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## Use of High Resolution Google Earth Satellite Imagery in Landuse Map Preparation for Urban Related Applications

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### Abstract

The fundamental data required by urban planners and policy makers is accurate information on current landuse practices in a city or town and how it changes over the past for carrying out various urban planning and management activities. The free satellite imagery provided in global landcover facility (GLCF) which can be used to prepare the landuse maps as attempted in many studies has certain limitations. The images are of lower or medium resolution type and in many cases it may not be possible to obtain the latest image. To overcome this, one has to buy latest high resolution satellite image which is more expensive to purchase and sometimes it may not be possible to get the data due to security reasons. An alternative solution is to utilize Google earth imagery which is open source and provides clear view of buildings, roads, etc. and hence can be best utilized for urban related applications. The present study is an attempt in this direction, in which 340 individual tiles of Google earth images covering Vellore in Tamilnadu were extracted using Elshayal Smart open source software. They were then mosaicked and clipped to facilitate onscreen digitizing using GIS software. The area of various landuse classes was found using the prepared landuse map and zone-wise/ward-wise analysis was also performed. It was found that the area occupied by open land is 56.07 sq.km, which is the highest when compared to other landuse classes. Next to open land, built-up area occupies an area of 28.83 sq.km. The percentage split of all the four landuse classes were 60.69, 31.21, 7.83 and 0.26 for open land, built-up, agricultural and water bodies respectively. Use of Google earth imagery in urban change detection analysis was also explored by utilizing the images of 2007 and 2014. If budget is a constraint in purchasing high resolution satellite imagery, then one could consider utilizing free Google earth images as proposed in the present study for urban related applications.

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## 1. Introduction

Urbanization is a major concern in most of the metropolitan cities in the world. It is said that, between 2010 and 2050, the number of people living in the world's urban areas is expected to grow by 80 percent, i.e., from 3.5 billion in 2010 to 6.3 billion in 2050 (Moss and Neill, 2012). This twofold rise may lead to many urban related problems in world's cities and India is no exception to this. More people are migrating from rural to urban areas for better job opportunities and living conditions in recent decades due to economic growth in the country. Next to Maharashtra and Gujarat, in Tamilnadu, 50% of the total population of the state was living in major cities of the state, which is one of the highest in the country (State Planning Commission, 2012). This shows that most of the cities in the state are experiencing rapid urbanization in recent decades. Urbanization is unavoidable in a developing country like India. However if it is not controlled properly may result in loss of productive agricultural land, deforestation, crowded habitats, water distribution and sewage treatment problems, air and noise pollution, traffic congestion, etc.

Accurate and current urban landuse information is an essential data required by planners and policy makers for carrying out various activities in urban planning and management. For example, the landuse data is useful for urban planners and researchers in preparation of master plan, planning of smart cities and satellite towns, provision of basic amenities and urban infrastructure facilities, analyze the changes that have occurred in the landuse over the past years, prediction of future landuse, urban sprawl analysis, etc. In recent decades, the use of satellite data has replaced the traditional field survey methods in preparing urban landuse maps due to advancements in remote sensing and geographic information systems (GIS). Many studies have reported in India and abroad, in which the authors have collected multi temporal satellite images and using image processing techniques such as unsupervised and/or supervised classification, maps showing various landuse categories at different time periods were prepared (Sudhira *et al.*, 2004; Sun *et al.*, 2007; Jat *et al.*, 2008; Guzelmansur & Kilic, 2010; Basawaraja *et al.*, 2011; Butt *et al.*, 2012; Feng and Li, 2012; Rahman *et al.*, 2011; Sarvestani *et al.*, 2011; Moghadam and Helbich, 2013; Hegazy and Kaloop, 2015). In most of the reported studies, satellite images were downloaded from global landcover facility (GLCF) (GLCF, 2015).

