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Analysis of Inland Wetland using advance Remote Sensing and GIS on IRS P6 February 2005 Data of Bhopal (M.P.)

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ABSTRACT

Wetlands are the transitional zones between permanently aquatic and dry terrestrial ecosystems. Wetland systems directly and indirectly support millions of people, providing goods and services to them. The use of remote sensing technology for the mapping, identification, inventory and classification of the wetlands has been a common application of satellite imagery. Remote sensing has provided a great mean to study various ecosystems of the earth including wetlands by providing cost and time effective data. For a country like India, with its vast biological and cultural diversity, a comprehensive use of remote sensing, GIS and other related technologies is of great use in their conservation.

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1. INTRODUCTION

Wetlands represent the interface between land and water (Dugan, P.J., 1990). They have great significance in terms of ecological, economical and social benefits. Wetlands in India are among the least protected ecosystems and are threatened and fast disappearing. They are subjected to both natural and human forces. The alarming loss of wetlands all over the globe had initiated an inter-governmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. This treaty was signed in Ramsar, Iran, in 1971 and is known as 'Ramsar Convention'. Total area of India so far designated under wetland ecosystems is 4050536 ha (1461 ha natural and 2589265 ha. man-made) (Jain, et al, 2008). In India wetlands are distributed in different geographical regions ranging from cold arid zone of Ladakh to wet Imphal, from the warm and arid zone of Gujarat – Rajasthan to the tropical monsoon based regions of Central India and the wet and humid regions of southern peninsula (Parikh, et al, 2003).

Wetlands are found throughout the world under many names and descriptions. They take many forms including marshes, estuaries, mudflats, mires, ponds, fens, pocosins, swamps, deltas, coral reefs, billabongs, lagoons, shallow seas, bogs, lakes, and floodplains. There are also human-made wetlands such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms and canals. Wetlands cover about 6 per cent of earth's land surface (Bazilevich, N.L., *et al.* 1971) and are distributed in all climatic zones of the earth except Antarctica. The rapidly expanding human population, large scale changes in land use/land cover and burgeoning development projects and improper use of watersheds has all caused a substantial decline of wetland resources of the country. For the long-term conservation planning of wetlands, spatial data and information is required for any intervention. India had lost more than 80% of their original wetlands (G. Manju et al., 2005). Thus prevention of degradation of wetland is becoming the major issue. Realizing the importance of the wetlands, the present study was taken up with the specific objective of ;

- To delineate the wetland in the extracted study area.
- To characterize the wetland in different turbidity levels.
- To characterize the wetland in different aquatic vegetation levels
- To delineate the land use classes of study area.
- To obtain a land use classification image with major land use classes and wetland classes.

2. DATA RESOURCES & STUDY AREA

2.1. Data Resource

Pre and post monsoon, IRS LISS IV is used. IRS-P6 (also known as RESOURCESAT-1) is an advanced remote sensing satellite built by Indian Space Research Organization.

Table 1. Data Resource

Sr. No.	Sensor/ Satellite	Row	Path	Resolution (Meter)	Date of procurement
1.	IRS-P6	43	102	5.6	28/02/2005

2.2. Study Area

Bhopal is the capital of the Indian state of Madhya Pradesh. Bhopal is also known as the City of Lakes for its various natural as well as artificial lakes. It has two very beautiful big lakes, collectively known as the Bhoj Wetland. These lakes are the Upper Lake (built by King Bhoj) and the Lower Lake. The geographical location of study area lies within *Latitude:* 25° 81′ 614″ to 25° 61′ 029″ N, *Longitude:* 74° 11′ 45″ to 74° 17′ 91″ E. Bhopal has an average elevation of 427 meters (1401 ft). The study area is spread across 30425.8 hectares.

2.3. Methodology

The toposheet is geo-corrected by selecting image geometric correction option from the data preparation tool by using minimum 20 GCP's. The toposheet is geo referenced by using UTM WGS 84, zone 43 projection. Once the RMS error is less than half a pixel, the transformation is saved and the toposheet is resampled. Now the geo-referenced toposheet is used to geo-reference the LISS 4 image by interactively examining the toposheet and LISS 4 image. Thus geo-referenced LISS 4 image is then used for further process. As the LISS 4 image available to us carries a large area which is not required in the thesis therefore the image is subsetted for extracting the study area. The boundary of study area from the Bhopal district map is then extracted by using AOI tool. The extracted boundary which is the vector layer is now used to extract the study area from the whole dataset by using the subset option, the extracted study area is shown in figure No. (1). The obtained subset image is unsupervised classified in six land use classes. Obtained unsupervised classified image in then regrouped.

