SATELLITE DATA AS A DECISION SUPPORT TOOL IN ENVIRONMENTAL ANALYSIS

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ABSTRACT

The use of high resolution satellite data is vital in assessing environmental risks, particularly when access to the environment is restricted, when the area of interest is large or when the assessment requires consideration of past environmental conditions. This paper demonstrates the application of satellite data (such as imageries and Shuttle Radar Topographic Mission SRTM data) as a decision support tool to manage the environment using the Federal polytechnic Ilaro (FPI) as a case. A digital map of the school environment was obtained from the Surveying and Geoinformatics department. Landsat 8 (8m resolution) satellite image was used as an overlay to vectorize and update the existing topographic details of the study area. Shuttle Radar Topographic Mission (SRTM 30m resolution) data was used in Surfer 10 and ArcScene to describe the topographic configuration of the area. The updated digital map and the surface topography of the area are tools for supporting engineering design, hydrological analysis (such as run off water, flow direction etc.), drainage as well as physical environmental planning for the area. The results shows that manipulation of satellite data (SRTM data) and map update from imageries cannot be over-emphasized as decision support tools in the physical planning processes of a built environment.

Keywords: Analysis, Decision tool, Environment, Satellite image, SRTM, High resolution

INTRODUCTION

High resolution satellite imagery have facilitated scientific research activities at landscape and regional scales. Availability of satellite images can provide spatial resolutions of 0.31m or better for analysis of urban growth and transportation development for assessment and monitoring. Multispectral sensors can provide increased spectral resolution that can be used to further analyze land cover and change detection, and how urban growth and associated transportation development impact these conditions.

The fast growth in population, urbanization, change in land use pattern in developing countries have resulted in damage of historical, biological, archeological, aesthetic, visual impacts and pollution in land, water, air and noise. The study area is fast experiencing increasing population in terms of staff and students as well as infrastructures (such as lecture theatres, toilets, offices, laboratories etc.) to cater for the increasing population. The most suitable location of these facilities can be viewed from satellite imageries. Water run off volume in the study area can be analyzed through heights generated from the SRTM image. The construction phases of these infrastructures and their management require a technology that involves onscreen viewing of the ongoing construction of the infrastructures so as be able to monitor the construction process and management of these facilities, hence the necessity of satellite data.

There are needs of spatial and non-spatial data which can be used in support of complex analysis and produce an alternative plan. Therefore satellite data are the fastest data which will augment much more accurate results and perform various geographic analyses even in complex situations.

One major challenge of executing a topographic survey of the area by the traditional method of surveying will be cumbersome, costly and time consuming especially going by the fast pace at which physical development is moving in the school. It is against this backdrop that this paper aimed at using satellite data to provide up to date information of the area and as a decision support tool to perform various geographic analyses even in complex situations.

The concern of this work is to use satellite data (Landsat 8 and SRTM) for map updating and as a decision support tool for environmental analysis of the area.

Nowadays though, satellite imagery undergoes a great deal of mathematical manipulation and can yield quantitative analyses of atmospheric temperature, humidity, motion and many more meteorological variables (Suparco, 2017). The major advantage of satellites is their ability to produce near-global coverage, which becomes especially important over oceans and remote, unpopulated land regions, where other methods of observation are impracticable. Over large areas of the southern hemisphere, satellites are the only means of Earth observation. As well as observing changes in surface features such as vegetation and sea surface temperature, satellite imagery can also capture the development of transient features such as clouds of water or ice and plumes of ash or dust. Relatively little work on this topic has been published in the peer-reviewed literature to date especially in Nigeria.

Satellite images

The ability to visualize & evaluate the impact on the surrounding environment is crucial to design, build and manage successful projects. High quality geospatial information is vital to engineers, surveyors, designers and architects.

When a collection of remotely sensed imagery and photographs considered, the general term "imagery" is often applied. An image is two types a monochrome image and a multicolor image (Kalyankar, N.V. and Al-Wassai, F.A., 2014). Satellite images provide an economical, accurate and rapid means of obtaining quick assessment for any significant physical project in the environment e.g., landcover mapping, Hydrological applications, As-built surveys, environmental construction etc.

Satellite imageries can help create a more accurate base map, which is a map on which primary data and interpretations can be plotted such as roads, rivers, and city boundaries.

The satellite can provide a shot of the target area, for example, the site of a construction project, when needed.

With high-resolution satellite data, GIS and CAD users can acquire imagery related to a project area and within days have the new imagery ingested in their GIS or CAD system.

Another reason to use satellite imagery is for multi-spectral analysis. Multi-spectral imagery is useful in a variety of applications such as soil features, fire risk management, wetlands mapping and vegetation analysis and classification. Multi-spectral imagery can capture light from frequencies beyond the visible light range, such as infrared. "This can allow extraction of additional information that the human eye fails to capture,"

Already many government and non-government industries use satellite imagery in their daily work. Federal agencies use it to help manage industries that impact transportation, infrastructure, urban development, environment and homeland security.

State and local governments use satellite and aerial imagery to map essential public service projects. For example, towns, cities and counties use imagery to understand the make-up of their areas for tax assessment, public works and public safety applications.

There are many advantages to using satellite imagery. This is because satellite imagery is collected digitally, there is no data loss during the scanning process.

GIS and Satellite data have greatly expanded opportunities for data integration, analysis, modeling, and mapping for environmental monitoring and assessment, disaster response, public health, agricultural biodiversity, conversation and forestry etc. High resolution satellite imagery have facilitated scientific research activities at landscape and regional scales. Availability of satellite images can provide spatial resolutions of 0.31m or better for analysis of urban growth, transportation development for assessment and environmental monitoring.

Petabytes of satellite imagery have become publicly accessible at increasing resolution, many algorithms for extracting meaningful social science information from these images are now routine, and modern cloud-based processing power allows these algorithms to be run at global scale (Donaldson, D and Storeygard, A, 2016).

Shuttle Radar Topography Mission (SRTM)

Topography is basic to many earth surface processes. It is used in analyses in agriculture, geomorphology, ecology, hydrology, geology, and many others, to describe processes and of predicting them through modeling (Andy, Jorge, Andy, Andrew, & Mark, 2004).

