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Generation of 3-D City Model for Urban Utility Information System Using Digital Photogrammetry & GIS Technology

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Abstract - In the urban environment due to the rapid rate of urbanization and industrialization, it needs proper planning, management and requires up-to date digital spatial information for multifaceted applications with higher accuracy. Digital photogrammetry provides maps and databases to support decision-making and futuristic planning as well as to access the utility services in urban areas for civilians well being. The objective of the study is to access the various urban utilities for civilian's wellbeing and develop a 3D model of the area for planning and monitoring of Dahisar urban area of Mumbai City. Cadastral map (G F/15) and utility information from National Informatics Centre (NIC) has been used to assess household information with each building details. Aerial stereo pairs are used to generate 3D model after data processing and orthorectification by applying LPS software. Attribute data has been attached to each building as a separate layer by using ArcGIS software. Land use / land cover classification has been carried out to identify various utility services sectors like school, hospital, banks, public toilets, commercial area, bus stops etc. The utilities like school and bank are better towards western and south-western part.

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Keywords : Digital Photogrammetry, Orthorectification, Utility Information System.

I. Introduction

Urbanization is a problem which has assumed gigantic dimensions in some of the technically and industrially advanced countries of the world. It means the concentration of population in the economically developed and industrialized centres and other big cities. This leads to much congestion and many social and economic problems. It is now a universally recognized fact that the progress of man depends upon social planning, upon a perfect harmony between man and his total environment. For organised way of urban planning, up to date information about build up areas and urban infrastructure is prerequisite. Digital photogrammetry and GIS techniques can facilitate the planner in decision making to make the urban environment much more suitable for living.

With the rapid development of GIS techniques, 3D GIS have emerged as a reality. Creation of 3D city model using conventional stereo images of aerial photos or satellite images is cumbersome and is a less cost-effective technique for many applications (Jalli and D, 2007). Planners, urban designers, landscape architects, and other planning professionals use computerized visualization techniques to encourage participation of the public for better urban planning. Many of the techniques they employ can be incorporated into a GIS (Meenar and Ambrus, 2006). The use of 3D functions is particularly powerful for the creation of DEMs and 3D visualization models which are used in a very wide range of application for urban planning (Naidoo and Mohamed, 2007). Remote sensing studies in conjunction with urban GIS modelling have the potential to provide the information needed for urban planning and management. Urban utility information system incorporates different data components like spatial, attribute models etc.
3D city models with urban utility information system can be used to support management policies and future planning of urban resources.

II. Objective

For the present study, following objectives have been formulated.

- To create the 3d city model for urban planning and development.
- To assess the utility infrastructure of Dahisar region of Mumbai city by developing utility information system (UIS).

III. Study Area

Mumbai city is the 'Economical Capital' of India. The study area is a part of Dahisar region which is located towards northern side of Mumbai. The study area covers 376011.16 sq. m area and located between 19° 15' North to 19° 15' 20" North Latitude and 72° 51' 40" East to 72° 52' East Longitude. Average height of study area from MSL is only 10 meter.

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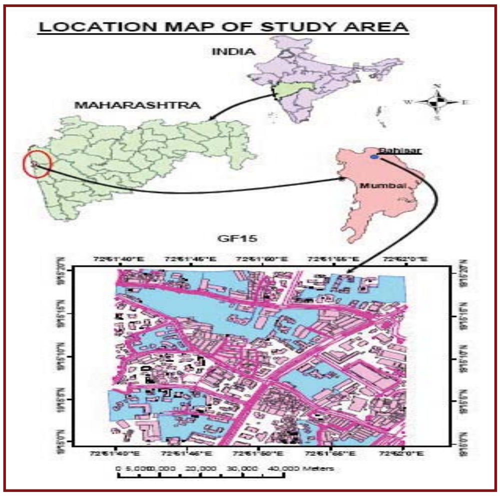

