CHAPTER 6

RESULTS AND DISCUSSION

6.1 OBJECT ORIENTED ANALYSIS

Urban area mapping and creation of Geographic Information System is one of the current area of research in survey and urban planning department from the national and international level. Because of recent technological advancement in the space born satellite remote sensing, where produces higher spatial resolution satellite data. For the low resolution remote sensing data, pixel based image classifications were produces a reasonable result. For higher resolution remote sensing data, the complexity increases for image classification compared to pixel based image analysis. Where as the object oriented image analysis produces meaningful information compare to pixel based method. The above method involves segmentation and then classification of images. In this study fuzzy based optimized segmentation process and classification is attempted. The above analysis results are discussed below.

6.2 OPTIMISATION OF SEGMENTATION PARAMETERS

The segmentation parameters were determined based on trial and error process. The initial value of the scale parameter has been taken as the value at which the objects start growing. The next higher values of scale parameter are solved according to the growth of the object. The color, shape,
compactness and smoothness values were selected according to the characteristics and sharpness of object.

6.2.1 Segmentation for Buildings

The selection of the initial value of the segmentation parameter was based on growth of the sub-objects. It is observed from Figure 6.1(a) that for the scale parameter of 10, the creation of sub-objects (grouping of pixels) produces unmeaningful number of sub-objects while compared to 20. Therefore, the initial scale parameter value was taken as 20 so that the segmentation of images into an object starts. The guideline mentioned in section 6.3 is followed for the subsequent steps (Levels) for further selection of the scale parameter as well as to determine the weighs between color to shape and compactness to smoothness.

![Figure 6.1 Selection of initial segmentation parameters](image)

Table 6.1 indicates that the selected segmentation parameters for the building feature for the consequent level. A typical sample of building feature is selected and its growth is observed, which is shown in Figure 6.2. It is inferred that, at level 1 the number of sub-object formed were higher
(36 nos) than the other levels. At level 1 the membership grade value (percentage of object belonging to a particular category) is 0.029, which represent that further segmentation is needed. As the object is allowed to grow at each level, the number of sub-object were observed to be lower (Level 2 - 20, Level 3 - 5, Level 4 - 2) than previous level. Whereas at level 5 the object is observed as a single object, ie each building object is segmented as one entity (all the sub-object are merged as one). The segmentation process ends at this level and its also called optimized segmented level. By increasing this level further, the nearby class will merge with the existing class. (E.g. the vegetation class will merge with building class), this process is called over segmentation. Therefore, segmentation were started at 5th level itself in order to avoid the over segmentation.

Table 6.1 Segmentation Parameter for building feature

<table>
<thead>
<tr>
<th>Level</th>
<th>Scale parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No. of sub-objects</th>
<th>Membership Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>35</td>
<td>0.029</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>20</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>5</td>
<td>0.10</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>110</td>
<td>0.1</td>
<td>0.9</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Segmentation at different level of a typical building feature at Anna University study area.
Figure 6.2 Segmentation of typical building class at different levels
**Fuzzy Membership Grade:** It is computed based on the percentage of object belonging to the particular feature. The value is computed at each level of the segmentation. For the building, as shown in Figure 6.3, at level 1 the object is segmented into 40 numbers of sub-objects. In level 2, 3 and 4 number of sub-object are 20, 5, 2, and 1 for which the fuzzy membership grade values are 0.025, 0.05, 0.10, 0.5 and 1. Further increasing the segmentation upto level 6 the object gets over segmented. Hence, the optimal segmentation is level 5.

**Fuzzy Membership Function for scale parameter:** Figure 6.3 shows that the segmentation parameter (0 to n) is represented in x axis and its membership grade (0 to 1) is given in Y axis.

![Fuzzy Membership function graph for scale parameter of building class](image)
From the Figure it is inferred for the scale parameter value from 20 to 60, the increase in membership grade value was obtained as 0.08. And from 60 to 80, increase in membership grade value was obtained as 0.4. Similarly for 80 to 110 the increase in membership grade value is 0.4 to 1. From the above analysis it is inferred that, the merging of object were slow for the scale parameter of 20 to 60 because of large number of heterogeneous object were presented in the building top surface. And by increasing the scale parameter from 60 to 110 heterogeneity were reduced so that the homogeneous objects were formed.

The Fuzzy Membership Function of the above phenomena is represented below.

\[
f_{xy} = \begin{cases} 
0 & x \leq 20 \\
0.029 + 0.00105 (x - 20) & 20 < x < 40 \\
0.05 + 0.002 (x - 40) & 40 < x < 65 \\
0.1 + 0.0162 (x - 65) & 65 < x < 90 \\
0.5 + 0.025 (x - 65) & 90 < x < 110 \\
1 & x \leq 110
\end{cases}
\]

The above membership functions and its graph can be used for the creation of automation. For example, to execute the segmentation process of building class to any other area, the scale parameter value of building feature can be interpreted with the membership grade (level) from graph or can be derived from the functional equation (6.1).

**FMF for color and shape:** The Fuzzy Membership Function graph for building features color and shape parameter is represented in Figure 6.4. The x axis indicates membership grade and y axis indicates shape and color parameters values.
The summation of color and shape parameter is always considered to be unity. For the segmentation of building the color parametric value is 0.8 to 0.1 at the same time shape value is 0.1 to 0.9. From figure 6.4, it is inferred until the parametric value of 0.5 for both the cases, there is a minimum increase in the membership grade, which indicates poor segmentation. Once it crosses 0.5, the color and shape membership value get increased rapidly. Because less weightage is assigned for color and more weightage is assigned for shape.