The topographical changes of the sediment load in the coastal landforms has been estimated from the temporal DEMs using the extracted cross-shore profile analysis that provide adequate information on geomorphic change of the various landforms in vertical scale (Zandbergen, 2008). The Shuttle Radar Topography Mission (SRTM) is an international research effort that obtained digital elevation models on a near-global scale from 56°S to 60°N to generate the most complete high-resolution digital topographic database of Earth prior to the release of the ASTER GDEM in 2009. (Nikolakopoulos, Kamaratakis, & Chrysoulakis, 2010)

It was flown in February 2000 and collected the first ever high-resolution near-global digital elevation data. The final SRTM data have become widely available at 1 arc-second resolution for the United States and 3 arc-second resolution for other areas (Zandbergen, 2008).

It has created an unparalleled data set of global elevations that is freely available for modeling and environmental applications. The global availability (almost 80% of the Earth surface) of SRTM data provides baseline information for many types of the worldwide research (Gorokhovich, Y and

Voustianiouk, A., 2006). The SRTM provides for the first time a near-global high-resolution digital elevation model (DEM) with great advantages of homogeneous quality and free availability. The last 10 years or so have seen rapid advances in the data processing and applications of SRTM DEM (Zhang, Meng, and Yang, L., 2011).

Topography determines factors like land formations, tectonic activity, air and water flow. This is why scientists use topography data in climate models. Accurate topography of the land is also needed when designing cellular tower or a hydroelectric dam.

Digital topographic data of mountain ranges, obtained with Shuttle Radar Topography Mission data, will allow geologists to test new models of how mountains form and determine the relative strength of the forces that uplift and crumple mountains and the erosive forces which polish and reshape them.

SRTM data are now used by archaeologists to study sites and human activity within their regional context so as to determine how the sites relate to each other and how they relate to the changing landscape.

The Shuttle Radar Topography Mission will provide archaeologists with a topographic view of both ancient sites and the current landscape, which they can use to help determine the boundaries of original sites. Also, they will be able to learn how and where these sites fit into the regional landscape, as well as probable migration routes through topographic barriers such as mountain ranges.

MATERIALS AND METHOD

The Study Area

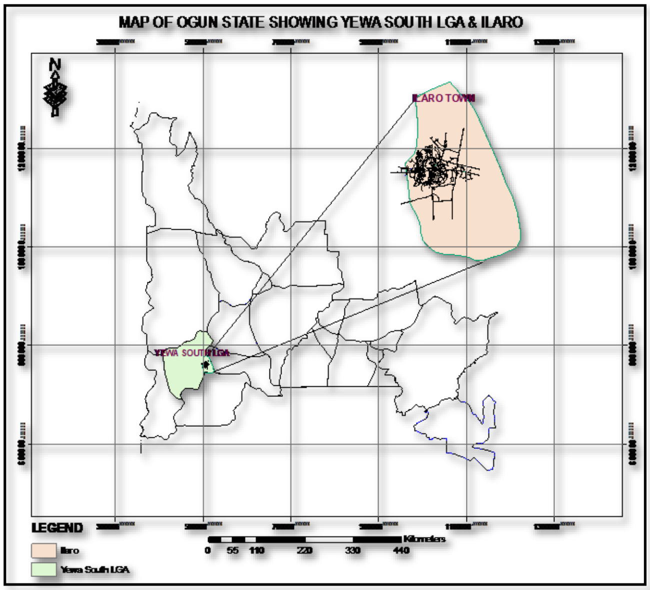

Figure 1: Map of Ogun State showing Yewa south LGA and Ilaro (Surveying & Geoinformatics department FPI, 2018)

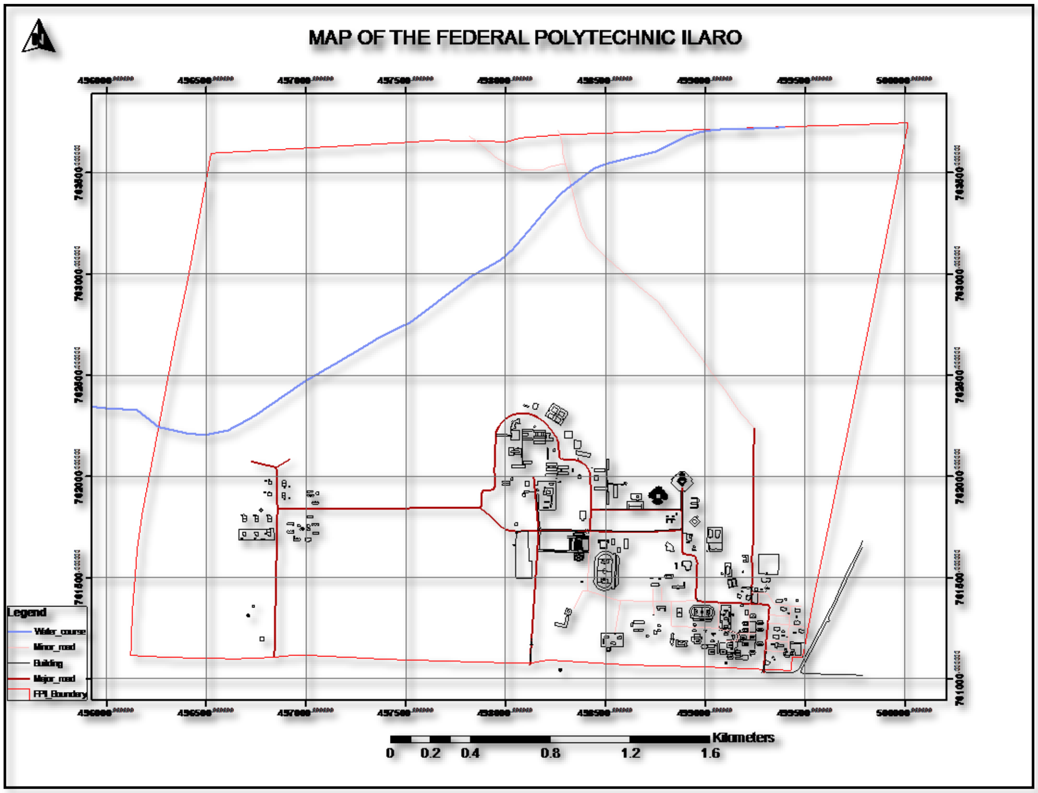

Figure 2: Map of the study area (Surveying & Geoinformatics department FPI, 2018)

Overlay and Vectorizing satellite image using ESRI’s ArcMap 10.2

The georeferenced Landsat 8 image (6m resolution) and SRTM (30m resolution) elevation data were obtained from the United States Geological Survey USGS.