For this both the image i.e. obtained unsupervised image and extracted FCC image of study area are loaded in two different viewers, and both the images are then examined interactively for regrouping the land use classes. All values belonging to the same class are changed to a single colour. The unsupervised classified image is then recoded by selecting GIS analysis from Image Iterpreter by using the values sparse vegetation-1, healthy vegetation-2, wetland-3, waste land-4, water body-5. Extracted FCC image of study area is loaded in new viewer and a vector layer of major settelments present in the area are vectorised by using AOI tool. The generated AOI is then recoded by using the recoded value 6 which is different from that use in Land use classification. Obtained recoded classified image and recoded steelment image are then overlayed to obtain one LULC classified image. For extracting the water mask BAND 3 of LISS 4 image is used, as water bodies are efficiently visible in BAND 3 and for extracting BAND 3 of LISS 4 the image is layer stacked. Obtained BAND 3 image is then density sliced by inetractively examinning it with the FCC image of study area. The DN values of water body present in the study area are observed and threshold value for water is noted. After obtaining the threshold value the BAND 3 image is recoded by assigning value 'one' all the pixels belonging to water body and making rest others to 'zero'. The water mask image obtained above is then masked with the extracted FCC study area image to obtain the water body image by selecting the 'mask' option from 'utilities'.

For turbidity classification the BAND 2 of extracted water body image, is extracted by using the 'layer stack' option from 'utilities'. The BAND 2 image extracted is then loaded in viewer for interactively density slicing, to obtain the threshold values for three turbidity levels i.e. low, medium, high turbidity. Lower is the pixel value heigher is the turbidity and respectively. After noting the threshold values for all the three levels the BAND 2 image is recoded. The recoded values for all three turbidity levels used are 10 for low turbidity, 20 for medium turbidity, 30 high turbidity. The recoded image obtained is loaded in a new viewer to assign different colours to all three turbidity levels. For aquatic vegetation classifiaction the NDVI of water body image is extracted, as the NDVI is a parameter, which gives a measure of the vegetation density. Indices option is selected from ‘spectral enhancement’ to obtain the NDVI image of water body image extracted. Now the NDVI image is interactively density sliced to obtain the threshold value for all four aquatic vegetation levels. These values are then used for recoding the NDVI image to new values.

The negative NDVI value represents negligible vegetation, while all the positive values are subdivided in poor, moderate and high aquatic vegetation classes. Values used for recoding are 1, 2, 3 and 4 respectively for negligible, poor, moderate and high aquatic vegetation. The turbidity classified image and aquatic vegetation classified image are then added together by selecting the operator function from utilites to obtain an image having 12 aquatic vegetation and turbidity classes together. All the 12 classes of turbidity and aquatic vegetation image is recoded into 12 new values. For obtaining the final output the classified and recoded image with 6 land use classes obtained is added with the image classified and recoded according to the various vegetation classes amongst the three turbidity levels. The final output contains land use classification image with 6 major landuse classes and 12 classes in the wetlands.

3. RESULTS AND ANALYSIS

3.1. Geometric corrections

Initially the toposheets are geometrically corrected in polynomial model and mosaic is carried out as the study area was lying in different toposheets. The mosaic image of toposheet is then used for geometric correction of IRS LISS 4 digital data using UTM WGS 84, zone 43 projection. The geometrically corrected image of LISS 4 is shown in figure No. (1).