Fuzzy Membership Function for color factor is as follows

\[
 f_{color} = \begin{cases} 
 0 & x > 0.8 \\
 0.029 - 0.105(x - 0.8) & 0.8 < x < 0.6 \\
 0.05 - 0.25(x - 0.6) & 0.6 < x < 0.4 \\
 0.1 - 4(x - 0.4) & 0.4 < x < 0.3 \\
 0.5 - 2.5(x - 0.3) & 0.3 < x < 0.1 \\
 1 & x < 0.1
\end{cases}
\] (6.2)
The value for the fuzzy membership function for shape parameter is
\[ f_{\text{shape}} = 1 - f_{\text{color}}. \]

**FMF for compactness and smoothness:** The Fuzzy membership graph for the building features of compactness and smoothness is represented in Figure 6.5. The x axis indicates membership grade and y axis indicates the parameter values of compactness and smoothness.

![Membership functional graphs for compactness and smoothness class](image)

**Figure 6.5 Membership functional graphs for compactness and smoothness class**

Figure 6.5, indicates that compactness and smoothness were inversely related. For increasing the parametric value from 0.5 to 0.8, the membership grade value has increased from 0.05 to 0.1 and for 0.8 to 0.9 of the membership grade value is drastically increased from 0.1 to 1.0.

Also its fuzzy membership function for smoothness is represented below.
The value for the fuzzy membership function for compactness parameter is $f_{\text{compactness}} = 1 - s_{\text{smoothness}}$.

### 6.2.2 Segmentation for Road

The segmentation of the road was carried out and the results are presented in Table 6.2. It indicates the segmentation parameter for road feature at different level and its membership grade value.

#### Table 6.2 Segmentation Parameter for road class

<table>
<thead>
<tr>
<th>Level</th>
<th>Scale parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of sub-objects</th>
<th>Membership grade value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>9</td>
<td>0.11</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>4</td>
<td>0.26</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>2</td>
<td>0.45</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

For the sequential level the other parameters is selected based on the growth of the object. A typical sample of road class is selected and it’s growth is observed, which is shown in Figure 6.6. At level 1 the number of sub object of the road class is 9. For level 2 and 3 the number of sub-object is 4 and 2, whereas at level 4 the sub-object is becomes 1. Therefore road becomes separate object and it can be considered as optimized.
Figure 6.6 Segmentation of typical road class at different levels

**FMF for color and shape:** The Fuzzy membership function graph for building features color and shape parameter is represented in Figure 6.7. The x axis indicates membership grade and y axis indicates shape and color parameters.
Figure 6.7 Membership functional graph for compactness and smoothness class

The relationship between scale parameter and membership grade is nearly a linear pattern. From this it is inferred that the sub-objects of road is almost homogeneous in nature.

Fuzzy Membership Function for the scale parameter is

\[
 f_{sp} = \begin{cases} 
 0 & x < 20 \\
 0.12 + 0.007(x - 20) & 20 < x < 40 \\
 0.26 + 0.0076(x - 40) & 40 < x < 65 \\
 0.45 + 0.022(x - 65) & 65 < x < 90 \\
 1 & x > 90 
\end{cases} \quad (6.4)
\]
The relationship between parameter value and membership grade is exponentially linear in pattern. (i.e) for the parameter value of 0.2 to 0.5. The increase in the membership grade value is 0.05 to 0.1 and for the parameter value of 0.5 to 1 the membership grade is 0.1 to 0.9.

And the Fuzzy Membership Function for color parameter is

\[
f_{\text{color}} = \begin{cases} 0 & x \gg 0.8 \\ 0.12 - 0.7 (x - 0.8) & 0.8 < x < 0.6 \\ 0.26 - 0.95 (x - 0.8) & 0.8 < x < 0.6 \\ 0.45 - 5.5 (x - 0.4) & 0.4 < x < 0.3 \\ 1 & x < 0.3 \end{cases}
\]

(6.5)

The value for the shape parameter is \( 1 - f_{\text{color}} \).
**FMF for compactness and smoothness:** The Fuzzy membership graph for the road features of compactness and smoothness is represented in Figure 6.9. The x axis indicates membership grade and y axis indicates compactness and smoothness.

![Fuzzy membership graph for Compactness and Smoothness parameter of Road feature](image)

**Figure 6.9  Fuzzy membership graph for Compactness and Smoothness parameter of Road feature**

The relationship between the parametric value and membership grade is non linear relationship.

Fuzzy Membership Function for smoothness is

\[
\tilde{f}_{\text{smooth}} = \begin{cases} 
0 & x \geq 0.5 \\
0.12 - 0.7 (x - 0.5) & 0.5 < x < 0.3 \\
0.26 - 1.9 (x - 0.8) & 0.3 < x < 0.2 \\
0.45 - 5.5 (x - 0.2) & 0.2 < x < 0.1 \\
1 & x < 0.1 
\end{cases}
\]  
(6.6)
The corresponding the compactness value is $f_{\text{compact}} = 1 - f_{\text{smooth}}$.

6.2.3 Segmentation for Open Area

The following table indicates the segmentation parameters for the open area features and its membership grade value for the consequent level is given in Table 6.3.

Table 6.3 Segmentation parameter for open area feature

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Scale Parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of Sub - objects</th>
<th>Membership grade value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>50</td>
<td>0.02</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>12</td>
<td>0.04</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>5</td>
<td>0.16</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td>110</td>
<td>0.1</td>
<td>0.9</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The initial segmentation is selected based on the guidelines and object stability. The object is allowed to grow to reach its final optimization. Figure 6.10 indicates the above said process.

