APPLICATION OF SATELLITE DATA FOR A SUSTAINABLE BUILT ENVIRONMENT

(Case of Federal Polytechnic, Ilaro)

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Abstract

Photographic images are remotely sensed information of the Earth obtained from above and have been recorded since the late 19th century, initially by cameras attached to balloons, kites, or pigeons. This remotely sensed information has been used for economic analysis since at least the 1930s. It is accepted and proven that Earth observation information gathered from spacecraft provides substantial benefits supporting economic development and supports informed policy and decision making. This paper focuses on the use of satellite data sets (such as satellite images and Shuttle Radar Topographic Mission SRTM data) as a decision support tool in environmental management in the Federal polytechnic Ilaro (FPI). A digital map of the school was obtained from the Surveying and Geoinformatics department. A 20m resolution Landsat 8 satellite image was used as an overlay to vectorize and update the existing topographic details of the school. Shuttle Radar Topographic Mission (SRTM 30m resolution) data was used in Surfer 10 and ArcScene to delineate the topographic configuration of the school. The updated digital map and the produced surface topography will support engineering design, hydrological analysis (such as run off water, flow direction etc.), drainage as well as physical environmental planning for the school. The results shows that manipulation of SRTM data and map update from satellite data using ArcGIS ArcScene and Golden Surfer surface modelling software cannot be over-emphasized as decision support tools in the physical planning processes of a built environment.

1.0 Introduction

The first meteorological satellite was launched in 1960 by the USA and provided cloud cover photography. Originally, satellite images were treated purely as qualitative pictures, which were manually viewed and interpreted by meteorologists. 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.

1.1 Satellite images

World Population is on the increase as well as landscape change with increasing economic boosts and governments have increasingly relied on up-to-date satellite imagery and other geospatial data for applications such as environmental planning, land registration. Remote sensing images are available in two forms: photographic film form and digital form, which are related to a property of the object such as reflectance. 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. 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).

Multispectral sensors can provide increased spectral resolution that can be used to further analyze environmental conditions, land cover and change detection, and how urban growth and associated transportation development impact these conditions.

1.2 Shuttle Radar Topography Mission (SRTM)

The Shuttle Radar Topography Mission (SRTM) 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). SRTM is an international project spearheaded by the National Geospatial-Intelligence Agency (NGA), NASA, the Italian Space Agency (ASI) and the German Aerospace Center (DLR). The Jet Propulsion Laboratory (JPL) of NASA operated a C-band system in ScanSAR mode covering a 225 km swath, and thus providing an almost complete DEM in the 56°S to 60°N latitude range (Hoffmann, J. and Walter, D., 2006).

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).

1.3 Some applications of Satellite data

- Urban mapping
- Hydrological applications
- Environmental impact assessment
- Soil water and drought monitoring
- Natural resource management
- Agriculture
- Forestry
- Risk management

