REMOTE SENSING TECHNIQUES FOR LAND USE/LAND COVER MAPPING IN MAHI RIGHT BANK CANAL COMMAND AREA, GUJARAT

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ABSTRACT
Remote Sensing (RS) data has become helpful in effectively managing the natural resources for sustainable development. Understanding and mapping the land use/land cover (LU/LC) pattern in canal irrigation command area is necessary for its effective management. The present study deals with land use/land cover mapping in MRBC (Mahi Right Bank Canal) command area of Gujarat state. RS digital data of IRS-P6 LISS-III sensor acquired on February 8, 2004 and IRS-1D LISS-III sensor acquired on November 26, 2002 were analyzed using digital image processing techniques. NDVI thresholding was used to separate the vegetation and non-vegetation areas, so that each category can be treated separately. In the next stage under vegetation and non-vegetation category for each date, K-means unsupervised classification was carried out using all four bands (Green, Red, NIR and SWIR) LISS III data as input. Using logical modeling approach the maps generated from November and February data were combined together, to get information about double and single cropped area. The results indicated that double-cropped area dominated most of the region except for the tail end of MRBC command area, where mostly Kharif rice is grown, which can thrive in salt affected area. The LU/LC map typically shows the inequity in canal water distribution.

Key words: Remote Sensing, LU/LC, MRBC, DN value etc.
1. INTRODUCTION

Remote sensing data are an important source of information for land use mapping. It has proved to be a very effective means of developing an integrated information system that can meet the challenges of managing lands for meaningful and sustainable utilization. Land use is the way in which, and the purposes for which, human beings employ the land and its resources: for example, farming, mining, or lumbering. Land cover describes the physical state of the land surface: as in cropland, mountains, or forests. Land use and land cover information is the basic prerequisite for the conservation and management of land, water and vegetation resources. Information related to spatial distribution of various classes of land use/land cover and their changes is desirable for planning, management and monitoring programs at local, regional and national levels. This information not only provides a better understanding of land utilization aspects but also play a vital role in the formulation of policies and problem required for development planning. Srivastava and Gupta (2001) reported that spatial distribution of land use/land cover information is desirable for any planning, management and monitoring programs at local, regional and national levels. This information not only provides a better understanding of land utilization aspects but also plays a vital role in the formulation of policies and program required for developmental planning. NRSA/DOS has carried out land use/land cover mapping for Agro-Climatic Zone Planning covering the 442 districts in the country on 1:250,000 scale using two seasons (Kharif and Rabi cropping season). In this IRS LISS I data of September to November was used for Kharif season and February to May was used for Rabi season. The project had followed a 22-fold classification scheme. Brahmabhatt et al. (2000) developed a classification scheme for land use/land cover mapping of a command area by modifying the national level land use/land cover classes to take into account the local classes present in the command area. Agrawal et al. (2003) have used NDVI (Normalized Difference Vegetation Index) data product of SPOT Vegetation sensor for land use and vegetation mapping of South Central Asia. This work has been done as a part of the Global Land Cover mapping project. Luong (1993) opined that the changes in land use/land cover due to natural and human activities can be observed using current and archived remotely sensed data.

2. STUDY AREA AND DATA USED

The Mahi Right Bank Canal (MRBC) command area in Kheda district of Gujarat state lies between 22°26' N to 22°55' N and 72°49' E to 73°23' E (Figure 1). The canal structure of MRBC comprises main canal (73.60 km length) which has 6 branch canals (total length 223 km) with 38 distributaries. The total culturable command area (CCA) under MRBC is 2,12,694 ha. The average annual rainfall in MRBC command area is 767 mm which spread over 35 rainy days. Physiographically, the command area of MRBC falls under the flood plains of the Mahi River. The climate of MRBC...
command is semi-arid. To prepare land use/land cover map of MRBC command area, following remote sensing and ancillary data are used.