**Fuzzy membership grade:** Percentage of object belongs to the particular feature indicates the membership grade. For level 1, the object was divided into 50 numbers of sub-subject. And in level 2, 3, 4 and 5 the number of sub-object were 12, 5, 2 and 1. Hence its membership grade values from level 1 to 5 are 0.02, 0.04, 0.16, 0.4 and 1.
**Fuzzy Membership Function:** For the above segmentation parameter the fuzzy membership graph is plotted. The graph between scale parameter and its membership function is shown in Figure 6.11.

![Sample Area of Open Space](image1)

![Level 1](image2)

![Level 2](image3)

![Level 3](image4)

**Figure 6.10** Segmentation of typical open area class at different levels
Figure 6.11 Fuzzy Membership graph for scale parameter of Open area Class

The relationship between scale parameter and membership grade of open area is parabolic in shape. The starting segmentation has low slope in shape and at the end of the segmentation it has high slope value.

Fuzzy Membership Function for scale parameter of open area feature is

$$f_{xy} = \begin{cases} 
0 & x < 20 \\
0.02 + 0.001 (x - 20) & 20 < x < 40 \\
0.04 + 0.0048 (x - 40) & 40 < x < 65 \\
0.16 + 0.0096 (x - 65) & 65 < x < 90 \\
0.4 + 0.03 (x - 90) & 90 < x < 110 \\
1 & x > 110 
\end{cases}$$

(6.7)
Figure 6.12 Membership function graph for color and shape parameter of Open area class

The relationship between the membership grade and parametric value is linear in pattern. The segmentation for 20 to 60 has low slope value and 60 to 110 the slope value is higher.

Fuzzy Membership Function for color parameter is given below:

\[
f_{\text{color}} = \begin{cases} 
0 & x > 0.5 \\
0.02 - 0.1 (x - 0.8) & 0.8 < x < 0.6 \\
0.04 - 0.6 (x - 0.6) & 0.6 < x < 0.4 \\
0.16 - 2 (x - 0.4) & 0.4 < x < 0.3 \\
0.4 + 3(x - 0.3) & 0.3 < x < 0.1 \\
1 & x < 0.1 
\end{cases}
\]  

(6.8)
Figure 6.13  Fuzzy membership graph for Compactness and Smoothness parameter of Open area feature

Fuzzy Membership Function

\[
f_{\text{smooth}} = \begin{cases} 
0 & x > 0.5 \\
0.02 - 0.1(x - 0.5) & 0.5 < x < 0.3 \\
0.04 - 1.2(x - 0.5) & 0.3 < x < 0.2 \\
0.16 - 2.4(x - 0.2) & 0.2 < x < 0.1 \\
1 & x < 0.1 
\end{cases}
\]  \hspace{1cm} (6.9)

The fuzzy membership function value for compactness=1-f_{\text{smooth}}

6.2.4  Segmentation for Vegetation

Table 6.4 indicates the segmentation parameters for the vegetation features and its membership grade value for the consequent level. The above segmentation process is shown in Figure 5.14.
The initial segmentation is selected based on the guidelines and object stability. And the object is allowed to grow to reach its final optimization. The following Figure 6.14 indicates the above said process.

Percentage of object belongs to the particular feature indicates the membership grade. For at level 1 the object is divided into 30 no's of subject. And in level 2, 3, 4 and 5 its number of sub-object is 25, 10 and 1. So its membership grade value from level 1 to 5 are 0.02, 0.04, 0.1 and 1.

For the above segmentation parameter the fuzzy membership graph is plotted. The graph between scale parameter and its membership function is plotted in Figure 6.15.

Table 6.4 Segmentation Parameter for Vegetation feature

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Scale Parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of sub-objects</th>
<th>Membership grade value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>30</td>
<td>0.02</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>25</td>
<td>0.04</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 6.14 Segmentation of typical Vegetation class at different levels
Figure 6.15  Fuzzy Membership function graph for scale parameter of Vegetation class

The relationship between scale parameter and membership grade is half of normal distribution in pattern. For the scale parameter values of 20 to 60, the increase in membership grade value is 0.01 to 0.1, because of more heterogeneity presented in the feature. But from 65 to 90 the value is 0.1 to 1.0, higher the value it has less heterogeneity.

Fuzzy Membership Function for the scale parameter is

\[
\begin{align*}
    f_{sp} &= \begin{cases} 
    0 & x < 20 \\
    0.02 + 0.001(x - 20) & 20 < x < 40 \\
    0.04 + 0.0024(x - 40) & 40 < x < 65 \\
    0.1 + 0.036(x - 65) & 65 < x < 90 \\
    1 & x > 90 
    \end{cases}
\end{align*}
\]  

(6.10)
Fuzzy Membership Function for the color factor is

$$f_{\text{color}} = \begin{cases} 0 & x \geq 0.3 \\ 0.02 - 0.1(x - 0.8) & 0.8 < x < 0.6 \\ 0.04 - 0.3(x - 0.6) & 0.6 < x < 0.4 \\ 0.1 - 0.9(x - 0.4) & 0.4 < x < 0.3 \\ 1 & x < 0.3 \end{cases}$$ (6.11)

The value for the shape parameter of the vegetation class = $1 - f_{\text{shape}}$.  