- Disaster monitoring
- Maritime
- Defense and security

Table 1: satellite sensor data characteristics

Very High Resolution Satellites						greater than 10m			
Satellite	Panchromatic Resolution	Multispectral resolution	Pan-sharpened resolution	Multispectral Bands available	Swath width	Min area to purchase	Programmable	Stereo availabl e	Largest scale
Worldview-2	0.5m	2.0m	0.5m	4 or 8 bands	16.4km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	Yes	1:1500
Worldview-1	0.5m	No multispectral band available		None	17.6km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	yes	1:1500
GeoEye-1	0.5m	2.0	0.5m	4 bands	15.2km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	Yes	1:1500
QuickBird	0.6m	2.44m	0.6m resampled	4 bands	16.5km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	No	1:2000
Pleiades	0.5m	2.0m	0.5m resampled	4 bands	20km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	Yes	1:2000
IKONOS	0.82m	3.2m	0.8m resampled	4 bands	11km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	Yes	1:2500
Skysat	0.9m	2.0m	0.9m	4 bands	8km at Nadir	50km^2	Yes	Yes (in future)	1:2500
High Resolution Satellites									
Spot 6	1.5m	6.0m	1.5m	4 bands	60km at Nadir	25km^2 for archive 100km^2 for new capture	Yes	Yes	1:5000
Spot 5	2.5m or 5m	10m at nadir	2.5m	4 bands	60x60kms at nadir	20X20Kms	Yes	Yes	1:7500
ALOS Archive only	2.5m	10m	2.5m	4 bands	70x70 for AVNIR (multispectral) or 35x35 Km for PRISM (panchromatic)	Single scene	No	Yes	1:7500
RapidEye		5m		5 bands	77kms at nadir	500km^2 for archive 3500km^2 for new capture	Yes	No	1:15,000
Spot 4 Archive only	10m	20m	10m	4 bands	60x60 Kms at nadir	Single scene	No	No	1:30,000
Mid Resolution Satellites									
Landsat 8	15m	OLI=30m TIR=100m resampled to 30m	15m	7 OLI bands 2 TIR bands	180X180 Kms width	Single scene	No	No	1:40,000 pan sharpened
ASTER		VNIR=15m SWIR=30m TIR=90m		3 VNIR bands 6 SWIR bands 5TIR bands	60km width	Single scene	Yes (excluding SWIR)	Yes	1:40,000 VNIR & SWIR
Landsat 7	15m	TM=30m	15m	6TM bands 2 (gains)*TIR	180X180 Kms	180X180 Kms	No	No	1:40000 pan sharpened
		TIR=60m resampled to 30m							
Landsat 5 Archive only		TM=30m TIR=60m resampled to 30m		6TM bands 1*TIR	180X180 Kms	180X180 Kms	No	No	1:80,000

Geoimage (2011)

1.4 Research Problems

Presently there are no up to date topographic information about the school, especially towards the northern part of school. The available topographic information is scanty and does not cover the entire school premise. To carry out a topographic survey of the school 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 topographic information of the entire school in time and energy with state of the art technologically advanced software.

1.5 Aim

The remit of this work is the use of satellite data sets (such as satellite images and Shuttle Radar Topographic Mission SRTM data) as a decision support tool for built environmental management in the Federal polytechnic Ilaro, Ogun State.

1.6 Objectives

The above aim is achieved through the following itemized Objectives:

- Acquisition of satellite data (Landsat Image and SRTM) of the study area
- Overlay and Vectorizing satellite image using ArcGIS's Arcmap.
- Image draping and digital surface generation.

2.0 Methodology

The aim of the work is achieved through the following itemized methodologies:

2.1 Acquisition of satellite data (Landsat Image and SRTM) of the study area

A 20m resolution Landsat 8 image and 30m resolution SRTM elevation data were obtained from the United States Geological Survey USGS. Both the satellite image and the SRTM data have already been georeferenced.

2.2 Overlay and Vectorizing satellite image using ArcGIS's Arcmap.

The georeferenced satellite image was launched in ArcGIS ArcMap. Shape files of the features were created in Arc catalogue to house the database for vectorized details found on the image.

Existing topographic details of the school features in dwg file formats were imported from CADD drawing and converted to shape files for editing purpose.

2.3 Overlay (image draping) and digital surface generation.

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.

2.4 Data Needs.

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 20meter resolution) 2010	Spatial	USGS	Raster