The GLCF provides satellite data at free of cost to promote research in the use of remotely sensed data. However it has certain limitations. The images are having only lower and medium spatial resolution (size of each pixel on the ground) in the range of 30m to 80m collected from sensors such as Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), etc. Another limitation is that it may not be possible to obtain a latest satellite data or the image for the current year. In GLCF, one can get satellite images only upto 2010 or before. The solution to overcome the above limitations with GLCF is to purchase the latest high resolution satellite imagery having spatial resolution less than or equal to 1m either from Indian remote sensing satellites like Cartosat-2 or US based satellites like Worldview-2 or Quickbird. But it may be more expensive to purchase such high resolution images.

An alternative solution is to download Google Earth (Google, 2015) and use the satellite images provided in that for preparing the land use map for the region of interest. The advantage of using Google earth is that it provides the latest satellite imagery having spatial resolution less than 1m. In recent years, most popular image processing and GIS softwares like ERDAS IMAGINE, ENVI, ArcGIS, etc. have provided tools to visualize and import Google earth images. Another advantage of Google earth is that it provides images taken at different time periods which will be very useful for urban planners to perform landuse change detection studies. The only limitation of Google earth is that it may not be possible to obtain the original multispectral band data. That means it is not possible to get the actual pixel numbers or the brightness/reflectance values and hence image classification using unsupervised or supervised techniques cannot be carried out. However, as the spatial resolution is very high, it is possible to visually see on the image, buildings, roads, water bodies, etc. and on-screen digitizing in GIS can easily be performed to prepare the landuse map. Hence in the present study, an attempt has been made to prepare the landuse map using Google earth imagery for Vellore in Tamil Nadu, which experiences tremendous urban growth in recent decades. A detailed step-by-step procedure on how to download the satellite images from Google earth, import them, mosaicking, clipping and performing onscreen digitizing is presented in this paper for the preparation of landuse map. The areas of various landuse classes within corporation zones and wards were calculated and analyzed. The

changes that have occurred in the built-up area over a period of two years was also analyzed to explore the usefulness of Google earth in performing change detection analysis. The following section detailed the literature review; the description of study area is explained in section 3. The section 4 explains the methodology adopted in this study and results are discussed in section 5 followed by concluding remarks in section 6.

## 2. Literature review

A review of important studies which utilized the satellite images in landuse classification for urban related applications was attempted and presented in this section. Sudhira *et al.* (2004) used satellite image from LISS-3 sensor of Indian remote sensing satellite (IRS) having spatial resolution of 23.5m to prepare the landuse map through supervised classification. The landuse map was used to study the urban sprawl along the highway connecting Mangalore and Udupi in Karnataka. Jat *et al.* (2008) used images from various sensors like Landsat MSS (79m. resolution), TM, ETM+ and IRS LISS 3 for preparation of maps depicting landuse across various years and used it to study the urban growth and sprawl pattern of Ajmer city in Rajasthan. Guzelmansur and Kilic (2010) studied the urban landuse changes using the satellite images from Landsat MSS, TM and ETM+ through image classification method. Basawaraja *et al.* (2011) studied the temporal changes in landuse pattern using IRS LISS-3 satellite images of Raichur city in Karnataka. Rahman *et al.* (2011) used IRS LISS-3 satellite image of 2005 to prepare the landuse map through supervised classification technique. The authors mentioned that due to the high cost of very high resolution satellite images such as Worldview-2 having a spatial resolution of 0.46 m with eight spectral bands, it is not possible to purchase and use it even though it has wide variety of applications in the field of urban planning. Feng and Li (2012) analyzed the urban sprawl pattern of Nanjing, China using the landuse maps obtained from Landsat MSS and TM images. Moghadam and Helbich (2013) studied the past urban landuse changes in Mumbai city with the help of landuse maps prepared using the satellite data (Landsat MSS, TM, and ETM+) obtained from GLCF.