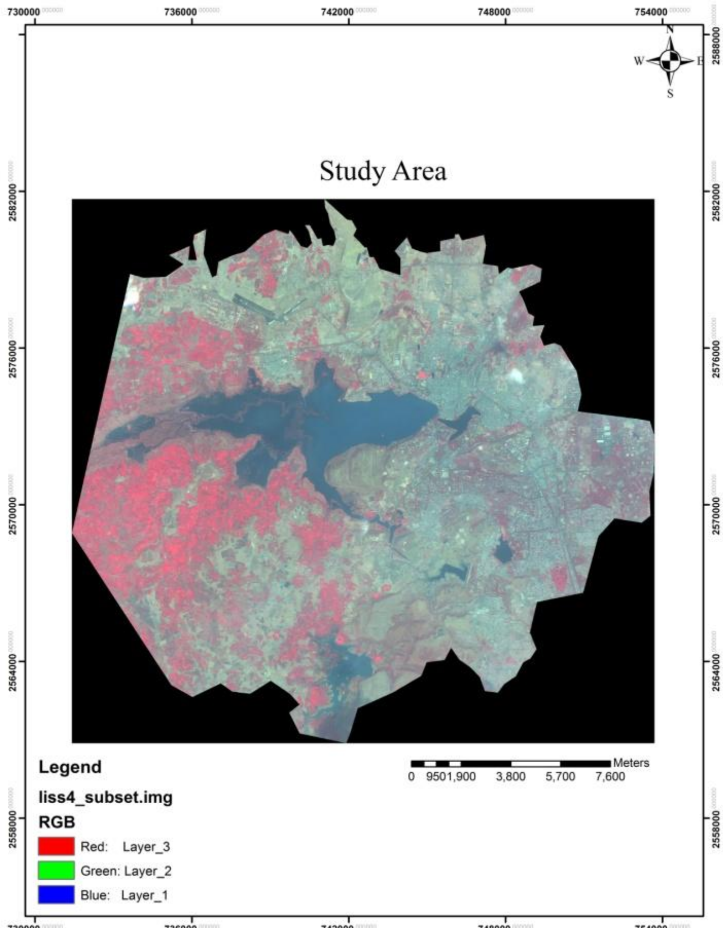

Figure 1. Geometrically corrected image of LISS

3.2. Classification

The geometrically corrected LISS 4 image is then used for land use classification to carry out the separation of study area into various land use categories. The unsupervised classification is adopted and classes are merged on basis of spectral behaviour. By using supervised algorithm the entire study area is classified into 5 classes namely water body, waste land, settlement, healthy vegetation and sparse vegetation. The proper attention is given to the 'marshy' and 'swampy' areas, as these constitutes important components of the wetlands, but could not be separated along with the water bodies' which are being separated independently. Interactive help from topographic maps was taken for locating swampy areas and the classified map of the study area as shown in figure No. (2) and the area covered under each category is summarized in table No. 2.

Table 2. Area of LULC in Study Area

Sr. No.	Class name	Area (hectares)
1	Water body	2913.14
2	Sparse vegetation	3416.31
3	Healthy vegetation	3242.13
4	Wetland	3805.49
5	Settlement	10529.4
6	Wasteland	5145.16