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

2.5 Description of Study Area

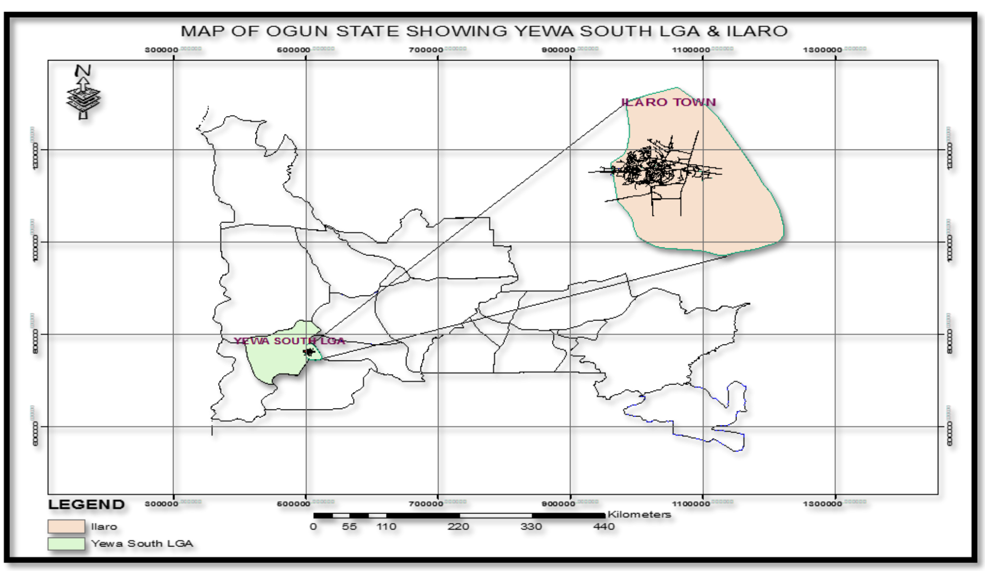

Figure 1: Map of Ogun State showing Yewa south LGA and Ilaro (Surveying & Geoinformatics department FPI, 2010)

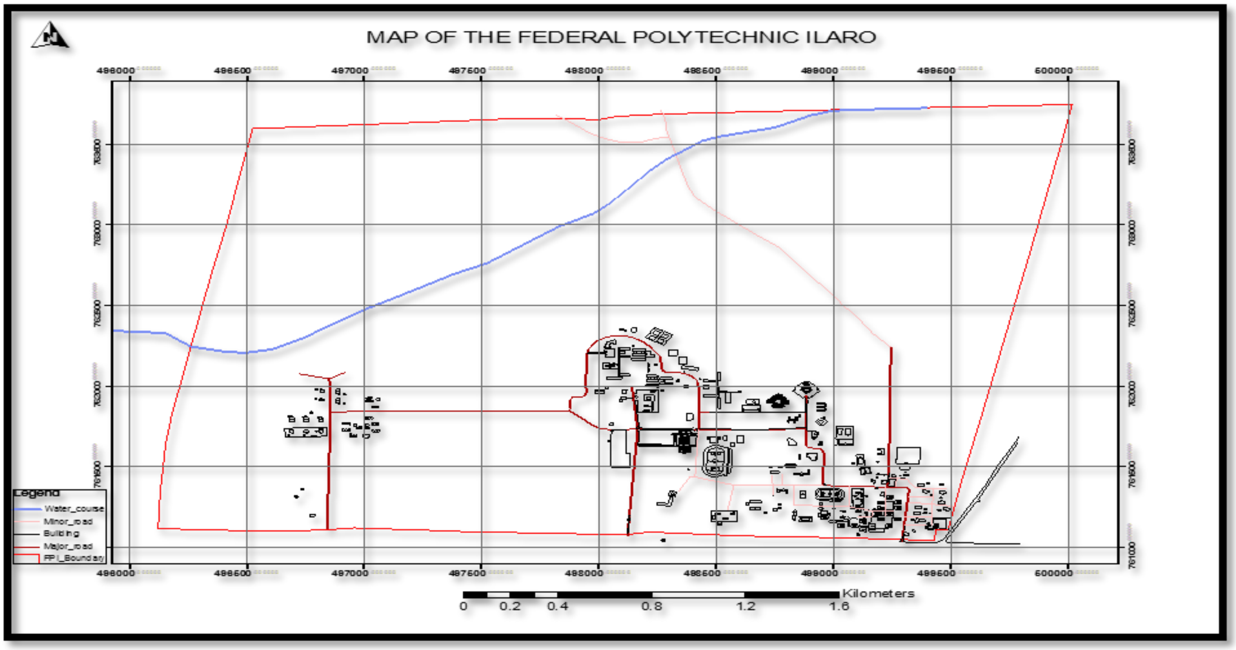

Figure 2: Map of the study area (Surveying & Geoinformatics department FPI, 2010)

3.0 Result Presentations

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.