In all the above studies reviewed above, it was found that the authors have used satellite images from sensors such as Landsat MSS, TM, ETM+ and IRC LISS-3 to prepare the landuse maps of different years for urban applications. In most of the studies, the images were downloaded from GLCF. Even though GLCF provides satellite data at free of cost, it has certain limitations. The images provided by GLCF are of medium resolution only with pixel size ranging between 30m and 80m. Since it may not be possible to visually see the individual buildings, roads, etc. with this spatial resolution, the landuse maps can be prepared only through automated image classification methods such as supervised or unsupervised classification techniques, which will never yield 100% accurate results. Another limitation with GLCF is that it may not be possible to obtain a latest satellite data or the image for the current year. In GLCF, one can get satellite images only upto 2010 or before. The solution to overcome the above limitations with GLCF is to purchase the latest high resolution satellite imagery having spatial resolution less than or equal to 1m. The Indian remote sensing satellite having such high resolution is Cartosat-2 and US based satellites like Worldview-2, Quickbird and IKONOS also offers images with high spatial and spectral resolution. As pointed out by Rahman *et al.* (2011), it is very expensive to purchase such high resolution images even though they could be used for wide variety of urban related applications.

The present study tries to propose an alternative solution for the above said problems, by utilizing free Google earth images for landuse map preparation as one can able to clearly see individual buildings, roads, water bodies, etc. in Google earth image. The advantage of using Google earth is that it provides the latest satellite imagery having spatial resolution less than 1m. In recent years, most popular image processing and GIS softwares like ERDAS IMAGINE, ENVI, ArcGIS, etc. have provided tools to visualize and import Google earth images. Another advantage of Google earth is that it provides images taken at different time periods which will be very useful for urban planners to perform landuse change detection studies. Even though it has more advantages, only very limited studies have performed on the use of this excellent data source for landuse map preparation (Ohri & Poonam, 2012; Jacobson *et al.*, 2015). The only limitation of Google earth is that it may not be possible to obtain the original multispectral band data and hence image classification using unsupervised or supervised techniques cannot be carried out. However, as the spatial resolution is very high, it is possible to visually see on the image, buildings, roads, water bodies, etc. and on-screen digitizing in GIS can easily be performed to prepare the landuse map. In the present study, an attempt has been made to show a clear methodology on how to perform downloading/importing of

the Google earth image to GIS software, mosaicking of many tiles to single image, clipping to the required area and onscreen digitizing. Urban change detection analysis using Google earth images taken at different time periods was also shown. The details of the study area are discussed in the following section.

### 3. Details of the study area

The study area selected for the present study is Vellore in Tamil Nadu, India. Vellore being close to Chennai and having well connected road and railway network, it experiences a fast and tremendous urban growth after it has been declared as a city corporation in 2008. It is one of the 12 municipal corporations in the state of Tamil Nadu. Fig.1 shows the location of Vellore district in Tamil Nadu and the map of Vellore corporation. It has a total area of 92.4 km<sup>2</sup> and population of 4,84,690 as per the census data collected in 2011. It comprises 4 zones, namely, Vellore fort, Sathuvachari, Shenbakkam and Katpadi. The corporation contains a total of 60 wards with 15 wards in each zone. The main highways that passes through the city are, national highway (NH) number 46 (Chennai – Bangalore (east west corridor)) and NH-234 (Mangalore-Villupuram (North south corridor)). The railway station for Vellore is located in Katpadi on the northern side of the Vellore corporation where the two main railway lines were crossing, namely, Chennai – Bangalore line and Tirupathi- Villupuram line respectively.