Table 2.1 – Data Needs

Data	Data Type	Data Source	Data Format
Map of Federal Polytechnic Ilaro (2010)	Spatial/map	Department of Surveying & Geoinformatics, FPI	Digital
Shuttle Radar Topographic Mission (SRTM 30m) elevation data (2010)	Spatial	United States Geological Surveys USGS	Raster
Georeferenced Satellite image (Landsat 8 6meter resolution) 2010	Spatial	USGS	Raster

However, the above identified data have been obtained from reliable sources.

The image was overlaid on the existing digital map of the area in ArcMap. Infrastructures under development were also mapped out from the image. This was done by creating shape files in Arc catalogue to house the database for each infrastructures to be vectorized (figure 3). Having digitized the infrastructures and other associated features like water pipelines, road networks etc, the SRTM data was under laid beneath the image and the digital map of the campus terrain in ArcScene environment (Figure 5) to generate series of surface maps e.g. Hillshade, Contour map, Aspect map, TIN etc. 3D surface model, wireframe and grid vector map (showing run off water direction) (Figures 11, 12 & 13) of the terrain was produced using Surfer 10 software.

RESULTS AND DISCUSSION

For the purpose of this work, the numerical information on the SRTM data cannot be satisfactorily represented in tables or charts only. This work justifies the beauty of using satellite data through the presentation of its findings in raster (pictorial) and vector (map) form for the audience to appreciate the essence of satellite data for the management of a built environment.

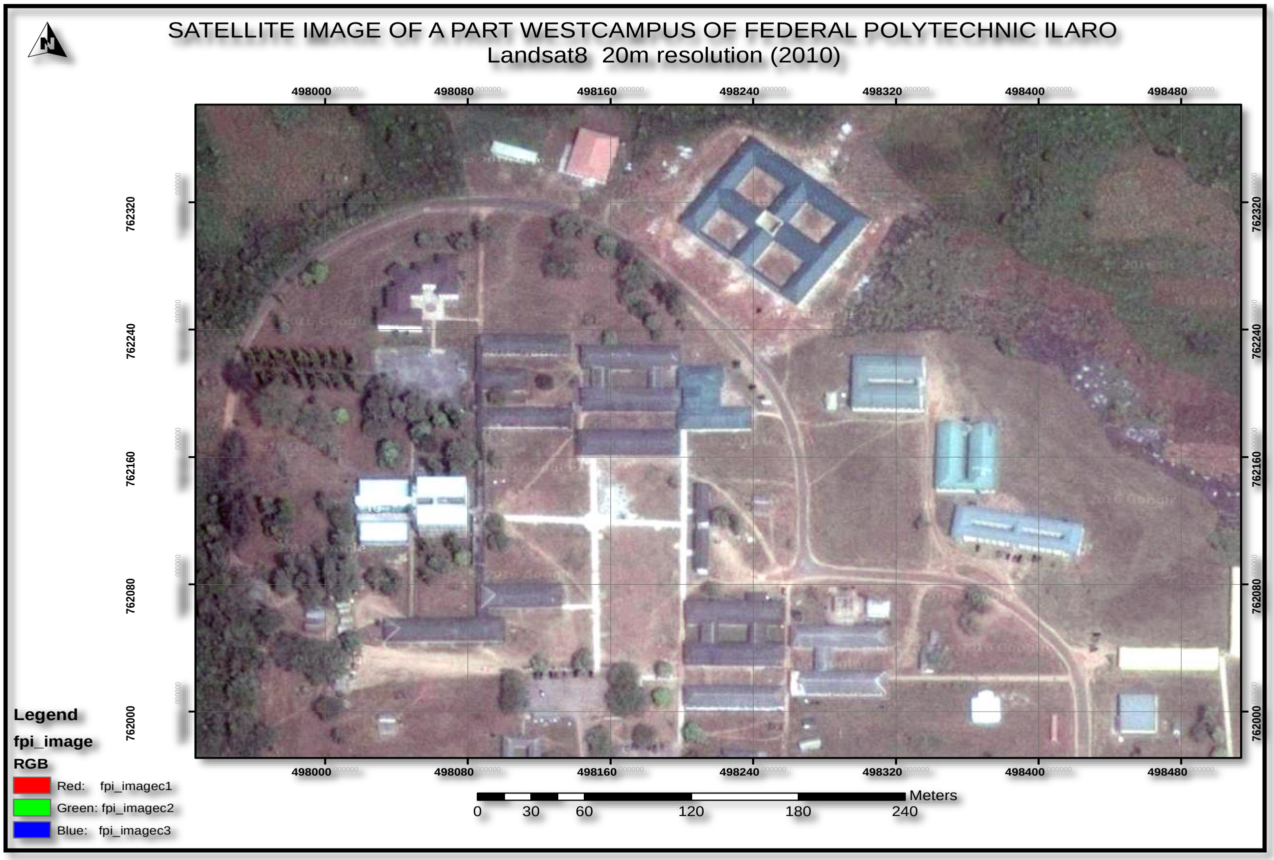

Figure 3: Satellite image of part of the study area (Landsat 8 2010)