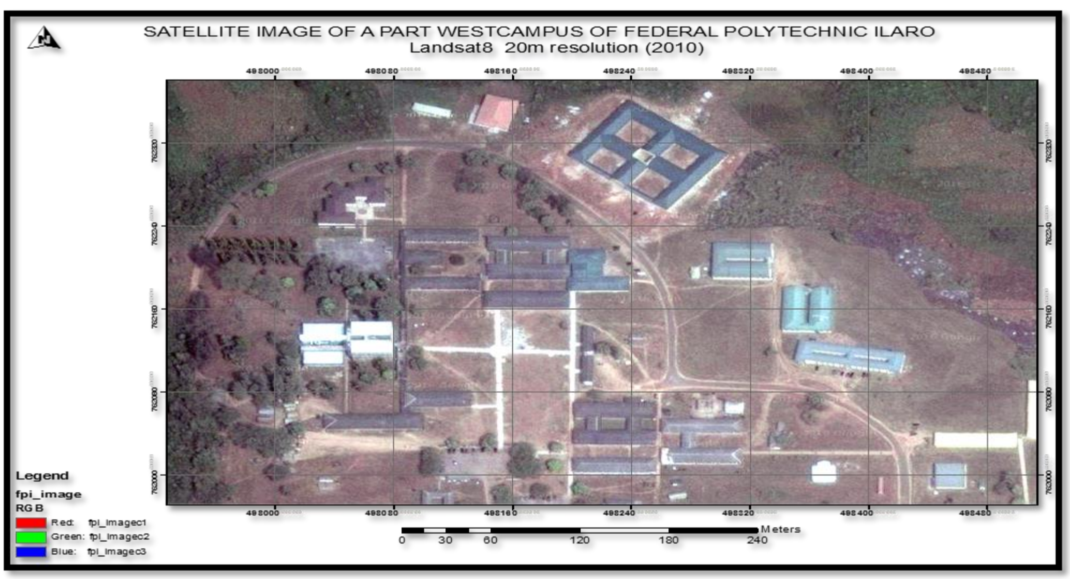

Figure 3: Satellite image of part of the study area (Landsat 8 2010)

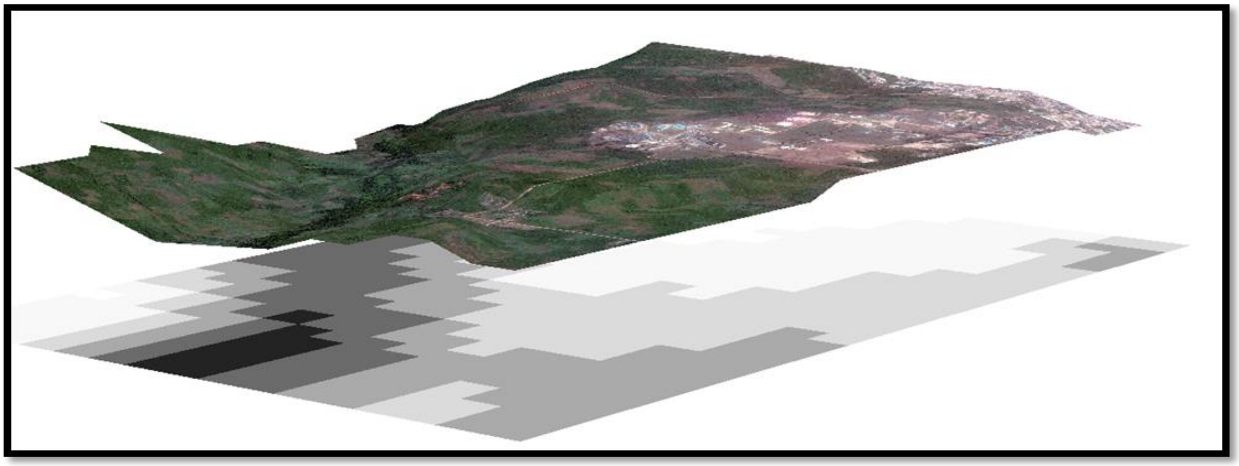

Figure 4: Figure showing satellite image of the study area draped on SRTM data (Landsat 8 & SRTM 2010)