Fig.1 : Location Map

IV. Database & Methodology

Data for present research is used from both primary and secondary sources. From primary source, Ground control Points (GCPs) have been generated by using the GPS. Cadastral map (G F/15) of Mumbai city at 1:1000 scale has been used as a base map. Aerial photographs at 1:6000 scale of the same region have been acquired to generate 3D model. Apart from these, the utility information like apartment name, stores, their utility (Office, Bank, Commercial, Residential etc.) has been collected from National Informatics Center (NIC). This information is further used to create land use/ land cover map of the study area by using ARCGIS software. Aerial photo orthorectification is one of the essential task of our study. Orthorectification is a processing step in which aerial photos are adjusted to correct distortions due to topographic relief, lens distortion, and camera tilt. Using fifteen well distributed GCPs, orthorectification was carried out. The points which can be easily identified on aerial photographs and on ground have been considered for GCPs. For this, mainly road Intersections, corners of buildings, corner of open land plots etc were chosen for GCPs in the stereoscopic neat model area. After Image Orthorectification, images were precisely overlapped on each other which are further used for vecterisation to extract building shape as it gives 3D view of study area.

After feature extraction in LPS software, the data which was in '.dgn' format has been converted in Shape file (.shp) to generate a new personal Geodatabase in ARCGIS software. After generating the personal Geodatabase map of study area, the attribute data of utility information has been attached with feature class with unique id number. Various queries have been generated to assess the utility infrastructure of Dahisar area in SQL.

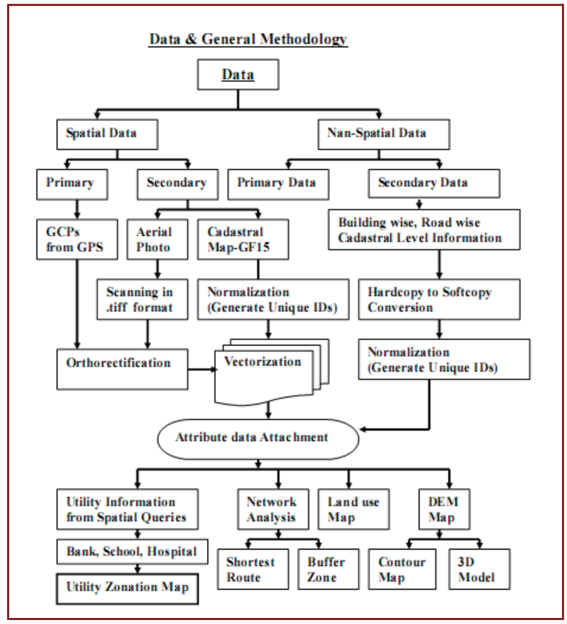

Fig. 2 : Flow Chart of Research Methodology

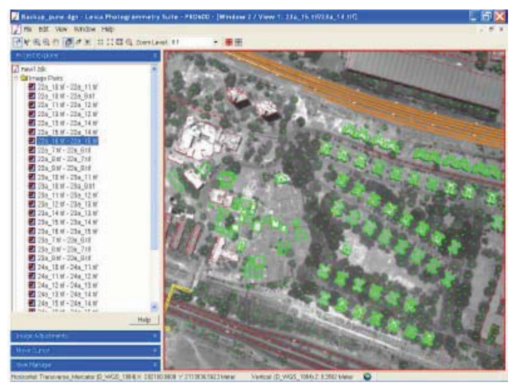

Fig. 3 : Feature Extraction

V. Result and Discussion

a) 3D City model

Three-dimensional city models are usually comprises information about terrain, streets and vegetation in build-up areas. Now a day, interest in 3D city models has risen significantly. These models are very useful to identify illegal constructions with respect to sanctioned FSI. It can also be used for property tax collection. Telecommunication companies use such type of model to find out suitable locations for antenna.