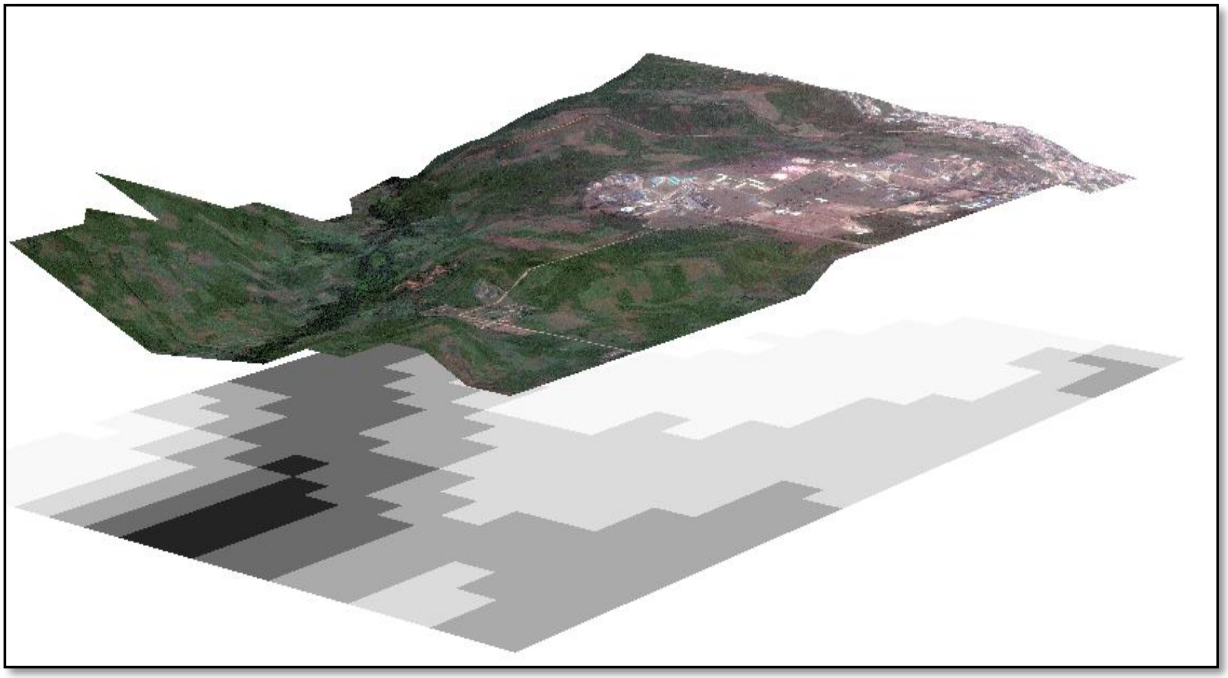

Figure 4: Figure showing satellite image of the study area draped on SRTM data (Landsat 8 & SRTM 2010)

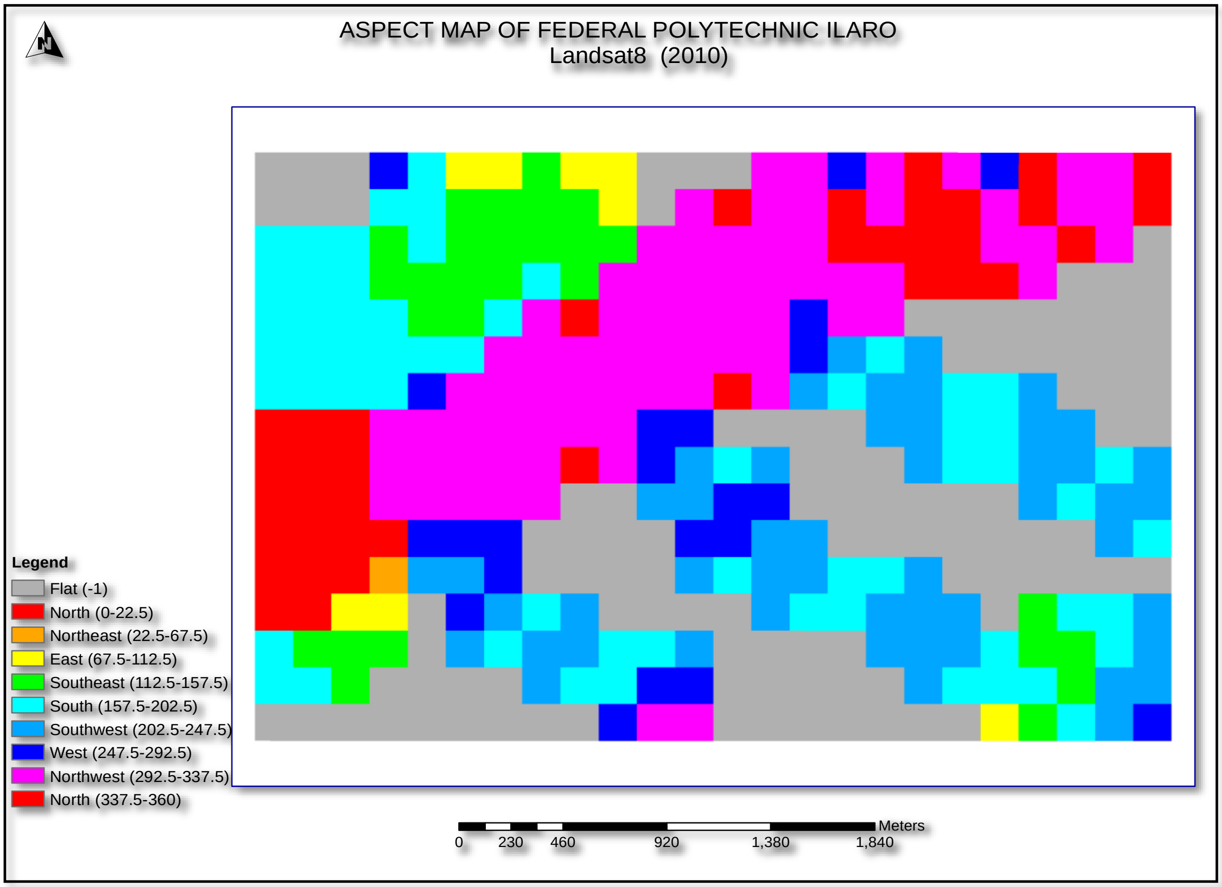

Figure 5: Figure showing Aspect map of the study area (Result of present study, 2018)

