LAND COVER MAPPING OF KHULNA CITY APPLYING REMOTE SENSING TECHNIQUE

Masum Billah\(^1\) and Gazi Anisur Rahman\(^2\)
\(^1\)Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh, jewelurp@dhaka.net
\(^2\)KTH, Sweden, gazirm74@hotmail.com

Abstract

Information on land use and land cover is required in many aspects of land use planning and policy development, as a prerequisite for monitoring and modeling land use and environmental change, and as a basis for land use statistics at all levels. Remote sensing can provide frequent land cover of an area which can be a great tool to monitor urban land use pattern and change for physical planning of an urban area. As a metropolitan city Khulna has a distinctive land use pattern. Analyzing space born satellite image of the city this distinctive land cover was explored with sufficient accuracy. Analysis of LANDSAT TM image of showed that the largest land cover of Khulna city was vegetation and Built-up area was second.

BACKGROUND

Remote Sensing is the science and technology by which the characteristics of objects of interest can be identified, measured or analyzed without direct contact. Each object has unique and different characteristics of reflection or emission in different environment. An object and it’s environmental condition can be identified using reflected or emitted electro-magnetic radiation from that object. Remote sensing uses this technology to identify and understand the object or the environmental condition through the uniqueness of the reflection or emission.

The use of satellite image is popular world wide but its application is limited in Bangladesh. Remote sensing technology already has been proved as a time saving and economic technology than any other method of spatial purpose map preparation and also for spatial data collection. Data related to land space is an important and basic tool to land use planners. Remote sensing can provide required data in short time with a reasonable accuracy. Planers may use this data to monitor urban growth pattern, urban sprawl, land management, urban structural change, find out potential land for development.

Everything on earth is changing with time. Land cover map can be a powerful tool to compare the changes of an area over time. It is impossible to cover a large area in short time through manual survey but with remote sensing (land cover map) it is an easier task.

Khulna is a divisional head quarter and a metropolitan city but entire city is not yet developed. It still contains paddy land, homestead with orchard and kitchen garden etc. With land cover map it can be revealed how much area of this city is using for what purpose, what are the pattern of land use change over time etc. which will help the policy makers to take necessary measure to ensure sound physical environment of the city.
OBJECTIVES

- To identify possible application and prospect of Remote Sensing in urban planning.
- To produce land cover map of Khulna City, Bangladesh using satellite image with the help of Remote Sensing technique.

APPLICATION AND PROSPECT OF REMOTE SENSING IN PLANNING

Planners have traditionally relied on field surveys and censuses for the data required to carry out their planning tasks. Planners commonly complain that the urban databases developed by traditional methods show incomplete spatial coverage, are poorly organized and based on incompatible criteria (Coiner and Levine, 1979). For some time now, planners have relied on Remote Sensing for urban land use and land cover data to overcome some of these problems (Jensen, 1983; Ford, 1979).

The results of many studies in North America and West Europe demonstrate that high resolution satellite data such as SPOT-HRV and LANDSAT TM are very useful for gathering land use and land cover information (Jadkowski and Ehlers, 1989; Ehlers et al., 1990), land use change detection (Martin, 1986) and urban growth analysis (Kam, 1994). These encouraging results have attracted the attention and interest of developing countries (Kam, 1994).

Application in urban land use mapping

In developing countries satellite Remote Sensing was initially used for surveying, identifying, classifying, mapping and monitoring natural resources. More recently, planners and researchers in developing countries have investigated the ability of satellite data to provide timely and up-to-date information on the urban environment, especially for urban land use mapping (Gastellu-Etchegorry, 1988; UNESCAP/UNDP, 1985; UNESCAP/UNDP, 1987).

A study in Indonesia used digital SPOT-XS data to create an up-to-date land use map for Yogyakarta and its surroundings (Gastellu-Etchegorry, 1988). The study showed that simple spectral classification of SPOT data was faster, more convenient and resulted in better cartographic documents.

Application in monitoring urban growth

Mahavir and Galema (1991) used SPOT data to monitor the growth pattern of Chiangmai, Thailand. They visually interpreted panchromatic print of a SPOT image of 1:20000 scale. They reported that they achieved an overall accuracy of 92.7 percent in the interpretation of the SPOT image. The study concluded that SPOT data are a useful data source for quick and overall assessments of urban growth trends, both quantitatively and qualitatively (Kam, 1994).

Dimyati and Kitamura (1990) used multistage and multidata satellite images to analyse the growth of Samarinda, Indonesia. This study employed digital image analysis techniques to classify 1984 LANDSAT MSS data and 1987 SPOT-HRV data separately. Its resulting images were overlayed to reveal the residential growth process of the study area from 1984 to 1987.
Application in monitoring urban sprawl
Satellite data can also be used to monitor areas experiencing rapid urban sprawl. A study in Barranquilla, Colombia compared SPOT satellite imagery taken in May 1986 with a 1982 city map of Barranquilla to highlight land use changes detection (Brouwer et. al., 1990). The result of the study helped planners to receive data quickly and to redirect their resources at required areas. The satellite data facilitated a quick and accurate urban growth assessment to be carried out, not by a computer or Remote Sensing expert, but by a town planner having only a modest knowledge of Remote Sensing (Kam, 1994).