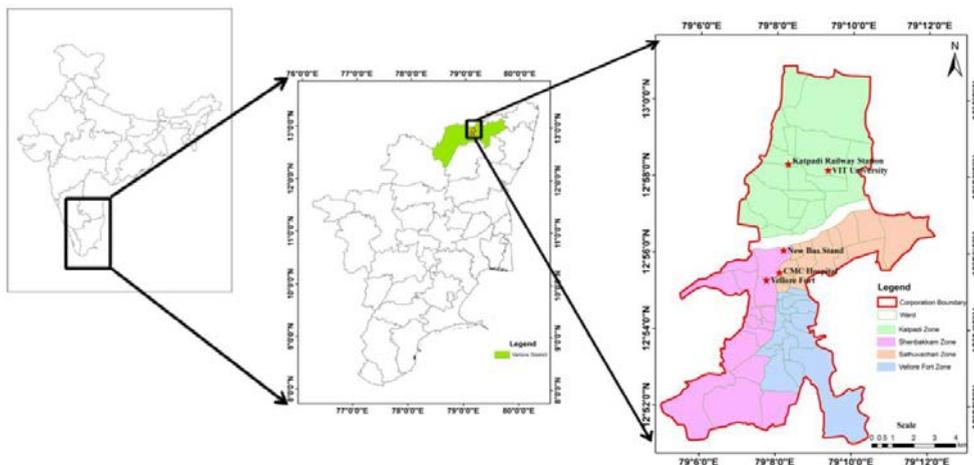


Fig.1. Map showing the location of Vellore district in Tamilnadu (middle) and Vellore corporation (right)

A century before Vellore and Katpadi were two small towns separated by large tracts of agricultural land and Palar river. Over a period of time, the towns have merged to form one continuous urban area, the process of which is called as ‘conurbation’ from an urban planner point of view. The important tourist attractions in Vellore are Vellore fort and Golden temple. Both the places attract large number of tourists throughout the year. Also, Vellore is one of the most preferred educational destinations in our country in both engineering and medicine due to the presence of world class institutions like VIT University and Christian Medical College and Hospital (CMCH). In order to cater the accommodation needs of the faculty and students, during the last 4 decades, many residential areas were formed such as Gandhi nagar, Thiru nagar, Bharathi nagar, VG Rao nagar, Vaibhav nagar, etc. by converting agricultural lands to built-up area. Recently, 98 cities across India were selected by the central government in order to develop them as smart cities at a budget of Rs.50,000 crores. This smart city project aims to improve resident’s quality of life, provide a clean and sustainable environment and facilitate application of smart solutions. The present study area of Vellore corporation in Tamilnadu is one of the 98 cities selected for the smart city project. It may be essential for an urban planner to look at the current landuse pattern before they start planning for a smart city. The present study aims to prepare the landuse map using Google earth image for Vellore city corporation and the following section explains the step by step methodology in order to achieve the desired goal.

#### 4. Methodology

First the toposheets in 1:25000 scale, numbered 57 P/1/SW, SE, NE and NW covering the study area of Vellore corporation were collected from Survey of India (SOI). The toposheets were scanned and georeferenced using the 16 ground control points (GCPs) of known latitude and longitude values using ArcGIS 10 software. The corporation map of Vellore was georeferenced using the SOI toposheets through image to image registration. Locations which can be identified in both toposheet and corporation map such as road intersections, railway crossings were considered during image to image registration. The boundary of the Vellore corporation as seen in Fig.1 is digitized and has been converted from ArcGIS shape file format (.shp) to Google earth compatible format (.kml). The Google earth was downloaded and the digitized corporation boundary in .kml format was opened in Google earth. An open source software called Elshayal Smart (Elshayal, 2015) was downloaded and used to extract the Google earth images that fall within the study area boundary. The advantage of Elshayal smart software is that it downloads the images along with the coordinate information from Google earth and hence the downloaded images can be directly utilized for any kind of GIS analysis without the need for georeferencing. A total of 340 images acquired on December 5, 2014 covering the entire study area were downloaded. The individual images were then mosaicked to form one single image and converted from geographic coordinate system (latitude/longitude) to projected coordinate system (northing/easting) using Universal Transverse Mercator (UTM) projection in Arc GIS 10. The image covering within the corporation boundary was clipped using the digitized corporation boundary map. Finally on-screen digitizing of various landuse classes were performed to prepare the landuse map. The landuse classes that were considered in the present study were built-up area, open land, agricultural area and water bodies.