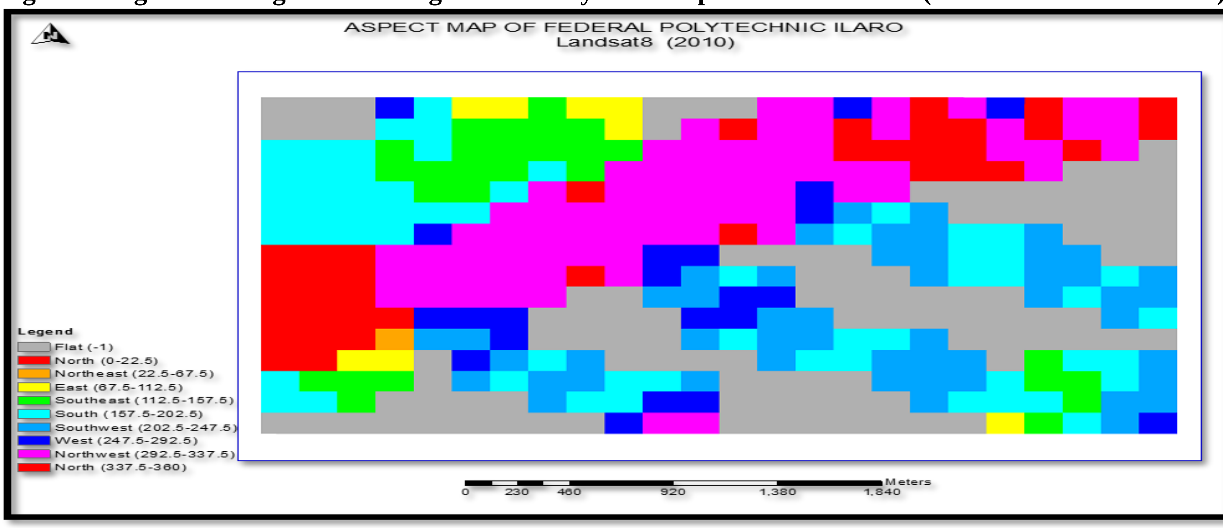

Figure 5: Figure showing Aspect map of the study area (Result of present study, 2017)

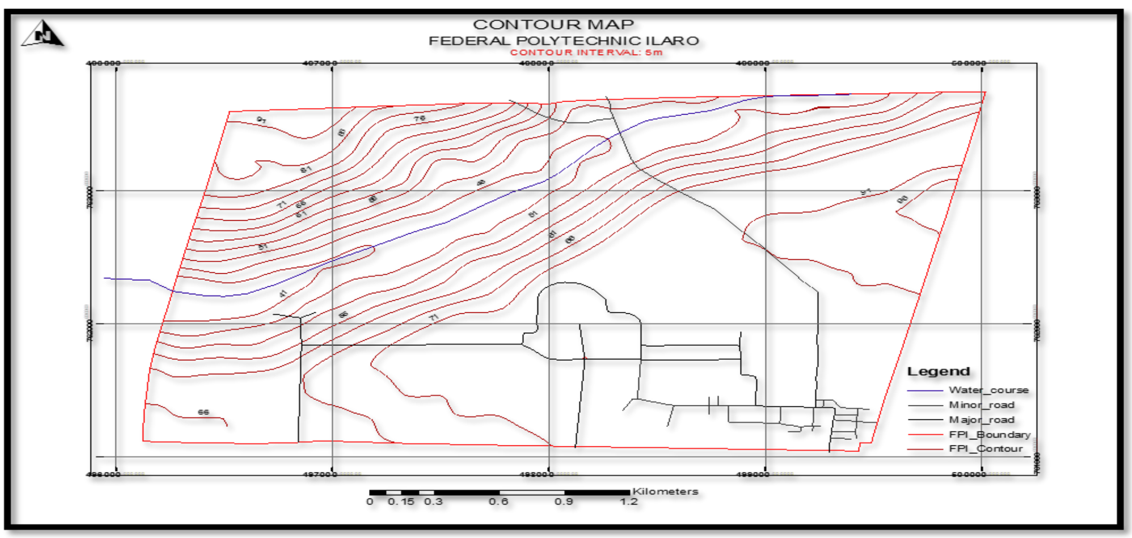

Figure 6: Figure showing Contour map of the study area (Result of present study, 2017)