The applications discussed above show how urban planning and management can be benefited using satellite images. Still, most of the applications of satellite data made by urban planning agencies in developing countries are experimental (Kam, 1994). In Bangladesh this technique can be used for urban land use monitoring and forecasting future land use. Traffic management and planning in an already developed city like Dhaka is very difficult. In this case high resolution satellite image can help to select necessary measure. Encroachment of open space in urban area can be identified applying Remote Sensing. Remote Sensing can find out rain water or flood water stagnation in urban area very efficiently for necessary measures. Suitable land space for future urban growth can be found out using satellite image and planners can guide urban growth thereby for sound urban development. For linear utility service network design the suitable way and barriers can be assessed through Remote Sensing technique. In fact there are many other prospects of Remote Sensing in urban planning which have to be explored through research.

PRESENT SITUATION OF BANGLADESH
Emergence of Geographic Information System (GIS) and Remote Sensing technology as an efficient tool for detailed survey, mapping, modelling, monitoring and analysis especially in countries like Bangladesh has paramount importance. In recent days in Bangladesh GIS and Remote Sensing technology has been applied in diverse sectors in a limited scale without a long term planning and management strategy. It is currently applied in both public and private sectors, at NGO’s, research organization and universities. In public sector application of these tools are mainly centred on agencies, which are being supported by foreign fund. At present GIS and Remote Sensing application are limited in the field of water resources management, agriculture and forestry in Bangladesh (Nasreen, 1999).

Some factors affected the successful implementation of this technology; they are attributed as skilled manpower, accessibility of Remote Sensing data and topographical maps and lack of coordination among the users. Poor technical supports from the vendors/suppliers are identified as one of the majors constrains for the operationalization of the Geoinformatics technology in Bangladesh. Apart from these, progress in acquiring and applications of GIS or Remote Sensing technology is hampered due to lack of sufficient financial and technical support from the Government on time. Lack of digital data format, standard and archiving procedures is one of the threats in the lifetime existence of the GIS and Remote Sensing databases (Nasreen, 1999).

There is an urgent need for long term planning and management strategy in order to make an appropriate use of this technology for the sustainable development of the country. Awareness among the policy makers, different professional and academicians need to be increase for the existence and sustainable use of this technology in the present and future.


STUDY AREA

The study area for this study was Khulna City of Bangladesh. Geographically, Khulna lies at 22°49’ north latitude and 89°34’ east longitudes. Its mean elevation is 7 feet above Mean Sea Level (MSL). Khulna City has not yet grown enough though it is a divisional headquarter. But in the last few years its growth rate is noticeable. Figure 1 shows the study area.

WORKING PROCEDURE TO PREPARE THE LAND COVER MAP

Land cover is the observed physical cover, as seen from the ground or through Remote Sensing, including the vegetation and human constructions (buildings, roads, etc.) which cover the earth's surface.

In this study a land cover map of Khulna city was prepared. The satellite image was classified in five land cover classes. The classes were:

1. Vegetation
2. Built-up Area
3. River/Deep Water
4. Shallow Water
5. Open Ground
**Used data/satellite image**

LANDSAT TM image was used for this study (Table 1). The properties of the image were:

- **Image Sensor:** LANDSAT TM
- **Image Format:** BIL
- **Number of Lines:** 2185
- **Number of Pixels per Line:** 1441
- **Spatial Resolution:** Band 1-5, 7 30m x 30m and band 6 120mX120m
- **Spectral Resolution:** 7 BANDS (1, 2, 3, 4, 5, 6, 7)

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength (µm)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.45-0.52</td>
<td>Coastal water mapping, soil vegetation differentiation, deciduous, coniferous differentiation</td>
</tr>
<tr>
<td>2</td>
<td>0.52-0.60</td>
<td>Green reflectance by healthy vegetation, excellent for pollution studies.</td>
</tr>
<tr>
<td>3</td>
<td>0.63-0.69</td>
<td>Chlorophyll absorption for plant species differentiation identifies contrast between the vegetation classes.</td>
</tr>
<tr>
<td>4</td>
<td>0.76-0.90</td>
<td>High reflectance for the vegetation, urban areas less reflective than the vegetation. Soil-crop and land-water contrasts are emphasized.</td>
</tr>
<tr>
<td>5</td>
<td>1.55-1.75</td>
<td>Important for the crop identification, crop water content and soil moisture content.</td>
</tr>
<tr>
<td>6</td>
<td>10.4-12.5</td>
<td>Hydro thermal mapping</td>
</tr>
<tr>
<td>7</td>
<td>2.08-2.35</td>
<td>Plant heat stress</td>
</tr>
</tbody>
</table>

**Image registration and rectification**

Image Registration is the technique for transforming the image co-ordinate to the real world co-ordinate. Geocoding Wizard of ER Mapper was used for image registration and for registration, rectification and image classification the source image was converted from ERDAS LAN format to ER Mapper ERS format (Figure 2). The parameters of geocoding were:

- **Geocoding type:** Polynomial
- **Polynomial order:** Linear
- **GCP picking method:** A pre registered image of the area.