The built-up area includes all buildings and roads; open land includes barren, rocky, scrub land and residential layouts; agricultural area comprise vegetation and agricultural lands; Water bodies consist of lakes, rivers, ponds and tanks. The built-up area was further subdivided into residential, commercial, industrial, institutional and recreational landuse classes. The residential landuse class includes all dwelling units such as detached, semi-detached houses and apartments. The commercial class includes all shops, stores, markets and shopping centres. All small and large scale industries were comes under industrial landuse category. The institutional landuse includes all educational institutions such as schools, colleges and institutions of higher education and research. Recreational landuse category includes all areas which are used for public recreational purposes such as parks, play ground, etc. Once the landuse map preparation is over, the area of individual landuse classes were calculated. The boundaries of 4 zones and 60 wards as shown in Fig.1 were also digitized and the area of various landuse classes within each zone/wards were also calculated and reported. An important advantage of Google earth is that it provides images taken at different time periods which can be used by urban planners to perform landuse change detection analysis. As a pilot study, one of the wards covering the Vaibhav nagar on the north eastern part of Vellore corporation was taken into account and the change in built-up area was calculated using the landuse maps of 2007 and 2014. The landuse map of 2007 was prepared in the same way as explained before using the Google earth satellite image. The results are discussed in the following section.

#### 5. Results and discussion

The landuse map prepared using Google earth image is shown in Fig.2 (left). The Palar river which separates the Vellore and Katpadi region was not taken into account as it not comes under any of the zones or wards in Vellore corporation. It was found that the area occupied by open land is 56.07 sq.km, which is the highest when compared to other landuse classes. In south and north eastern side of Vellore corporation, open scrub land with babul tree was found in many places and this is one of the reason for open land category to exhibit higher area when compared to other landuse classes. These babul trees consume large quantity of ground water for its growth and hence it results in decline in the ground water table. Next to open land, built-up area occupies an area of 28.83 sq.km. Most of the built-up area above Palar river were of agricultural lands in 1970s and 80s and due to urbanization, they have been converted to residential areas to meet the increasing population growth. But still at some places, the agricultural areas can be found on the eastern side along the Palar river. The total area covered by the agricultural land and water bodies were 7.23 sq.km and 0.24 sq.km respectively. The percentage split of all the four landuse classes were 60.69, 31.21, 7.83 and 0.26 for open land, built-up, agricultural and water bodies respectively.