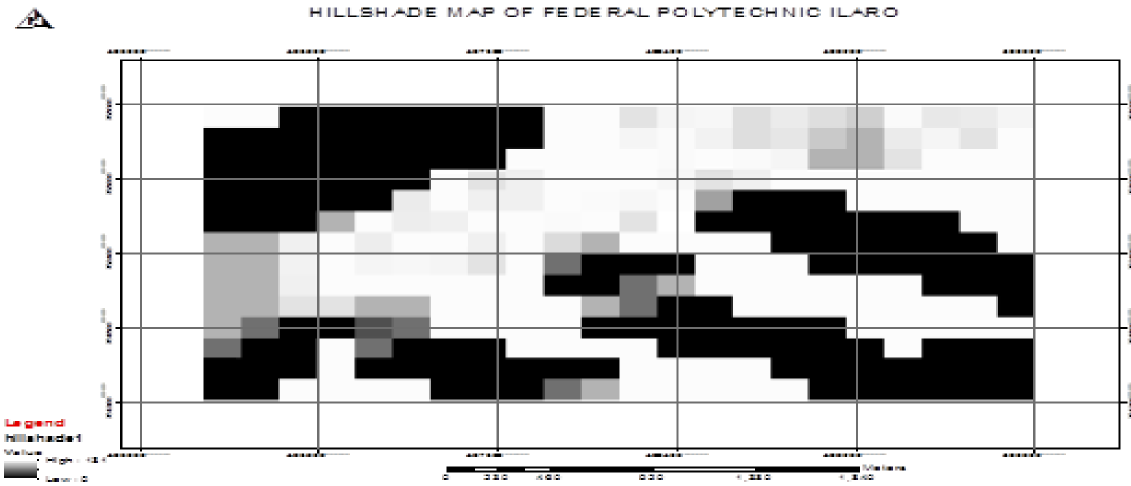

Figure 7: Figure showing Hillshade map of the study area (Result of present study, 2017)

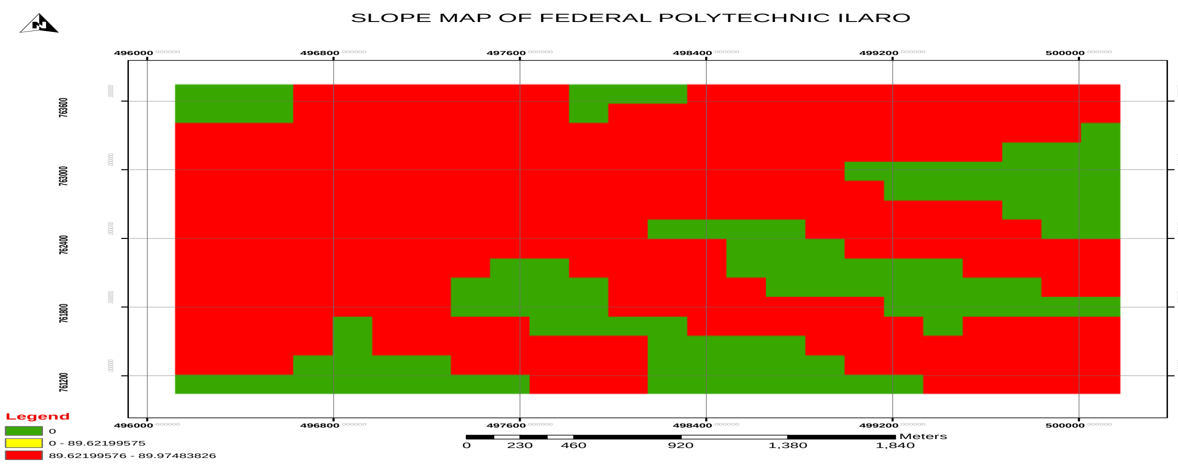

Figure 8: Figure showing Slope map of the study area (Result of present study, 2017)