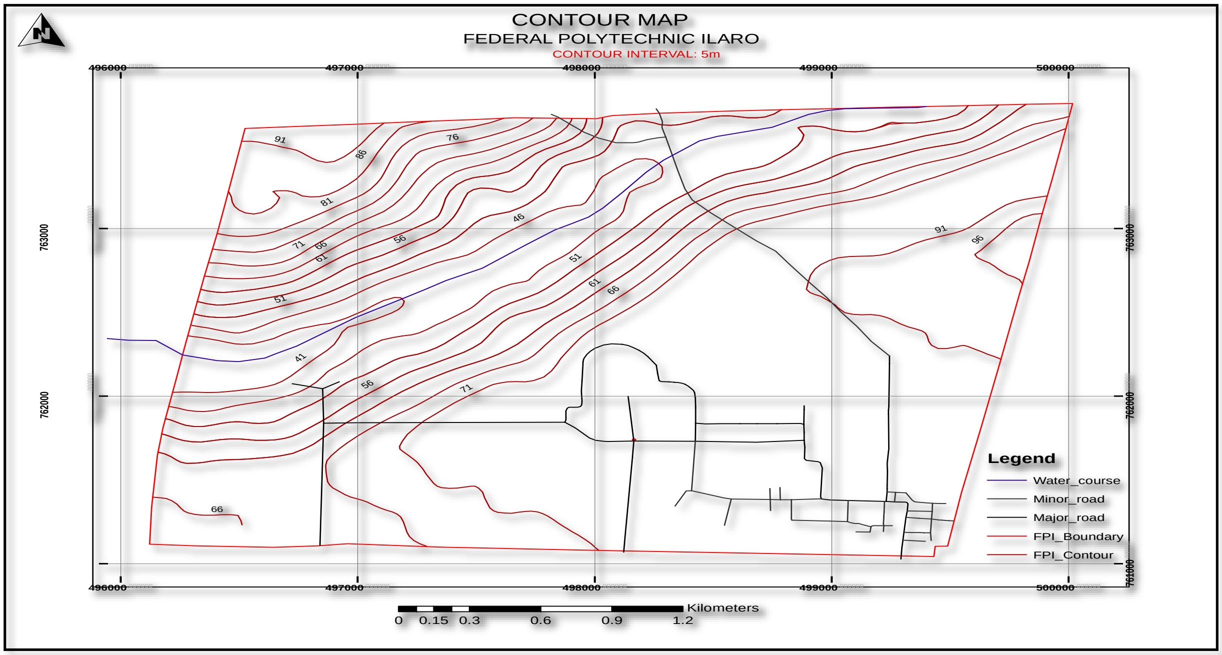

Figure 6: Figure showing Contour map of the study area (Result of present study, 2018)

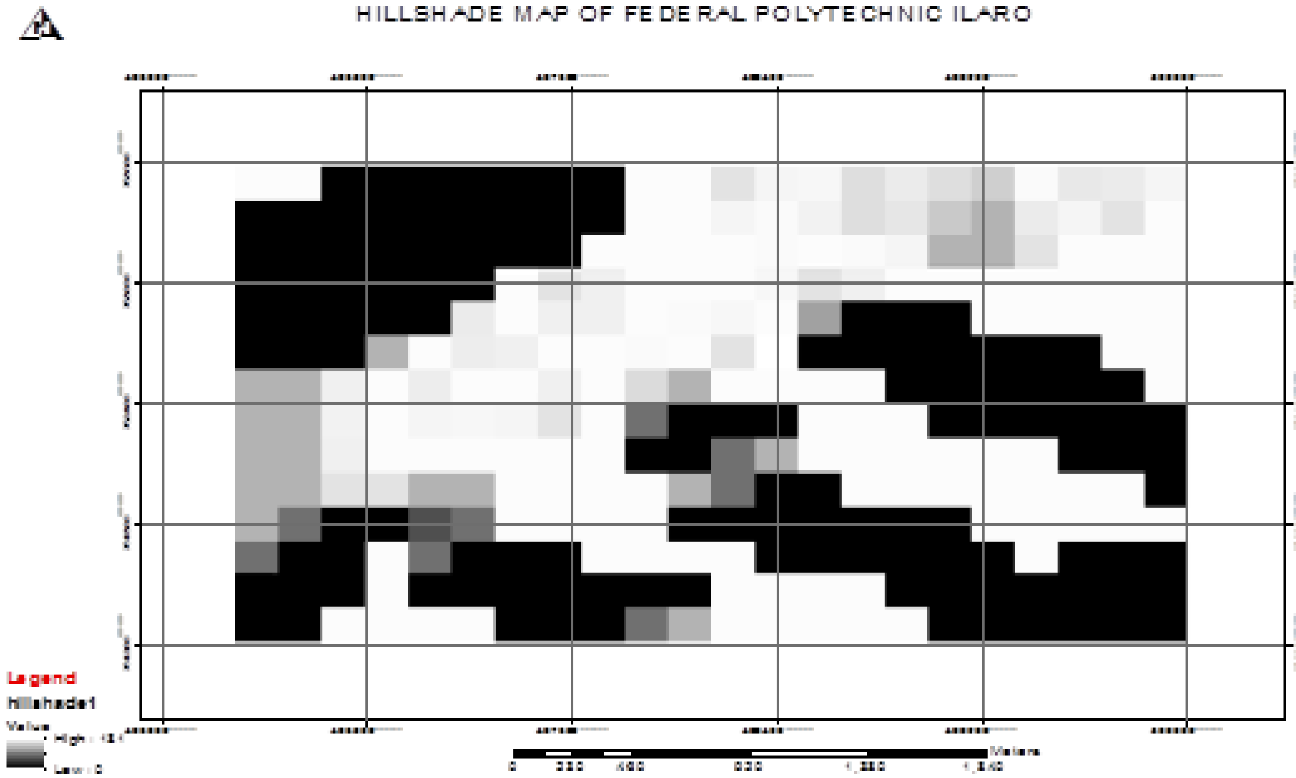

Figure 7: Figure showing Hillshade map of the study area (Result of present study, 2018)