Figure 6.16 Fuzzy membership function graphs for shape and color parameter of Vegetation class
Figure 6.17 Fuzzy membership function graph for Compactness and Smoothness parameter of Vegetation class

Fuzzy membership function for the smoothness parameter is

\[
 f_{\text{smooth}} = \begin{cases} 
 0 & x > 0.5 \\
 0.02 - 0.1(x - 0.5) & 0.5 < x < 0.3 \\
 0.04 - 0.6(x - 0.3) & 0.3 < x < 0.2 \\
 0.1 - 0.9(x - 0.2) & 0.2 < x < 0.1 \\
 1 & x < 0.1 
\end{cases}
\]  

(6.12)

The value for the compactness parameter of the vegetation class

\[ = 1 - f_{\text{smooth}} \]

6.3 VALIDATION OF SEGMENTATION PARAMETER

The derived segmentation parameter of an Anna university study area is compared with the other area (Adyar) of the similar data set. The selected study area (Adyar) has a similar kind of classes like building, road,
open space (playfield), water bodies and vegetation. But the functional use of the area is residential in nature. The study area is shown in Figure 6.18.

Figure 6.18 FCC of Quick bird data of Adyar area

Figure 6.19 Digital Surface Model of the Adyar study area

The Digital Surface Model of the study area is represented in Figure 6.19. The terrain has flat to gentle slope in nature.
6.3.1 Building Class

The segmentation parameters are selected for each class same as that of guidelines followed in section 6.3 of the Anna University study area. Here also the initial scale parameter is selected to produce the meaningful object and the value is 20. So the consecutive values were chosen according to the growth of the object. Table 6.5 shows the selected value of the consecutive parameters.

Table 6.5 Segmentation parameters for building feature of Adyar area

<table>
<thead>
<tr>
<th>Level</th>
<th>Scale parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of sub-objects</th>
<th>Membership Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>32</td>
<td>0.03</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>15</td>
<td>0.07</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>9</td>
<td>0.11</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1.00</td>
</tr>
</tbody>
</table>

And the model building object is taken, and its growth of sub-object is observed for the consecutive level, which is shown in Figure 6.20.
Figure 6.20  Multilevel segmentation of quick bird data – Optimisation of building class
It is observed from the above, that the building got segmented at level 4 and membership graph of the above (Adyar area) parameter is compared with the previous study area (Anna University) and the comparison graph is given below.

![Comparison graph](image)

**Figure 6.21 Comparison of Scale parameter for Adyar and Anna University study area**

It is observed that the trend of fuzzy membership function graph of Adyar area has followed the similar trend of Anna University area for the value of 20 to 60, because of similarity in the homogeneity of the top surface of the building. After that the Adyar area has reached the optimal segmentation earlier compared to the Anna University study area because of the lesser size of the object.

**Similarly the color, shape, compactness and smoothness parameter graphs also is compared with the previous study area, which are shown in Figures 6.22 and 6.23.**
Figure 6.22 Comparison of color and shape parameter for Adyar and Anna University study area

The fuzzy membership function graph for color and shape parameter of Adyar area compared to Anna University has the same trend for first three levels. Later on for other two levels Adyar reaches optimized segmentation earlier compared to Anna University area, because of less heterogeneity and shape.

Figure 6.23 Comparison of compactness and smoothness parameter for Adyar and Anna University study area
Similarly the fuzzy membership function graph for compactness and smoothness of Adyar area is compared to Anna University has a same trend.

### 6.3.2 Road

Main road is presented near to the study area of Adyar. The segmentation parameter for the road class is given in Table 6.6.

**Table 6.6 Segmentation Parameter for road feature of Adyar area**

<table>
<thead>
<tr>
<th>Level</th>
<th>Scale parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of sub-objects</th>
<th>Membership Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-7</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>55</td>
<td>0.02</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>25</td>
<td>0.04</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>15</td>
<td>0.07</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>5</td>
<td>0.20</td>
</tr>
<tr>
<td>5</td>
<td>110</td>
<td>0.1</td>
<td>0.9</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The model road object is selected and its level of segmentation is observed, which is shown in Figure 6.24.
Figure 6.24  Multilevel segmentation of quick bird data – Road class
Figure 6.25 Comparison of Scale parameter for Adyar and Anna University study area for road class

It is observed that the trend of fuzzy membership function graph of Adyar area has followed the similar trend of Anna University area, but reached the optimal segmentation earlier. This is because of larger size of the segmented sub-object at the Adyar study area.

Similarly the color, shape, compactness and smoothness parameter also is compared with the previous study area, which is shown in Figures 6.26 and 6.27.
The fuzzy membership function graph for color and shape parameter of Adyar area compared to Anna University has a same trend for all the levels. Later on Adyar reaches optimized segmentation earlier compared to Anna University area, because of less heterogeneity and shape.

**Figure 6.26** Comparison of Color and shape parameter for Adyar and Anna University study area

**Figure 6.27** Comparison of compactness and smoothness parameter for Adyar and Anna University study area
Similarly the fuzzy membership function graph for compactness and smoothness of Adyar area (Figure 6.27) compared to Anna University, has the earlier segmentation at the initial level, and increases at level 2, 3 and 4 and it merges at level 5.

6.3.3 Open Area

Adyar area has open area (playfield) small in size for the validated (Adyar area). The segmentation parameter for the open area class is given in Table 6.7.

<table>
<thead>
<tr>
<th>Level</th>
<th>Scale parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of sub-objects</th>
<th>Membership Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>20</td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>4</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>3</td>
<td>0.33</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 6.7 Segmentation Parameter for Open Area class of Adyar area
Figure 6.28 Multilevel segmentation of quick bird data – Optimisation of Open area
It is observed from Figure 6.29 that, the trend of fuzzy membership function graph of Scale parameter for Adyar area has followed the similar trend of Anna University area for the level 1, 3, 4, and 5, because of the homogeneity in the pattern. But the size of the merging sub-object is earlier at level 2 compare to other two levels.