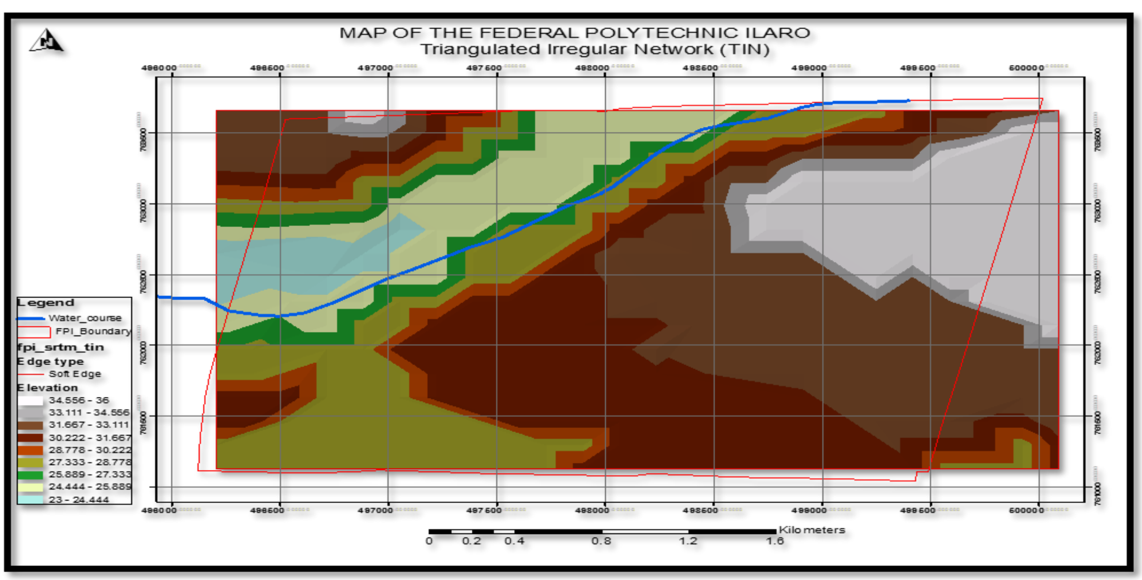

Figure 9: Figure showing Triangulated Irregular Network (TIN) of the area (Result of present study, 2017)

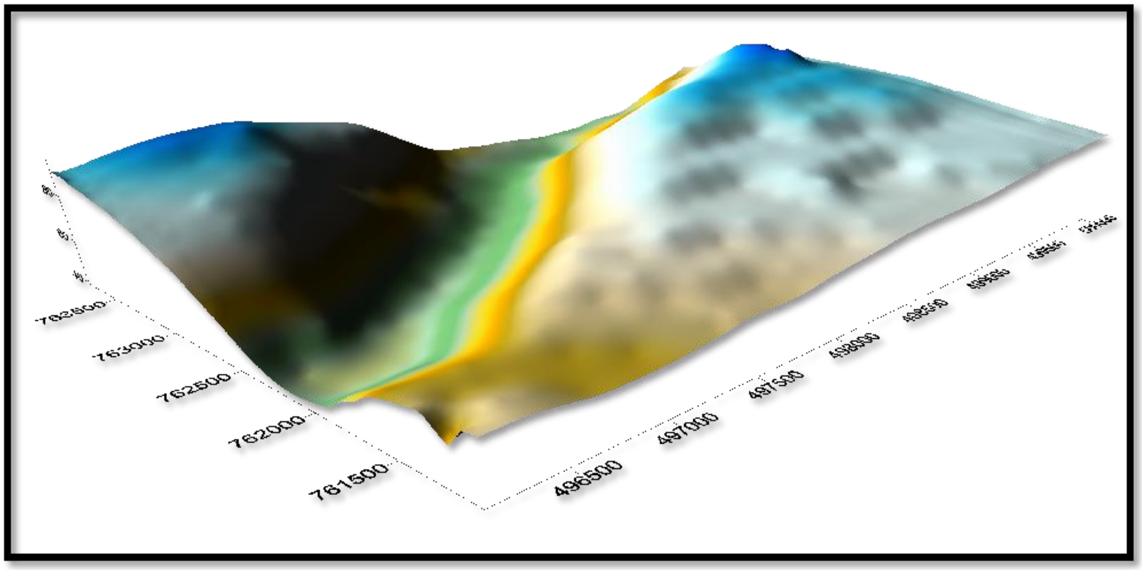

Figure 10: 3D Surface Model of the School (Result of present study, 2017)