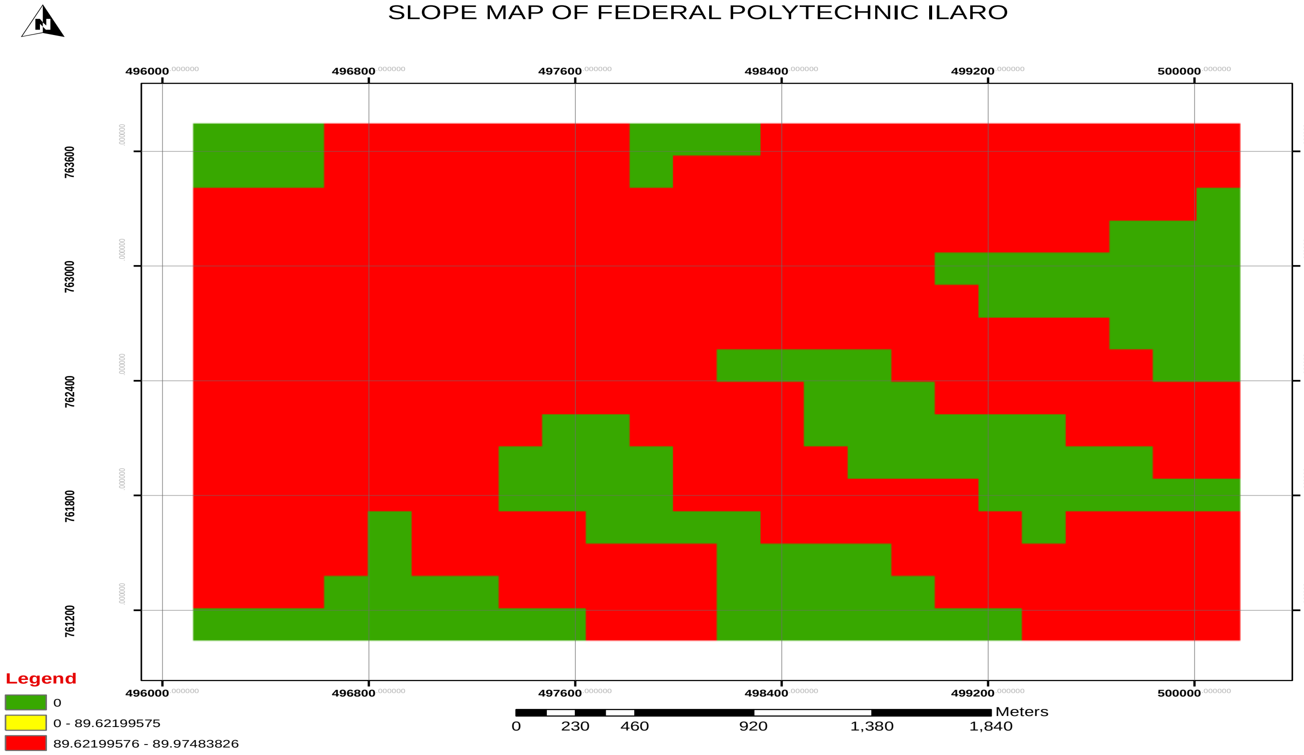

Figure 8: Figure showing Slope map of the study area (Result of present study, 2018)

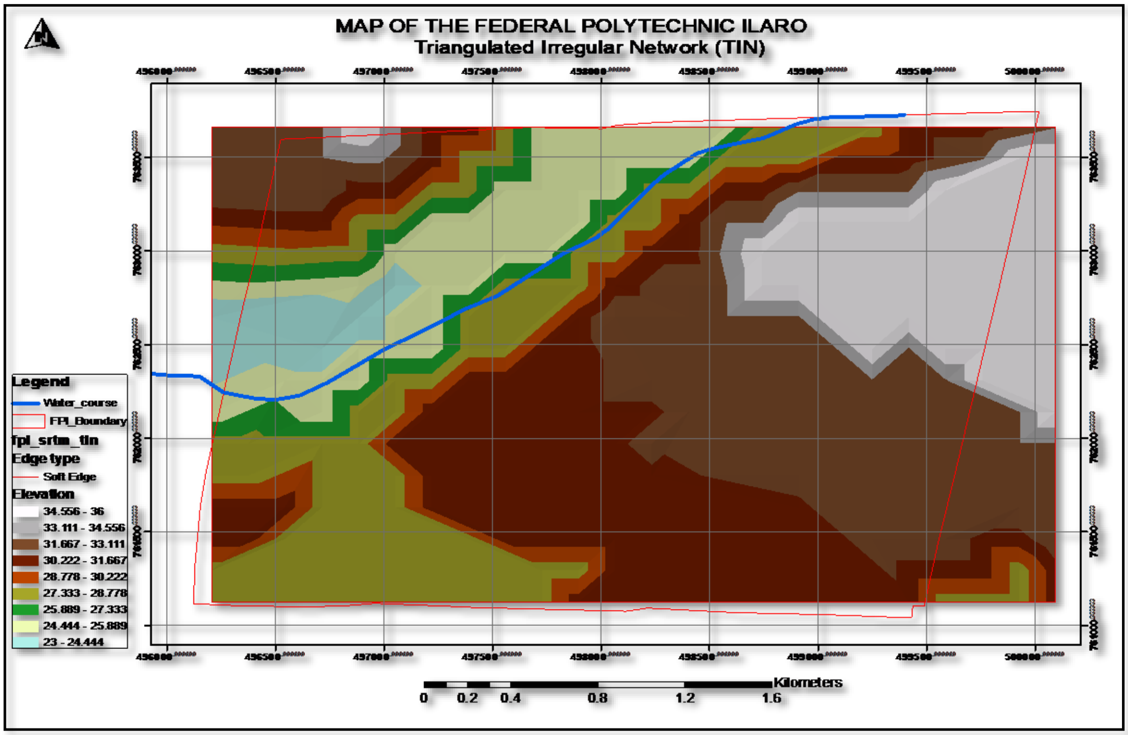

Figure 9: Figure showing Triangulated Irregular Network (TIN) of the area (Result of present study, 2018)