Figure 6.30 Comparison of color and shape for Adyar and Anna University study area for open area class
It is observed from Figure 6.30, the fuzzy membership function graph for color and shape parameter of Adyar area compared to Anna University, has a same trend for first three levels. Later on for other two levels Adyar reaches optimized segmentation earlier compared to Anna University area, because of less heterogeneity and its shape.

![Comparison of compactness and smoothness for Adyar and Anna University study area for open area class](image)

**Figure 6.31** Comparison of compactness and smoothness for Adyar and Anna University study area for open area class

Similarly the fuzzy membership function graph for compactness and smoothness of Adyar area (Figure 6.31) compared to Anna University, has similar segmentation at level 1, 5 and an earlier segmentation at level 2,3 and 4.
6.3.4 Vegetation

The vegetation is presented along the road as well as inside the parcel boundaries. The segmentation parameter for the above is given in Table 6.7.

Table 6.7 Segmentation parameter for vegetation class of Adyar area

<table>
<thead>
<tr>
<th>Level</th>
<th>Scale parameter</th>
<th>Color</th>
<th>Shape</th>
<th>Compactness</th>
<th>Smoothness</th>
<th>No of sub-objects</th>
<th>Membership Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.8</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>20</td>
<td>-7</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.3</td>
<td>4</td>
<td>-8</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>2</td>
<td>0.05</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>0.1</td>
<td>1</td>
<td>0.25</td>
</tr>
</tbody>
</table>

The segmentation is optimized at the level 4. And the model object is selected and at each level the segmentation process is observed in Figure 6.32.
Figure 6.32  Multilevel segmentation of quick bird data – Optimisation of Vegetation class
Figure 6.33 Comparison of Scale parameter for Adyar and Anna University study area for Vegetation

It is observed that the trend of fuzzy membership function graph of Adyar area has followed the similar trend of Anna University area, but reached the optimal segmentation earlier. This is because of larger size of the segmented sub-object at the Adyar study area.

Figure 6.34 Comparison of color and shape for Adyar and Anna University study area for Vegetation class
The fuzzy membership function graph for color and shape parameter of Adyar area compared to Anna University, has a same parametric value at first and last levels. For intermediate levels there is a gradual deviation for Adyar and Anna University area, because of less heterogeneity and shape.

![Graph of fuzzy membership functions](image)

**Figure 6.35 Comparison of compactness and smoothness for Adyar and Anna University study area for Vegetation class**

Similarly the fuzzy membership function graph for compactness and smoothness of Adyar area (Figure 6.35) compared to Anna University, has similar segmentation at level 1, 5 and an earlier segmentation at level 2,3 and 4. It is because of non importance of shape of the object.

### 6.4 OBJECT CLASSIFICATION

Classification means assigning the number of object to a certain class through the typical properties or conditions of the classes. Then the object becomes assigned (classified) to whether they have or they have not met these properties.
Knowledge Base Creation – Rule Base: It is created using the interpretation key element such as size, shape, tone and color, texture, pattern and contextual information or otherwise it is called as spectral, spatial, textural and relationship to neighbor. Interpretation key can be organized in two ways such as selective key and elimination key (Lillesand et al 2004). In the first step, the features used for the interpretation have to be determined but in later method it can be derived out. Here the selective key is used to select the feature and the class hierarchy is developed.

Class hierarchy: The significant interpretation key elements were identified for the selected urban landuse classes of the study area, which is given in section 4.2.1.3 such as building (includes concrete old and new, Tiled and asbestos roof), open area (vacant), vegetation, road (transportation) shadows and water bodies. The above landuse classes is discussed below:

Building: There are three sub-classes of buildings available in the study area according to the roof type and roof floor pattern. There are buildings with concrete structure (New), Concrete building covered with tar and with and without tar on Asbestos / tiled houses.

In the study area buildings are well separated and bigger in size (Institutional area) as well as in height (>G+1 to <G+3 floors) compared to residential buildings.

It get optimized in the level 6 of the segmentation process. It is observed that the following elements / parameters in the Table 6.9 were significantly used to identify the building features.

The above elements are given as a rule set for the classification / extraction of buildings from the segmented data for the identification of the
building classes. Each element is described in fuzzy membership. For example, the elevation parameter is described by its mean value of the segmented image object. It was computed during the segmentation process and the mean of elevation value for an object was calculated as

\[ CL = \sum_{i=1}^{n} Cli. \]  

(6.12a)

**Table 6.9 Interpretation key elements and parameter for building features**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Classes / object</th>
<th>Elements</th>
<th>Significant Features</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Building (Concrete cement)</td>
<td>Context</td>
<td>Mean Elevation value</td>
<td>80 to 178</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tone</td>
<td>Green band (Band 2)</td>
<td>300 to 700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Brightness</td>
<td>85 to 175</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Texture</td>
<td>GLCM homogeneity</td>
<td>0.3778 to 0.8345</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>band2 (All direction)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Building (Old tiles)</td>
<td>Mean value of Band (4)</td>
<td>Mean value of Band (4)</td>
<td>-65 to 20</td>
</tr>
</tbody>
</table>

The range of value is [0; full range]. The range was observed from 80 to 178 and where the fuzziness occurs in the range between 80 to 85, and 175 to 178. This is plotted in the fuzzy membership function slope and presented in Figure 6.36, which is in the trapezoidal membership form. The membership function for that feature is.

\[
f(x) = \begin{cases} 
0 & x < 80 \text{ & } x \geq 178 \\
\frac{x-80}{5} & 80 \leq x \leq 85 \\
\frac{x-175}{3} & 175 \leq x \leq 178 \\
1 & 85 \leq x \leq 175 
\end{cases}.
\]  

(6.13)
Figure 6.36 Fuzzy membership graph for building class

Road: The road is made up of bituminous tar coated. In the study area, only the main entrance road is visible and most of the other inner roads are covered by the trees / vegetation. It gets optimized in the level 4 of the segmentation process. And it is observed that the Table 6.10 show the parameters significantly used to identify the road features.