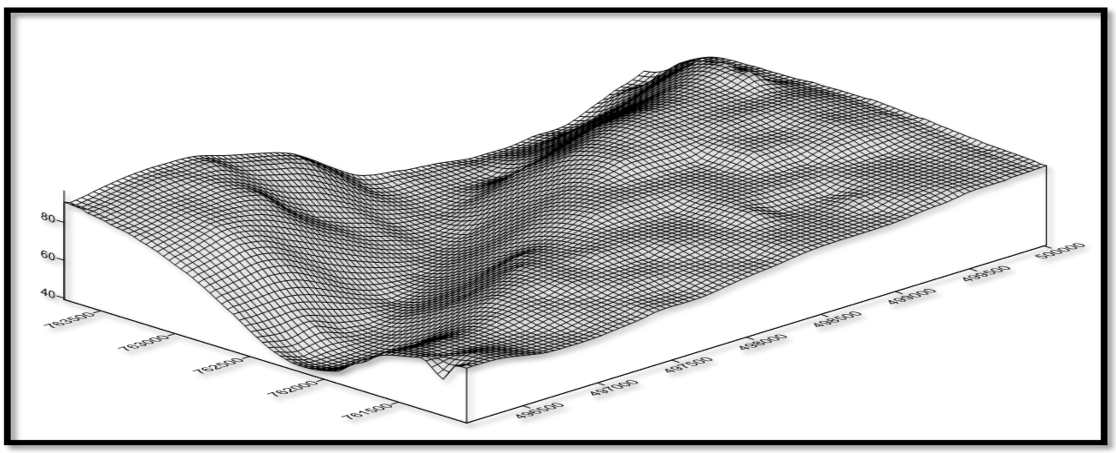

Figure 11: 3D Wire Frame showing the topography of Surface of the School (Result of present study, 2017)

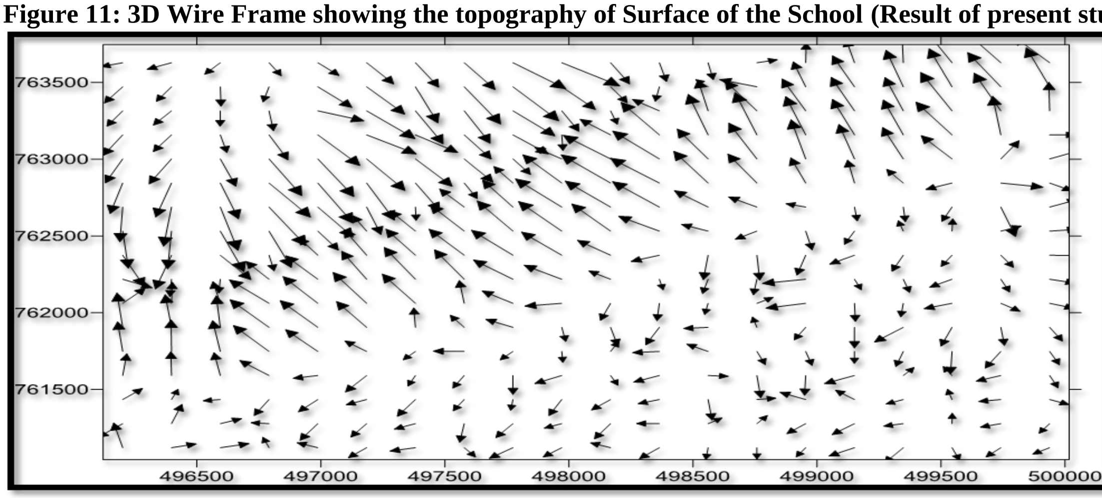

Figure 12: Grid Vector map showing runoff water direction in the School (Result of present study, 2017)

4.0 Discussion of Results

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 school and its surrounding areas. 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.

5.0 Conclusion and Recommendations

Environmental management is no doubt a sine-qua-non for a sustainable built environment. As a resource to any nation, the environment should be well planned, developed, conserved and managed. For this reason there is the need for up to date information about the current status and condition of the existing facilities in a satellite image.

Up to date digital map produced from satellite images on environmental services are needed for proper planning, design and execution of any service project. They are very vital in developmental process, infrastructure maintenance, fault detection and rectification by any utility management scheme. The availability of digital maps of the utility supply network is very necessary for network extension and integration.

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.

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