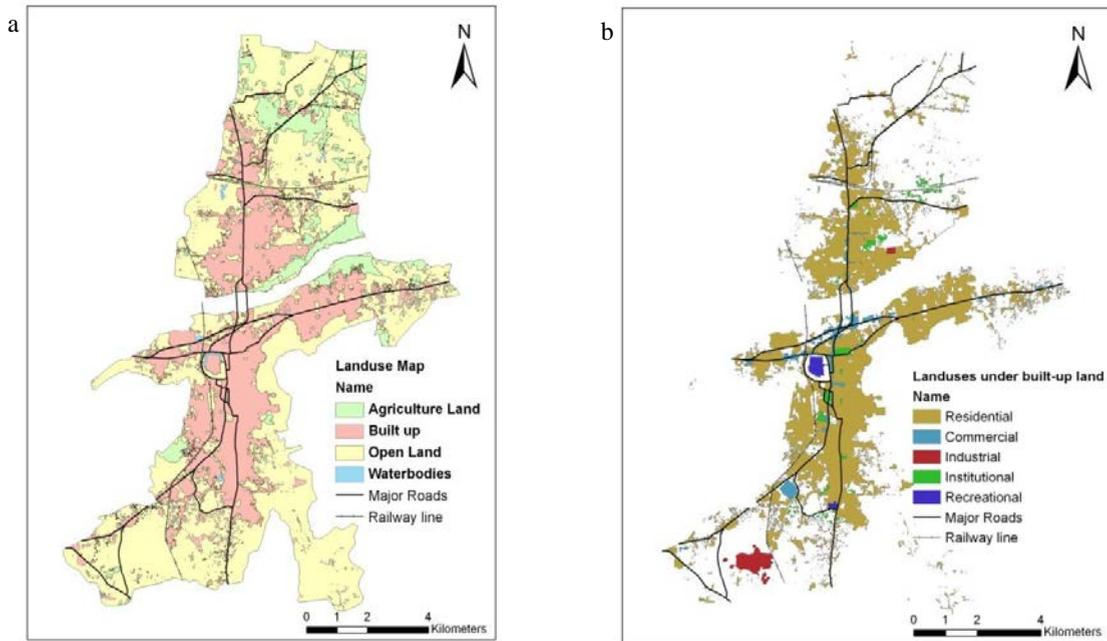


Fig.2 (a) Landuse map prepared using Google earth; (b) map showing the various landuse classes under built-up category (right)

Map showing the various landuse classes under built-up category is shown in Fig.2 (right). It was found that the predominant landuse is residential which occupies an area of 25.67 sq.km. The area of commercial, industrial, institutional and recreational landuse classes were found to be 1.2 sq.km, 0.76 sq.km, 0.87 sq.km, 0.31 sq.km respectively. The zone-wise percentage split of various landuses is shown in Fig.3. It can be seen from Fig.3 that the percentage of open land is high when compared to other landuse classes in all the zones. As expected, built-up area stands next to open land in terms of the area covered by that class. In any municipal corporation, generally the agricultural area would be very less or nil because the land prices will usually be very high within corporation boundary and hence the land owners will convert the agricultural lands to residential layouts. But in Katpadi and Sathuvachari zone of Vellore corporation, still one can find agricultural lands along the Palar river which occupies an area of about 15% and 9% of the total area of that zones respectively. The ward-wise analysis of built-up and agricultural area as shown in Fig.4 says that only in few wards, the agricultural area is found and in most of the other wards, built-up area was found to be predominant with agricultural land present in either negligible amount or nil.

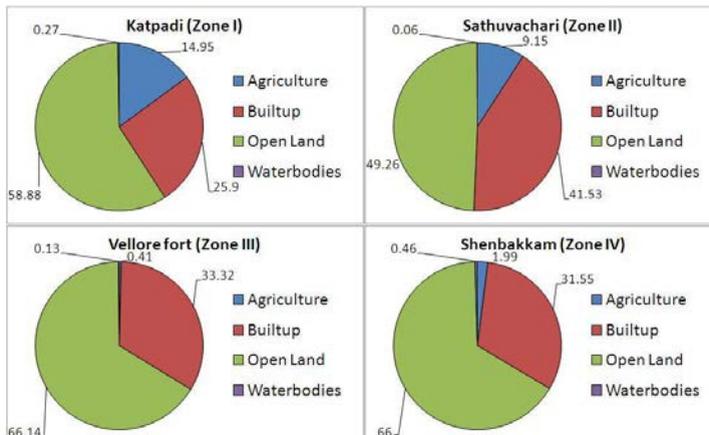


Fig.3. Zone-wise percentage split of various landuse classes in Vellore corporation