Table 6.10 Interpretation key elements and parameter for road class

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Classes / object</th>
<th>Elements</th>
<th>Significant Features</th>
<th>Range</th>
<th>Membership function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Road</td>
<td>Spectral / Tone</td>
<td>Mean value of the band 4 (IR)</td>
<td>72 to 150</td>
<td>Full range</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean value of Band 2 (Green)</td>
<td>190 to 270</td>
<td>Full range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spatial</td>
<td>Length / Width ratio</td>
<td>9 to 17</td>
<td>Full range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Textural</td>
<td>GLCM homogeneity (4)(All direction)</td>
<td>0.31 to 0.34</td>
<td>Full range</td>
</tr>
</tbody>
</table>
Each of the above parameter’s range value is described by fuzzy membership function graph which is shown in Figure 6.37 and the rule set is written by combining the other elements such as spatial (ratio of Length / Width) and textural homogeneity.

\[
    f_{[x]} = \begin{cases} 
        0 & x < 75 \\
        \frac{x - 75}{75} & 75 < x < 150 \\
        1 & x > 150 
    \end{cases}
\]  (6.14)

![Fuzzy membership graph for road class](image)

**Figure 6.37 Fuzzy membership graph for road class**

**Open Area:** The selected area, has a big vacant (playfield) area with presence of sand. And part of the ground is under construction of football pitch (different tone). And few of the open spaces is presented in the other part. The open area gets optimized in the level 5 of the segmentation process. And it is observed from the Table 6.11 shows that the significant parameter to identify the open area features.
Table 6.11 Interpretation key element and parameter for open area class

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Classes / object</th>
<th>Significant Features</th>
<th>Range</th>
<th>Membership function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open area</td>
<td>Tone Mean value Red band (2)</td>
<td>248 to 600</td>
<td>Full range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Texture GLCM homogeneity (2) (All direction)</td>
<td>0.4520 to 0.5289</td>
<td>Full range</td>
</tr>
<tr>
<td>2</td>
<td>Context</td>
<td>Not mean elevation value</td>
<td>87 to 140</td>
<td>Full range</td>
</tr>
</tbody>
</table>

Each of the above parameter’s range value is described by fuzzy membership function graph which is shown in Figure 6.38 and the rule set is written by combining the other elements such as texture of GLCM homogeneity, and it is not for elevation value (So that the presence of building is avoided).

![Fuzzy Membership for Open Area](Image)

Figure 6.38 Fuzzy Membership function slope for Open Area
**Vegetation:** Vegetation class covers grass, scrub and trees. In the selected study area vegetation covers 60% of the total area. In all the vegetation, three types of features can be discriminating. And it is observed from the Table 6.12 shows that the significant parameter to identify the vegetation features

**Table 6.12 Interpretation key elements and its parameter for vegetation class**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Classes / object</th>
<th>Significant Features</th>
<th>Range</th>
<th>Membership function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vegetation dark</td>
<td>Mean value of Band(4)</td>
<td>220 to 350</td>
<td>Trapezoidal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean value of Band 3 (Red)</td>
<td>0 to 150</td>
<td>Full range</td>
</tr>
<tr>
<td>2</td>
<td>Vegetation Light tone</td>
<td>Mean value of band 3</td>
<td>350 to 740</td>
<td>Full range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean value of Band 3 (Red)</td>
<td>0 to 150</td>
<td>Full range</td>
</tr>
<tr>
<td>3</td>
<td>Vegetation Grass</td>
<td>Mean value of band 3</td>
<td>500 to 740</td>
<td>Full range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean value of Band 3 (Red)</td>
<td>0 to 150</td>
<td>Full range</td>
</tr>
</tbody>
</table>

All the vegetation classes (Dark and Light grass) is classified using the mean value of the band 4 at different ranges. Because the fourth band has Near Infra Red (NIR), vegetation it is clearly separable from the other features.
In the process of satellite image classification, the image pixels are automatically assigned (by the classification software) to one of a number of output classes. Two methods of image classification were utilized, such as supervised and unsupervised. Supervised classification, as the name suggests, involves the user defining, by delineating training sites, the output classes to which pixels will be assigned. On the other hand, unsupervised classification or image clustering requires no pre-classification input from the user and pixels are split into a number of groups (to be specified by the user), based on their spectral similarity. Supervised classification formed the core of the classification work, while an unsupervised classification was performed to assist in the selection of training sites.
Table 6.13 lists the classes that were mapped through supervised classification. These classes represent that one or more classes were spectrally inseparable. For example vegetation class comprise of different vegetation at different stages of growth, which is indicated in dark and light tones.