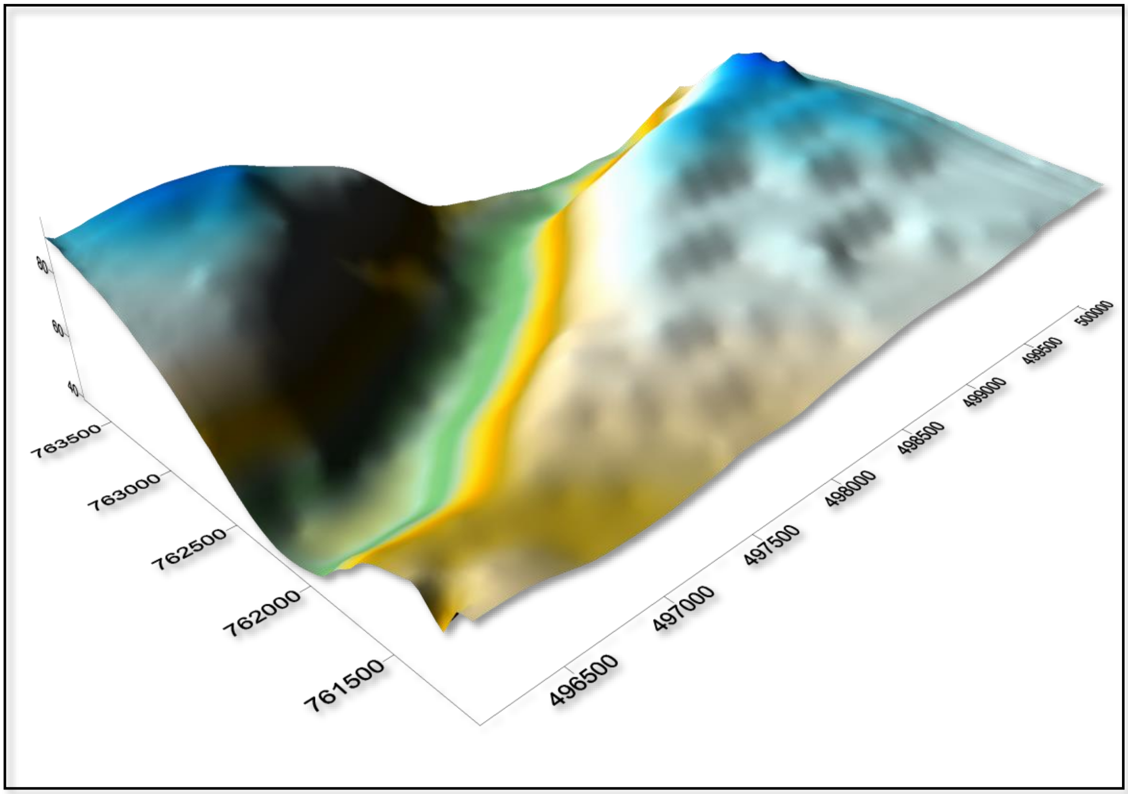

Figure 10: 3D Surface Model of the School (Result of present study, 2018)

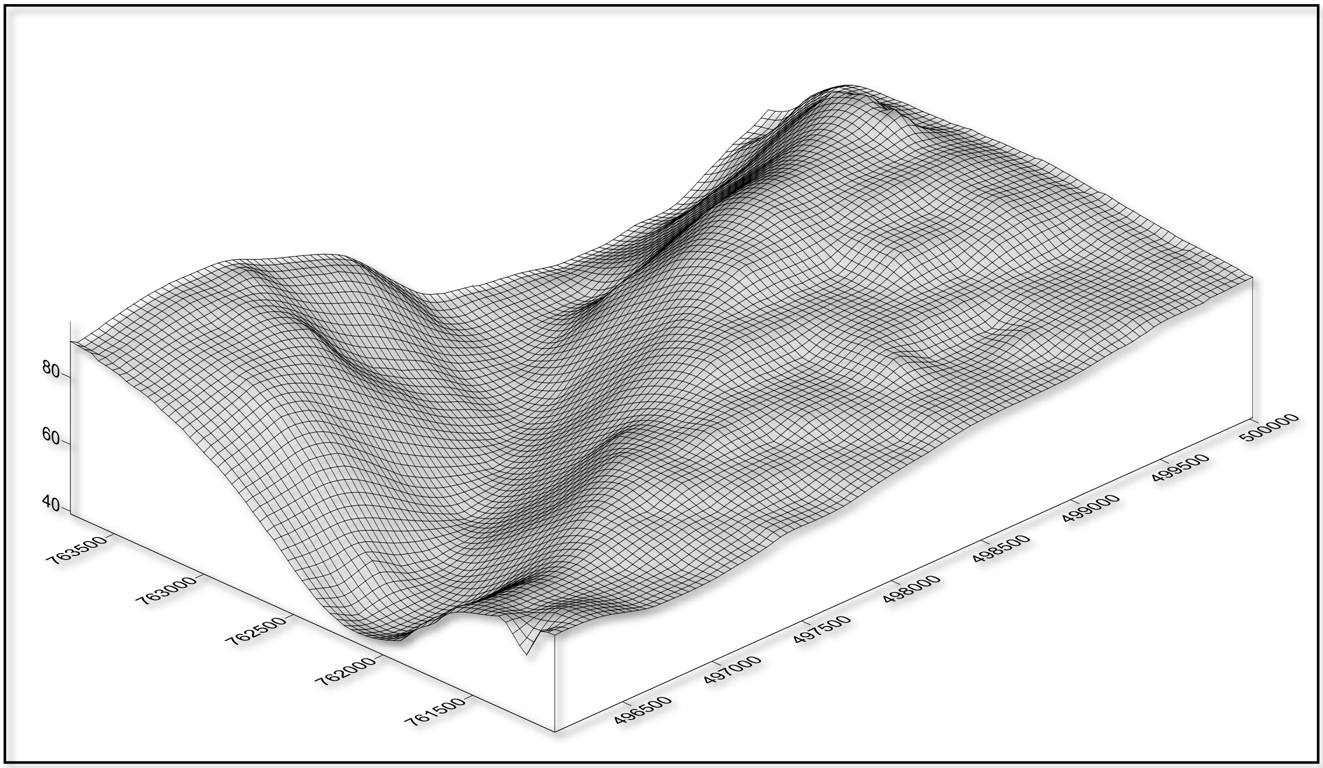

Figure 11: 3D Wire Frame showing the topography of Surface of the School (Result of present study, 2018)