![Image Registration Process](image.png)

**Output coordinate space**

Datum: INDIAN60
Projection: NUTM46
Coordinate type: Eastings/Northing
**Rectification**

Lines: 740  
Cells: 530  
Cell dimension: 30X30  
Null cell value: 0

**Image enhancement**

Image enhancement makes image cells prominent to understand image features on display device. This procedure makes it easy to identify and select ROIs (Region of Interest). In this study linear stretching and filter operations was performed for image enhancement.

**Bands selection for display**

Source image (LANDSAT TM) of this study contained 7 spectral bands. For display purpose 3 bands were selected which helped selection of training areas. For this study R: 7  
G: 4  
B: 3 were found suitable.

**Image classification**

**Training stage**

In training stage location, size, shape and orientation of each pixel type for each class was analysed to categories the satellite image accordingly. Some regions have been selected from Khulna City area for five land cover class through training process. The locations of ROIs are presented in Figure 3a. The features of the regions are described in Table 2.

![Figure 3: (a) Selected regions for supervised classification. (b) Land cover map of Khulna City, Bangladesh.](image-url)
Table 2: Features of selected region for classification.

<table>
<thead>
<tr>
<th>No. of region</th>
<th>Open land</th>
<th>Built-up Area</th>
<th>Vegetation</th>
<th>Stagnant/ shallow water</th>
<th>River/ deep water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cells</td>
<td>34</td>
<td>590</td>
<td>374</td>
<td>18</td>
<td>515</td>
</tr>
<tr>
<td>Area in acres</td>
<td>3.06</td>
<td>131.21</td>
<td>33.66</td>
<td>1.62</td>
<td>46.35</td>
</tr>
<tr>
<td>Area in hectares</td>
<td>7.56</td>
<td>53.11</td>
<td>83.18</td>
<td>4.00</td>
<td>114.53</td>
</tr>
</tbody>
</table>

Classification stage

Each pixel was categorised into land cover class to which it closely resembles. If the pixel was not similar to the training data, then it was labelled as unknown. Supervised classification of ER Mapper was used for image classification. ‘Minimum Distance Classification’ was used as it gave best result among all supervised classification available in ER Mapper.

Output

Classified image was exported from ER Mapper image format ERS to BIL format to make it computable with ArcView. The classified image was converted to GRID format for spatial analysis in Spatial Analyst of ArcView. Khulna City area was separated from the rectangular GRID applying an Avenue Script. Figure 3b presents the result.

LAND COVER ANALYSIS

The total area of each land cover was calculated from total GRID cell number of each land cover. The result is presented in Table 3. Among 12537.3552 acres area of Khulna City 6091.546 acre was vegetation coverage. The second largest land coverage was build-up area which was 4466.2368 acre. The other area coverages are river/deep water 1281.9136 acre, shallow water 402.7664 acre and 294.9024 acre in open ground.

Table 3: Land area in different land cover in Khulna City.

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>No. of Cells</th>
<th>Area in Acres</th>
<th>Area in Hectares</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>27390</td>
<td>6091.536</td>
<td>2465.10</td>
<td>48.59</td>
</tr>
<tr>
<td>Buildup Area</td>
<td>20082</td>
<td>4466.2368</td>
<td>1807.38</td>
<td>35.62</td>
</tr>
<tr>
<td>River/Deep Water</td>
<td>5764</td>
<td>1281.9136</td>
<td>518.76</td>
<td>10.23</td>
</tr>
<tr>
<td>Shallow Water</td>
<td>1811</td>
<td>402.7664</td>
<td>162.99</td>
<td>3.21</td>
</tr>
<tr>
<td>Open Ground</td>
<td>1326</td>
<td>294.9024</td>
<td>119.34</td>
<td>2.35</td>
</tr>
<tr>
<td>Total</td>
<td>56373</td>
<td>12537.3552</td>
<td>5073.57</td>
<td>100</td>
</tr>
</tbody>
</table>

Though Khulna became Metropolitan City at 1984 it still contains 48.59 percent green land (Vegetation) and only 35.62 percent build-up area. The build-up area is mainly concentrated in two clusters. The first cluster is around Khalishpur area and another cluster is around (Central Business District) CBD area. Also a linear growth pattern along Rupsha and Bhairab River is prominent in the growth pattern of Khulna City.

CONCLUSION

Space borne satellite image can provide up to date information about an area. This information can be an important tool for the planners. In fact in context of Bangladesh Remote Sensing technology is an unexplored field. By using this rarely used tool land cover map of Khulna City was prepared in this study with reasonable accuracy. So this technology can be used to other cities of Bangladesh to monitor urban growth pattern.
REFERENCES