**Table 6.13 Classes Resulting from Supervised Classification**

<table>
<thead>
<tr>
<th>Class</th>
<th>Comprising/Part of the class Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building (Concrete)</td>
<td>Concrete roof top of Single story or multistory building of residential / Institutional / Industrial / Commercial building</td>
</tr>
<tr>
<td>Building (Tiles)</td>
<td>Tiled roof top of building</td>
</tr>
<tr>
<td>Building (AC Sheet)</td>
<td>Workshop / Industries / Godown of Aspestos Cement sheet</td>
</tr>
<tr>
<td>Open Area</td>
<td>Open ground / Area</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Vegetation (Dark / light color)</td>
</tr>
<tr>
<td>Road</td>
<td>Bituminous tar road</td>
</tr>
</tbody>
</table>

**6.5.1 Training Site Selection**

The statistical validity of the results of the classification is dependent on two characteristics of training inputs, namely, the size and representativeness of the sample. In order to obtain suitable training site data, the guidelines described below were followed:

From literature review (Lillesand and Keifer 1994), the number of pixels used to train the classifier should be between 10n and 30n for each class, where n is the number of spectral bands.
In this study, four spectral bands were input into the classifier, equating to an area of between 1283 and 1017 pixels and 13,04,811 sqm of area (78.28 hectare).

In order that the classifier had the greatest probability of accurately assigning pixels to a class, sites were selected so that the spectral properties are as homogeneous as possible (Cognalton 1991). For example, a building in the centre of a target vegetation type within a training area will increase the likelihood of misclassification.

By taking above into consideration the number of pixels for classification of each classes and it is the location of the feature were selected for sampling, and its number of pixels with its graphical plot is given below.

The samples selected for this study are given below:

<table>
<thead>
<tr>
<th>Class</th>
<th>Number of Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building of concrete structure</td>
<td>2325 pixels</td>
</tr>
<tr>
<td>Building of Old tiles</td>
<td>1331 pixels</td>
</tr>
<tr>
<td>Building of AC sheet</td>
<td>1142 pixels</td>
</tr>
<tr>
<td>Open Area 1</td>
<td>3870 pixels</td>
</tr>
<tr>
<td>Open Area 2</td>
<td>1467 pixels</td>
</tr>
<tr>
<td>Vegetation 1 Light green</td>
<td>2633 pixels</td>
</tr>
<tr>
<td>Vegetation 2 Dark green</td>
<td>2985 pixels</td>
</tr>
<tr>
<td>Road</td>
<td>2975 pixels</td>
</tr>
</tbody>
</table>
6.5.2 Reference site selection and Accuracy Assessment

The known surface features from reference sites field surveys and examination of other data sources are compared with the classified image, often in the form of contingency table or error matrix.

In this study, the reference sites were derived using stratified random sampling of sites in the classification. The samplings were stratified so that classes that occurred infrequently were adequately represented in the total sample. The stratified random sampling procedure was performed using ERDAS software.

Before processing with the classification of imagery, the training sites were analyzed to ensure that they were composed of any outlaying pixels. An evaluation of the data frequency histograms for each training site was conducted to ensure that the training data were normally distributed.
Normal distribution of training data was an assumption for the classifier to be used later.

To determine whether the classes for which training sites were identified were in fact spectrally separable, a supervised classification was performed and the percentage of correctly classified pixels within each training site was assessed.

The maximum likelihood classifier is used in the classification. This classifier accounts for the mean and covariance of each class by estimating the likelihood of a class at any digital value. This is the most rigorous algorithm provided that certain requirements are adhered to (Huang and Mausal 1994). This classifier assumes that the training data for each class in each band are normally distributed.

### 6.5.3 Classification Accuracy Assessment

Classification accuracy refers to the correspondence between a class label assigned to a pixel and the true class. The accuracy of the mapping for each class has been assessed with regard to class boundary and size. Based on these considerations the confidence rating of high, medium and low have been assigned to each class (Table 6.14).

- **High** - Accurately mapped with few unconformity location
- **Medium** - High natural variability resulted in uncertainties
- **Low** - High uncertainties, requires many ground truth verification
Table 6.14  Confidence rating for different classes by visual and digital method

<table>
<thead>
<tr>
<th>Class</th>
<th>Visual Identification</th>
<th>Imagery classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building (Concrete)</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Building (Tiles)</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Building (AC Sheet)</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Vegetation</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Open Space</td>
<td>High</td>
<td>Above Medium</td>
</tr>
<tr>
<td>Road</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

6.5.4  Overall accuracy

Table 6.15 gives the Error matrix for the all classes. It produces 87.42% of the overall accuracy (K value of 0.842). From the overall, the vegetation was classified with higher accuracy. Road and building has very low accuracy level because of the spectral separability of the classes. The individual classes are explained below.

**a. Building Cement Concrete**

MLC correctly produces only 71% of building cement concrete class. Because nearly 20% of open area pixels were misclassified in to this category. Mainly because of the closeness (similarities) in spectral characteristics of band 2 & 4 (Figure 6.40 for profile 1 & 11).
b. **Buildings of Asbestos sheet / roof type with tar coated**

These buildings types were classified at the accuracy of 82.7%. The main reason of this misclassification is due to poor spectral separability (band 2, 3, & 4) of the profiles (Figure 6.40, profile 4, 6&7). The profile 4 & 7 are following the same trend in the band 2, 3 & 4. The separability of road and rooftop tar is very poor. So the misclassification is happened, which is shown in Figure 6.41. And spectral profile of 3 & 6 also following the same trend except at band 4, the tar coated roof type has very less reflectance value in band 4.

![Building rooftop with tar coated](image)

*Figure 6.41 Building rooftop with tar coated (Spectrally similar to road)*
6.42 Asbestos roof top (Spectrally similar to road)

c. Open space

It produces a good accuracy of 91%. Other 9% error occurred because the building cement concrete were classified into an open space because of the spectral misclassification. And the covered open surface by mosaic store is classified into building surface, which is shown in Figure 6.43.

6.43 Open space covered with white stone
d. Vegetation

Vegetation is classified with 93% of accuracy. Because it has high spectral separability in 4th band comparing to the other features.

e. Road

Road is classified with 69% accuracy. Few of the building old tiles pixels were misclassified into this class, which is shown in Figures 6.44 and 6.45.