2.1. Remote Sensing Data
For preparation of land use/land cover map the digital IRS-P6/1D LISS-III sensor data were used (Table 1.)

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Sensor</th>
<th>Path/Row</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRS P6</td>
<td>LISS-III</td>
<td>93/56</td>
<td>January 15, 2004</td>
</tr>
<tr>
<td>IRS P6</td>
<td>LISS-III</td>
<td>93/56</td>
<td>February 08, 2004</td>
</tr>
<tr>
<td>IRS 1D</td>
<td>LISS-III</td>
<td>93/56</td>
<td>November 26, 2002</td>
</tr>
</tbody>
</table>

2.2. Ancillary Data
The ancillary data includes statistical information and spatial data of canal network, command boundary, and topographical maps. The MRBC command area is spread over nine 1:50,000 Survey of India (SOI) toposheets, namely, 46 B/6, B/7, B/10, B/11, B/14, B/15, 46 F/1, F/2 and F/3. Out of these, there are four main sheets (46 B/10, B/11, B/14 and B/15), which are completely covered by the command area.

![Figure 1](image)

**Figure 1** Location Map of Mahi Right Bank Canal (MRBC) Command

3. METHODOLOGY
The methodology adopted for preparation of land use/land cover map shown with help of flow chart in Figure 2. Digital image processing techniques have been used for preparation of land use/land cover map. The first step in digital analysis was the georeferencing the master image. The January 15, 2004 image was considered as the master image since the ground control points (GCP’s) were very clear. This image was first geo-referenced by taking various control points from SOI toposheets. Subsequently, the February 08, 2004 and November 26, 2002 image were geo-referenced by taking image-to-image GCP’s. During all these procedures it was tried to keep the RMSE (root mean square error) of GCP model within 2-3 pixels during map-to-image registration and less than 0.5 during image-to-image registration.

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However, the detailed methodological approach for land use/land cover was carried out in following three main steps.

![Flow Chart of Adopted Methodology](image)

**Figure 2** Flow Chart of Adopted Methodology

### 3.1. NDVI Thresholding

NDVI (Normalised Difference Vegetation Index) thresholding was carried out to separate the vegetation and non-vegetation areas, so that each class can be treated separately in later stages. The NDVI was computed as follows:

\[
NDVI = \frac{(NIR - R)}{(NIR + R)}
\]

Where: NIR = Digital number of the pixel in Near-Infrared band, and 
R = Digital number of the pixel in Red band

After analyzing the spectral reflectance, and corresponding NDVI values of vegetation pixels in both the images (26th November and 8th February) the following logic was applied to discriminate between vegetation and non-vegetation areas. In case of 26th November data, NDVI value greater than or equal to 0.05 was classified as vegetation class and NDVI value less than 0.05 was classified as non-vegetation class (Figure 3). While, in case of 8th February data, NDVI value greater than or equal to 0.25 was classified as vegetation class and NDVI value less than 0.25 was classified as non-vegetation class (Figure 4).

![Vegetation & Non-vegetation differentiation using NDVI Thresholding for 26th Nov. Data](image)

**Figure 3** Vegetation & Non-vegetation differentiate using NDVI Thresolding for 26th Nov. Data
3.2. K-Means Unsupervised Classification

Separate masks (bitmaps) were generated for vegetation and non-vegetation classes for each date. Under each mask for any date, K-means classification was carried out using four bands (Green, Red, NIR, and SWIR) as input. Thus, the vegetation classes were divided into crop, plantation, scrublands and fallow. The non-vegetation classes were divided into, urban, wasteland, salt affected area, fallow, water bodies and water logged area. However due to poor discrimination among themselves, the overlapping classes such as urban, wasteland and salt affected area were combined into a single class. Further digital numbers (DN) of different land use/land cover classes analyzed in different bands (Green, Red, NIR, and SWIR) for each dates figure 5.
4. RESULTS AND DISCUSSION