To develop 3D city model, it is important to choose appropriate data and suitable method (Kobayashi, 2007). Instead of airborne laser scanning data, Aerial photographs are mainly used to create 3D city model for the present study. In this research, aerial photographs are used in order to produce DTM or base of the 3D city model. In addition, the other entities that can be placed in 3D city model such as streets, trees, and parking lot have been extracted from same stereo-pairs. The main processes which have been carried out to generate the 3d city model includes orthorectification, stereo model creation, vectorisation, layer extraction and base model development. First of all, orthorectification of aerial photograph has been carried out by using fifteen well distributed GCPs. The points which can be easily identified on aerial photographs and on ground have been considered for GCPs. After Orthorectification, aerial photographs were precisely overlapped on each other and stereo model has been created by using LPS software. Stereo model processing is the process to orient aerial images. The stereo images are then used for the vectorization stage by digitizing the building outline with the help of topomouse and LCS glasses and 3D points have been extracted. These 3d points have local coordinate (x, y) and height information (z). In order to complete the base model for 3D city model, the DTM are generated from 3D points and the buildings outline are draped onto the DTM. Figure 2 shows the process of DTM generation and Figure 3 shows the building outline on DTM. The geometry and the height of the buildings are based on the buildings outlines. At this stage, landscape effect has been added to the model to make the model more realistic by using ArcScene software.

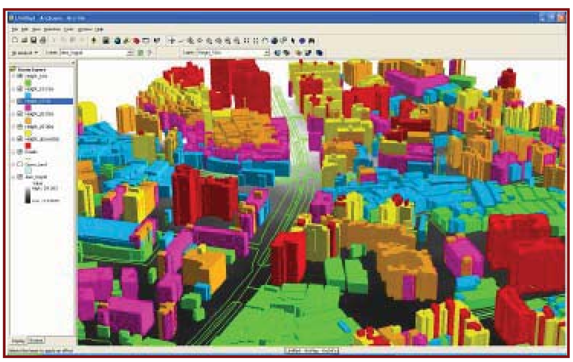

Fig. 5 : Vertical Growth Distribution

By using the 3 D model, the vertical growth map has been created to classify various buildings according to their height as per figure 5, the minimum elevation of a building is 4.5 m and maximum is 60.5 m. With respect to their elevation, build up area is being classified in to six classes. The analysis reveals that 10 per cent buildings are between 10 to 15 m height.

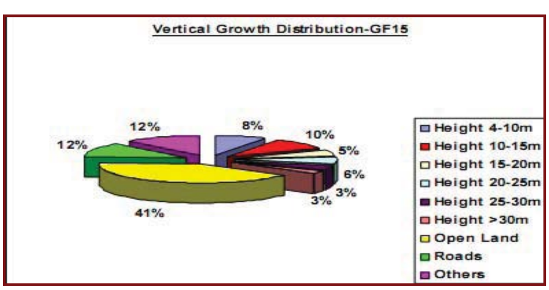

Fig. 4

b) Assessment of Urban Utility Information

GIS is emerging as an important planning, management and operations tool for the utility industries. Utility being the nerve centre and basic infrastructure requirement and authority/ planner must ensure that all the components are functional with no breakdown. The authorities should ensure regulation in consumer services. To facilitate management of such a system, the task is made substantially flexible and the system condition if presented visually on a geographical data, it facilitates easy tacking and attention. Executing a GIS with a defined system design basis will go a long way in successful utility management. By joining spatial and aspatial data like utility information, various queries can be generated to assess utility infrastructure by applying utility information system. With this we can easily identify the locations of various utilities like hospitals, schools, banks, petrol pump, ATM centers, public toilets, government offices, markets etc. The area with sufficient utilities can be easily marked out by applying queries with the help of SQL.

Each utility centre provides facilities to surrounding area which comes under its service zone. In study region, two hospitals are available for providing health facility. Those are Mulgaonar hospital and Sanjeevan hospital. These hospitals are located in south-western part of the study region. By using buffer analysis method, a zone of 150 m has been demarcated. It shows that Mulgaonkar hospital and Sanjeevan Hospital covers 51629.09 sq.m and 48972.46 sq.m area respectively. These areas can be termed as 'Single facility zone' because it has only one source for health facility. The area which comes under two hospital zones (18884.9 sq.m) is known as 'Dual facility zone' because it has two options to avail health facility from both centres. The northern and eastern part is basically lacking in health services.