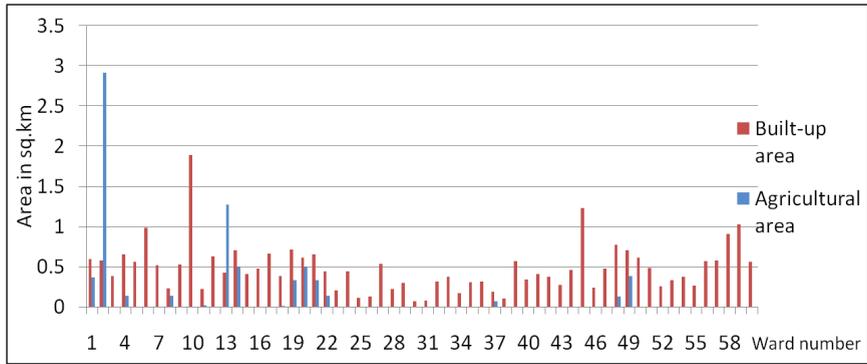


Fig.4. Ward wise built-up and agricultural area in Vellore corporation

In order to show the usefulness of Google earth images in urban change detection analysis, as a pilot study, ward number 8 covering the Vaibhav nagar – Phase 1 and 2 on the north eastern part of Vellore corporation was taken into account and change in built-up and agricultural area was calculated using the landuse maps of 2007 and 2014. Both the landuse maps of 2007 and 2014 were prepared using the Google earth satellite images and shown in Fig.5. It was found that agricultural area has been reduced from 0.252 sq.km to 0.135 sq.km and built-up area has increased from 0.042 to 0.239 sq.km. It is important to mention here that the ward level analysis of changes in landuse is not possible with any of the medium resolution satellite images such as Landsat ETM+, TM or LISS 3. However with Google earth images, one can able to clearly see the individual buildings and hence it becomes possible to perform landuse change detection analysis even at the ward level which will help the planners and policy makers for carrying out various urban planning and management activities.

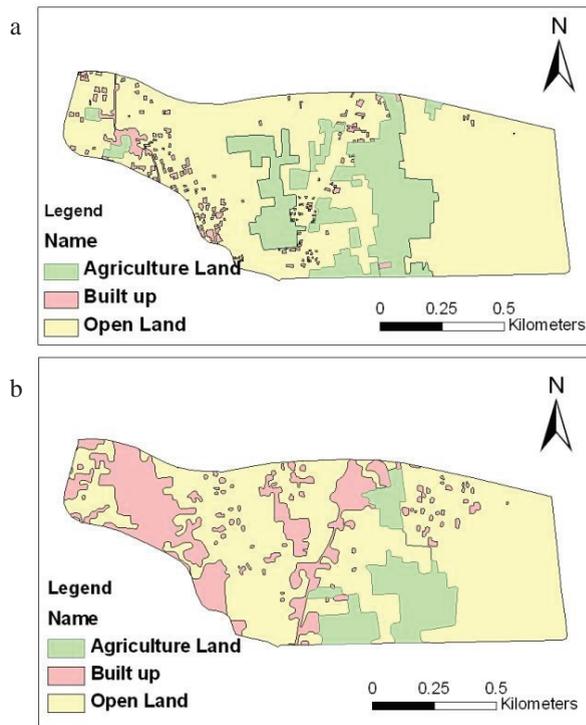


Fig.5. (a) Landuse map of 2007 for ward-8 in Vellore corporation ; (b) landuse map of 2014 for ward-8 in Vellore corporation

## 6. Concluding remarks

In recent decades, most of the Indian cities are facing urbanization as more and more people are migrating to urban areas. In order to have a proper control on urbanization, it is necessary for an urban planner to have accurate information on current landuse practices and should able to know how landuse changes over the years. The satellite images provided in GLCF which can be used to prepare the landuse maps has lower resolution and in most cases, it may not be possible to get the latest image. Purchasing latest high resolution satellite image is very expensive. To overcome the above said limitations, satellite images in Google earth can be best utilized as it is possible to see individual buildings, roads, etc. In the present study, an attempt has been made to show how this excellent source of information can be used in landuse map preparation. As a case study, Vellore in Tamilnadu was considered and 340 individual tiles of Google earth images were extracted using Elshayal Smart open source software. They were then mosaicked and clipped to facilitate onscreen digitizing using GIS software. The area of various landuse classes was found using the prepared landuse map and zone-wise and ward-wise analysis also was performed. Use of Google earth imagery in urban change detection analysis was also explored by utilizing the images of 2007 and 2014. If cost of purchasing a high resolution satellite image is a major constraint, then one could consider utilizing free Google earth images using the methodology proposed in this study for use it in many urban related applications.

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