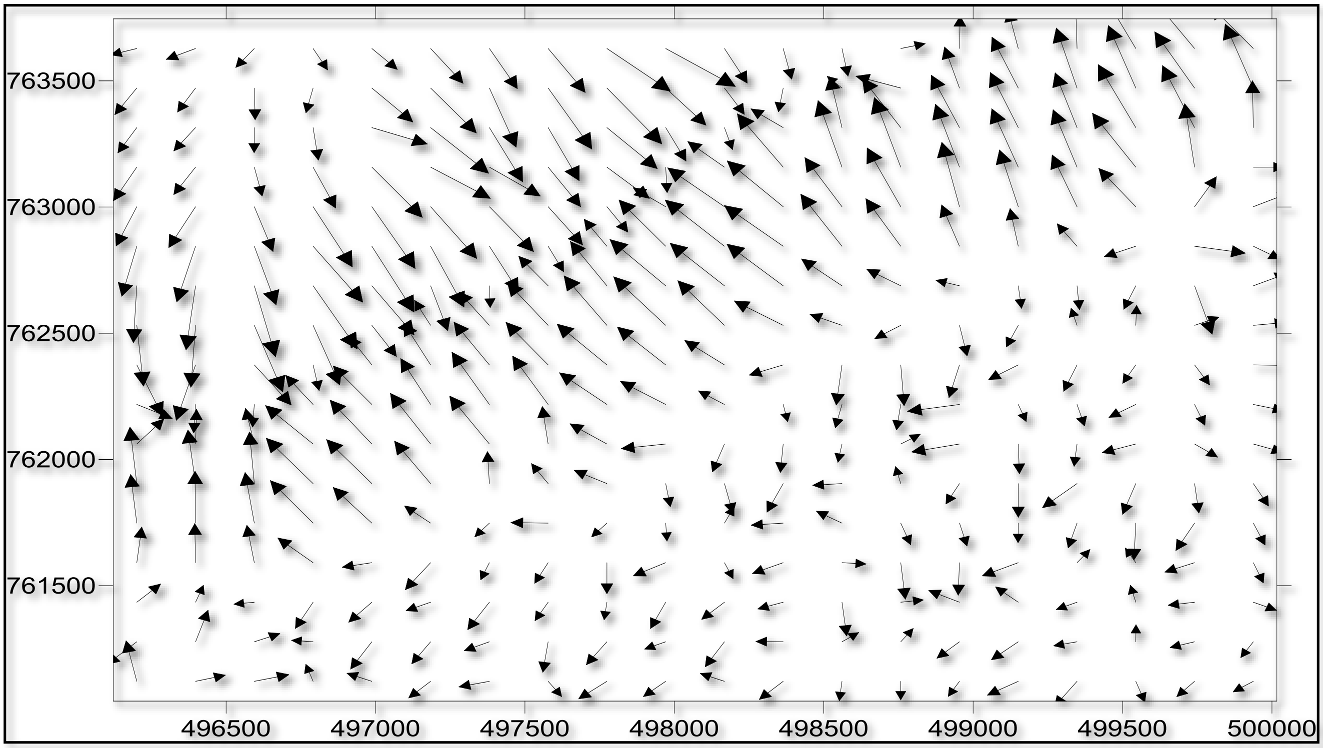

Figure 12: Grid Vector map showing runoff water direction in the School (Result of present study, 2018)

The Satellite image (Figure 3) helped to update and create a more accurate digital base map of the study area, which is a map on which primary data and interpretations are plotted such as roads, rivers, and city boundaries etc. Because satellite imagery is collected digitally, there is no data loss. This makes it contain more information, cover a larger ground area than aerial photos, and provides updates of the school land area. For the purpose of architectural, engineering and construction, the satellite imagery can be used to get a more comprehensive view of the area and its surroundings. SRTM data have generally been found to be of sufficient accuracy for hydrological model applications (Zandbergen, 2008). Topographic data are widely used to determine hydrological properties of a landscape, including the extraction of drainage networks, upstream catchment areas and water sheds. Combined with information on slopes, additional parameters such as wetness index and stream power can also be derived. The availability of SRTM DEMs now permits rapid, global assessment of catchment areas, channel slopes, estimates of discharge, spatial variations in stream power, and erosion rates. The surfaces that are produced (Figures 4-12) will be used as decision support tools. Figures 10, 11 and 12 are widely used to model rainfall-runoff processes. Based on the contour map (Figure 6) and the 3D surface map (Figure 4), the topography of the northern part of the institution is high and gently slopes downwards towards the southern parts of the school. Surfer was used to depict the directions of flow water in the school (Figure 5). The Vector map (Figure 12) shows the direction the surfaces faces. It is very useful in building construction and agricultural management. Its usefulness is pronounced in the laying of pipes where direction of flow is prominent. Vector map and 3D Wire frame (Figure 11) are useful for drainage network. The Hill shade map (Figure 7) is like aspect map (Figure 5). The color graduations in the legend of the Aspect map and the grey color in the legend of the Hillshade map show height variation and how rugged the landform is. The hill shade map is used in hilly area to determine the amount of sunlight that will be received in a given area. It can be used to determine the vest part of farmland to reserve for drying of crops after harvesting. Hill shades are used to portray relief difference and terrain morphology in hilly and mountainous areas. The color tones in a hill shade raster represent the amount of reflected light in each location, depending on its orientation relative to the illumination source. Triangulated Irregular Network, TIN map (Figure 9) is typically used for high-precision modeling of smaller areas, such as in engineering applications, where they are useful because they allow calculations of planimetric area, surface area, and volume. They allow for the capture of significant changes in surface form, such as topographical summits, breaks of slope, ridges, valley floors, pits, and cols. An aspect-slope map simultaneously shows the aspect (direction) and degree (steepness) of slope for a terrain (or other continuous surface). Aspect categories are symbolized using hues (e.g., red, orange, yellow, etc.) and degree of slope classes are mapped with saturation (or brilliance of color) so that the steeper slopes are brighter (Figures 5 & 8). Figure 4 shows the satellite image (Figure 3) of the study area in ArcScene, been draped over the SRTM image to visualize the DEM. The 3D surface map (Figure 4) shows the terrain undulation based on the digital number on the SRTM image.

CONCLUSION AND RECOMMENDATIONS

Satellite data have the ability to support environmental, health and safety aspects in a project in a time and cost effective way, provided limitations of the remote sensing systems (spatially, spectrally, temporally) are known and taken into account when analyzing surface features and sustainability issues.

As a resource to any nation, the environment should be well planned, developed, conserved and managed. For this reason Visual analysis of existing features and infrastructure based on up-to-date satellite imagery meant that the current status of critical infrastructure in the environment could be established.

The SRTM has advanced past its original objectives and has clearly demonstrated the potential of satellite radar altimetry. Complementary laser altimetry systems are already in operation, and future endeavors, such as the Terra SAR-X mission and the proposed WATER HM mission, will build on the experience gained with SRTM. It is envisaged by this paper that these satellite data should be adopted in environmental support and as decision making tools.

Also, many firms use aerial photography for projects that require high-resolution aerial data. These firms should consider the use of a variety of spatial data for evidence-based reports as a more practical alternative.

This study shows that satellite data in combination with environmental knowledge can be powerfully used to help companies establish an environmental baseline, to analyze impacts and risks, and to assess the integrity of existing infrastructure in areas where access is restricted, where the area of interest is large or where historic liabilities need to be investigated.

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