Figure 6.44 Road feature

Figure 6.45 Building roof tiles is covered with tar
Figure 6.46 Results of Conventional (Pixel) based Classification
Table 6.15 Overall classification accuracy by the conventional method

<table>
<thead>
<tr>
<th>Classified Data</th>
<th>Building Concrete</th>
<th>Building of Old Tiles</th>
<th>Open space</th>
<th>Veg Light</th>
<th>Veg Dark</th>
<th>Road</th>
<th>Shadow</th>
<th>Classified Total</th>
<th>Reference Total</th>
<th>Number Correct</th>
<th>User's Accuracy</th>
<th>Producer's Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Concrete</td>
<td>37</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>48</td>
<td>37</td>
<td>30</td>
<td>77.08</td>
<td>71.15</td>
</tr>
<tr>
<td>Building of Old Tiles &amp; AC Sheets</td>
<td>0</td>
<td>43</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>64</td>
<td>45</td>
<td>40</td>
<td>67.19</td>
<td>82.69</td>
</tr>
<tr>
<td>Open space</td>
<td>13</td>
<td>5</td>
<td>112</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>137</td>
<td>143</td>
<td>124</td>
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</tbody>
</table>

Overall classification accuracy = 87.42
Overall kappa accuracy = 0.842
6.6 OBJECT BASED APPROACH

The accuracy method as explained in sec 6.3.1. which was done by taking 645 pixels, using the stratified random sampling methods.

The overall accuracy obtained by this method is 93.47% (K value 0.92), which is given in Table 6.16 and output shown Figure 6.51. The level of accuracy for the individual classes are discussed below.

6.6.1 Building cement concrete

Buildings with cement concrete surface was classified with the accuracy of 86.4 %. The remaining error is, due to the presence of the building tiles. Even in a single building has two different tone/pattern in roof top which shows in Figures 6.47 and 6.48. The two kind of brightness in tiles produces different spectral objects.

Figure 6.47 Different tone and pattern of tiles in the top of the floor
6.6.2 Building of old tiles and old asbestos sheet

The 86.57% of building having old tiles produces correctly. The remaining were mixed with concrete building and road surface. Because the dark color in cement concrete is wrongly classified as old tiles. Comparing to the pixel based classification the results were improved because of considering height of the object.
6.6.3 Open Space

The obtained accuracy of the open space is 95.5%. Few of the concrete building surface is mixed with the open space, because of the spectral similarities.

6.6.4 Vegetation (Light and Dark)

The accuracy for the light and dark vegetation is 98 & 99%. The above accuracy is similar to the pixel based classification.

6.6.5 Road

Accuracy of the road classification is 89.6%. The Errors were occurred due to the presence of vegetation and its shadow which is shown in Figure 6.50.

![Figure 6.50 Road surface covered by vegetation (Trees)](image)

6.6.6 Shadow

The shadow’s were classified with 79% accuracy. Remaining were mixed with the vegetation / building during the segmentation process.
Table 6.16 Overall classification accuracy of the object oriented Image analysis

<table>
<thead>
<tr>
<th>Classified Data</th>
<th>Building Concrete</th>
<th>Building of Old Tiles</th>
<th>Open space</th>
<th>Veg Light</th>
<th>Veg Dark</th>
<th>Road</th>
<th>Shadow</th>
<th>Unclassified</th>
<th>Classified Total</th>
<th>Reference Total</th>
<th>Number Correct</th>
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<th>Producer's Accuracy</th>
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<td>643</td>
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</tbody>
</table>

Overall classification accuracy = 93.48%  
Overall kappa accuracy = 0.92
Figure 6.51 Result of object based classification

6.7 VALIDATION OF IMAGE CLASSIFICATION

The validated area’s (Adyar) segmented data is further classified as building, open area, vegetation and roads using the similar classification parameter which was followed for the Anna University study area. The Comparison of accuracy of Actual (Anna University) and Validated area (Adyar) are given in Table 6.17 and Figures 6.52 and 6.53.
Table 6.17  Comparison of accuracy of Actual (Anna University) and Validated area (Adyar)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Class</th>
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<th>Object Based method</th>
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<td>Adyar</td>
</tr>
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<tr>
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</table>

a. **Pixel based method**

1. The three classes (Building of old tiles, Veg light, Veg dark and road) of Adyar are following almost near or similar to the Anna University area.

2. The accuracy of building concrete class of Adyar is higher compare to the Anna university area. Because the vegetation cover is presented in the top of the building. Which also reflects that the vegetation accuracy of Anna University is higher compare to Adyar area.

3. Open space of the Adyar area is very less because, there are very small open spaces are available in each plot, so the open area is mixed with vegetation light and building concrete because of spectral similarities.

4. Roads were classified with higher accuracy in Adyar area because of the higher reflectance of bitumen and broader roads were presented in Adyar,
compare to low reflectance in Anna university area (Tar coated AC sheet get mixed with road in Anna University area).

Figure 6.52 Comparison of Anna University and Adyar area Pixel based method

b. Object based method

1. The overall accuracy of the Anna University area is improved in all the classes and especially the Building concrete new and road because of the elevation information.

2. The accuracy of building concrete and old tiles and AC sheets have almost similar accuracy.

3. Because of the presence of less area of Open spaces in Adyar area, pixel gets mixed with the nearby object, in turn produces less accuracy. In Anna University study area the open space is higher in turn it produces higher accuracy.

4. Vegetation feature has similar kind of accuracy on both the study area.
Figure 6.53 Comparison of Anna University and Adyar area Object based method