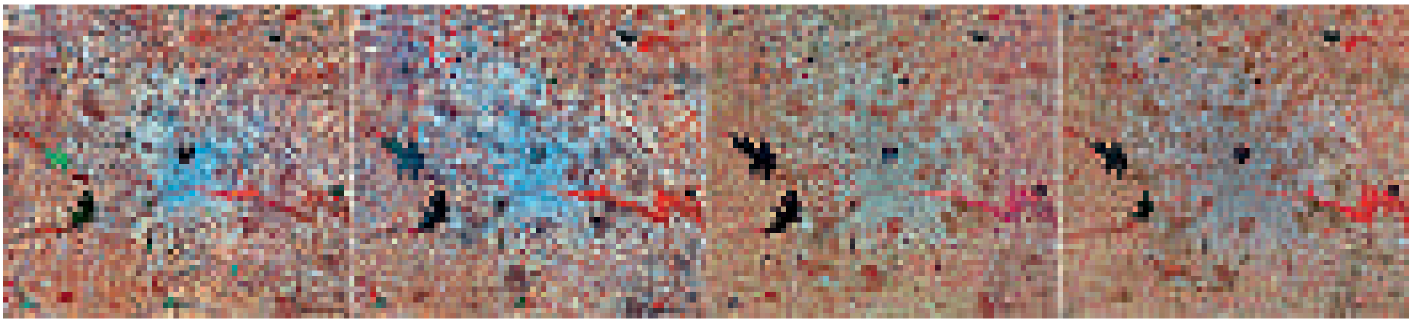

Figure 1. (l-r) Hyderabad metropolitan area depicted by Landsat 5 in 1988 and 1999 and Deimos-1 in 2011 and 2017.

provided essential information on terrain elevation, useful for topographic mapping and hydrological modelling.

Understanding urban sprawl

Deimos-1, the very first Spanish Earth observation satellite, has been providing data continuously since 2009. With a spatial resolution of 22m, a 650km swath and a revisit frequency of three days, it enables the timely monitoring of urban sprawl and the spatial direction of urban development on large metropolitan areas. The satellite's three spectral channels – red, green, NIR – were designed to be compatible with the ones of the Landsat series, allowing full compatibility and, therefore, enabling a seamless analysis of extended time series.

In this study, Deimos-1 data of Hyderabad from the years 2011 and 2017 were used together with resampled 22m Landsat 5 data from 1988 and 1999 (see Figure 1). The images were processed combining the near infrared, red and green bands. In this band combination, vegetation appears red, allowing for easy differentiation of vegetation-covered soil and urbanised land.

A careful image analysis was carried out to detect the main areas of changes of the city from 1988 to 2017. In particular, significant new infrastructures, including the Rajiv Gandhi International Airport on the bottom left side of the images, the outer ring road around the city and the new urban areas in the western metropolitan area, were detected.

After that, Deimos-2 VHR 75cm imagery was used to identify small-scale changes and heterogeneous urban structures of Hyderabad, enabling a highly detailed analysis of the urban morphology, including the detection of single houses and infrastructure networks.

Figures 2 and 3 show the capabilities for highly detailed analysis of the urban structure compared to the coarse resolution of the Deimos-1 image in Figure 1.

Flood risk assessment with Deimos-2

Growing urbanisation led to a significant reduction in the number of water bodies in Hyderabad, due to encroachments by residential colonies and commercial complexes. This resulted in increased runoff and flash flooding after sudden rain. In September 2016, the city suffered heavy rains, which caused floods in several neighbourhoods and killed seven people.

The basic parameter that influences drainage in any area is its topography. Therefore, DEMs displaying the geography, hydrography and terrain elevation are efficient and effective methods used to determine the features of drainage networks like size, length, and slope of drainage network and to determine the characteristics of basins. A notable feature of Deimos-2 is its off-nadir imaging ability (up to 45º), which enables

Figure 2. Outer ring road and small urban settlements pictured by Deimos-2 on April 21 2017

Figure 3. Rajiv Gandhi International Airport imaged by Deimos-2 on April 21 2017

Figure 4. (l-r) Deimos-2 stereo product acquired over Hyderabad on January 5 2017 at 11:06 UTC and 11:08 UTC, together with derived DEM

it to acquire VHR stereoscopic imagery. The stereo images are collected on the same orbit (along-track scanning) with suitable angles optimal for stereo viewing and manipulation. The Deimos-2 stereo product is composed of two images for which the angular difference can be adjusted. The main parameter characterising the system's stereoscopic capability is the base to height (B/H) ratio – the distance on the ground between the centres of overlapping images, which is used to determine vertical exaggeration.

Two images were acquired over Hyderabad on January 5 2017 at 11:06 UTC and 11:08 UTC; the resulting DEM was resampled at a spatial resolution of 1.5m (see Figure 4). Additional editing was applied to ensure hydrological consistency, by flattening the water bodies and verifying the regular flow of rivers or streams.

The Deimos-2 DEM shows how elevation varies along the city: from the lowest areas of approximately 470m along the riverbanks of Musi River to its highest district (approximately 560m) named Banjara Hills, in the northwestern part of the city. An analysis of the city´s DEM, along with the VHR Deimos-2 images, can reveal areas where the natural discharge of the city has been blocked, increasing the flooding risk. In addition, DEMs can be used to simulate water level scenarios and estimate flood extend and, therefore, evaluate the infrastructures at risk.

AN ANALYSIS OF THE CITY´S DEM CAN REVEAL WHERE THE NATURAL DISCHARGE OF THE CITY HAS BEEN BLOCKED, INCREASING THE FLOODING RISK

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