With respect to school facility, there are four schools in Dahisar area. A buffer zone of 200 m has been created from the school location.

The analysis shows that 52% area has only one school facility, 22.5% area has dual source and 0.5% area has got maximum school facility from three sources. The south-eastern part is having poor school facility. The bank facility is quite satisfactory in western part but it is lacking towards eastern part.

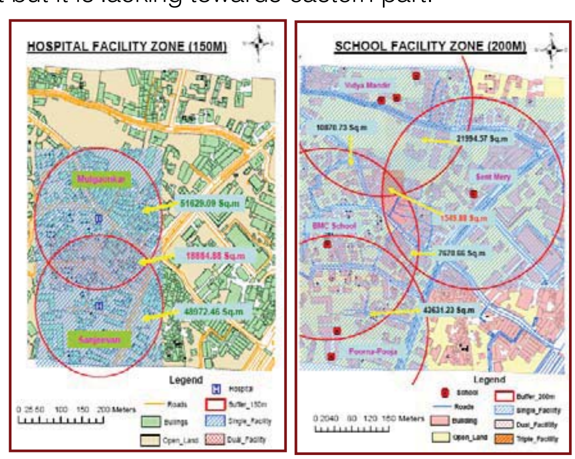

Fig. 6 : Hospital & School Utility Zone

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c) Land Use / Land Cover Map

Land use/ land cover information is prerequisite for many urban planning projects. In this study area, Land is used for various purposes like Residential, Industrial, Commercial, Slum, Open land, roads and other purposes. The land use/ land cover map has been prepared by taking help of ancillary data of NIC and aerial photographs in ARCGIS. Land use map is most important thematic map as it provides information about the present status of land use.

The analysis reveals that Dahisar sub-urban area is dominated by open land with 41 per cent as it indicates lots of future scope for planned development. Out of the total area, residential area is 27.72 per cent and industrial area is only 5.22 per cent.

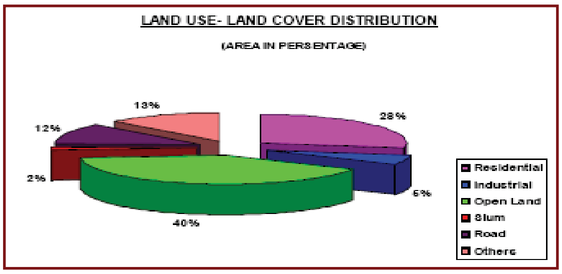

Fig.7 : Land Use/ Land Cover Distribution

d) TIN Map

TIN model of the study region has been generated to study surface topography of the area. To create this model, feature extraction tool of LPS has been used to estimate surface height of the area by point layer. Then this layer has been imported in ArcGIS and according to that TIN model has been generated. The analysis shows that elevation increases from north to south and the average height of this area is 10 m.

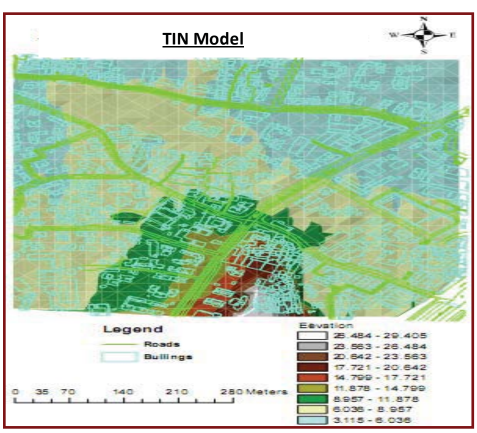

Fig. 8 : TIN Model

VI. Conclusion

In Dahisar region, residential area dominates with respect to other type of land use. The utilities like school and bank are better towards western and south-western part. Hospital services are poor in Dahisar region and there is urgent need to establish some new hospitals in the area. Digital photogrammetry with GIS modelling results in more accurate creation of 3D city model. These models with precise utility information are vital for urban planning and infrastructure development.

Acknowledgment

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