Using logical modeling approach the LU/LC maps generated from February, 2004 IRS-P6 LISS-III and November, 2002 IRS-1D LISS-III were combined together, to get information about double and single cropped area. Figure 3 and Figure 4 show that vegetation and non-vegetation classes differentiate using NDVI thresholding technique, for Kharif and Rabi season respectively. In each of the figures, there are three images. First image (a) shows the vegetation mask (yellow color) on the LISS III FCC. Since all the classes are hidden behind the mask only water bodies, urban area, wasteland and salt affected land are seen. Similarly when the non-vegetation mask (cyan) overlaid on image (b) only vegetation classes are seen. That is why the
image looks red, and the tone of the image varies depending upon the vegetation condition. In the image (c) both the mask are combined image and overlaid on the image. No portion of image is seen; only 2 classes of vegetation (yellow) and non-vegetation (blue) is found. Further K-means classification was carried out within in each mask to get different land cover classes. An analysis of digital numbers of different land cover/land use classes in different bands during two dates, i.e. November 26 and February 8 (Figure 5) showed that water has low digital number in all the bands. This is because water absorbs radiation in all bands. However among all the bands NIR and SWIR had lowest DN value for water. Urban, salt affected land and sand had high DN values in all the bands and in both the dates. That creates difficulty in separating these three classes and them always overlap in the classification. Among these three classes sand had highest DN value in all the bands. Crop had high DN value in NIR band and low DN value in red and SWIR bands. Fallow land produced low DN values in all the bands and all the dates; however those were not as low as water body. The computed statistics of LU/LC classes as derived from the two date remote sensing data is shown in table 2. The double season crops occupied the maximum area showing MRBC command is predominantly an agriculture area. Single season crop area was more in Kharif season than in Rabi season. The LU/LC map showed (Figure 6) that double crop dominated most of the region except for the tail end, where Kharif crop is mostly rice which can thrive in salt affected area. Tail end is also dominated by scrubland the land cover map typically shows the inequity in canal water distribution the tail end mostly having single season crop.

Table 2 Land Use/Land Cover Statistics for MRBC Command

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Land Use/Land Cover Classes</th>
<th>No. of Pixels</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rabi crops</td>
<td>669156</td>
<td>36954</td>
</tr>
<tr>
<td>2</td>
<td>Kharif crops</td>
<td>1688056</td>
<td>93223</td>
</tr>
<tr>
<td>3</td>
<td>Double season crops</td>
<td>2682553</td>
<td>148143</td>
</tr>
<tr>
<td>4</td>
<td>Waterbody &amp; waterlogged</td>
<td>84177</td>
<td>4649</td>
</tr>
<tr>
<td>5</td>
<td>Urban, wasteland &amp; saline area</td>
<td>435590</td>
<td>24056</td>
</tr>
<tr>
<td>6</td>
<td>Scrubland &amp; fallow land</td>
<td>712610</td>
<td>39353</td>
</tr>
</tbody>
</table>

5. CONCLUSION

The present study demonstrates the usefulness of satellite data for the preparation of land use/land cover maps depicting existing land classes for MRBC command by utilizing digital image processing techniques. Satellite remotely sensed data become useful to identify lands under management practices, which is critical to a better understanding land utilization pattern and its planning. For development and monitoring the land utilization pattern, preparation of land use/land cover map is necessary. Remote sensing technique is a very useful and less time consuming for land use/land cover mapping.
REFERENCES


AUTHOR’S BIOGRAPHY

Vijendrakumar M. Patel received the B.E. Civil Engineering, M.E. Civil Engineering and Ph.D. in Engineering & Technology (Thesis Submitted). He published more than 20 research papers in reputed SCI Journal, International Journals and International/National Conferences. He has presented many research papers in International/National Conferences/Symposiums. He has more than 10 years of research and academic experience at Indian Space Research Organization (ISRO), Ganpat University, Pandit Deendayal Petroleum University (PDPU) and Government Polytechnic. He has supervised many PG students.

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