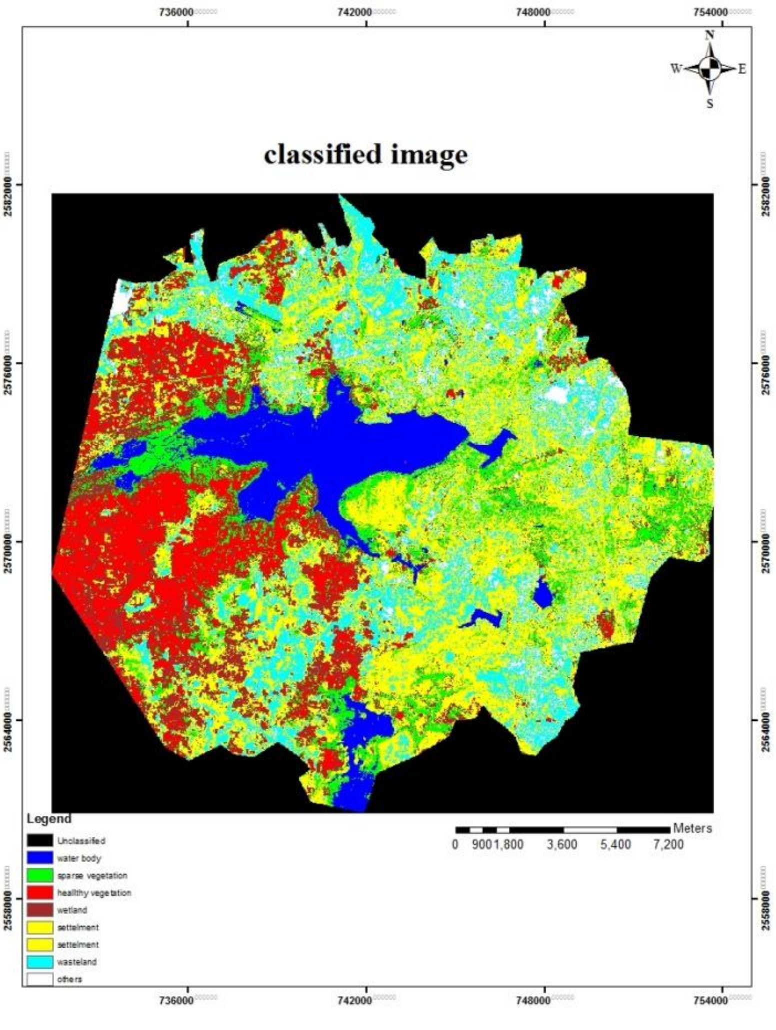

Figure 2. Classified Image

3.3. Separation of Water Bodies

Band 3 of LISS IV image data is examined interactively and ‘density sliced’ to find the threshold values for water and the waterbodies are then separated based on spectral values which are observed on histogram. After computing the threshold values of water, the water bodies are recoded to one value and rest of all values are made zero, thus a bit map is then generated of the waterbodies. This mask is then used for further classification of waterbodies in to turbidity pattern and aquatic vegetation and shown in Figure No. (3) and area covered by water body is tabulated in table No. 3

Table 3. Area of Water Body in Study Area

Sr. No.	Class Name	Area (Hectare)
1	Water body	2913.14

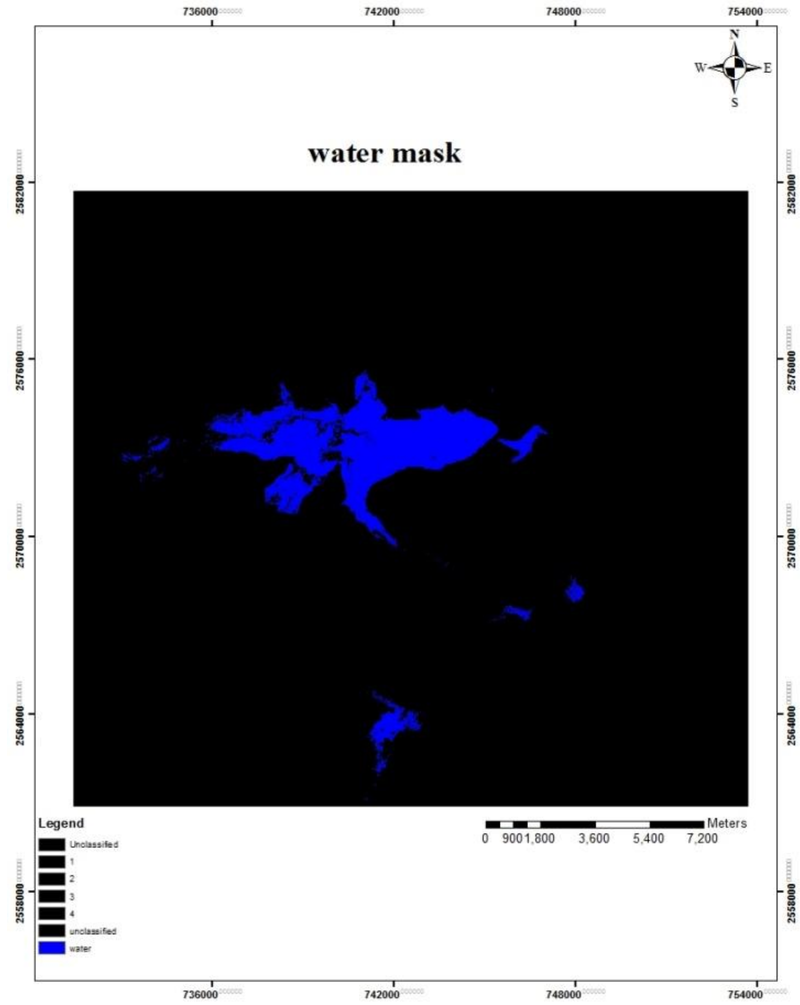

Figure 3. Water Mask

3.4. Turbidity patterns

For classifying the turbidity patterns of extracted waterbody image, the band 2 of IRS LISS IV image is used as turbidity patterns are best reflected in band 2. The density slicing of the band 2 data is carried out within the water body mask. Higher the DN values in band 2 image is classified as higher turbidity class, lower DN values are classified as low turbidity class and thus middle DN values are classified as medium turbidity class. The determination of the threshold for different turbidity levels is carried out by examining each pixel value of water bodies present in the area. The observed pixel values are then divided into three groups for showing low, moderate and high turbidity regions. Now the extracted band 2 image is then recoded to obtain three turbidity levels.

The recoded values being:
Low turbidity: 10
Medium turbidity: 20
High turbidity: 30

The area covered by turbidity levels is shown below in table No. 4 and turbidity classified image is shown below in figure No.4

Table 4. Area of Turbidity in Study Area

Sr. No.	Class Name	Area (Hectare)
1	Low Turbidity	1535.05
2	Medium Turbidity	1283.59
3	High Turbidity	58.0436

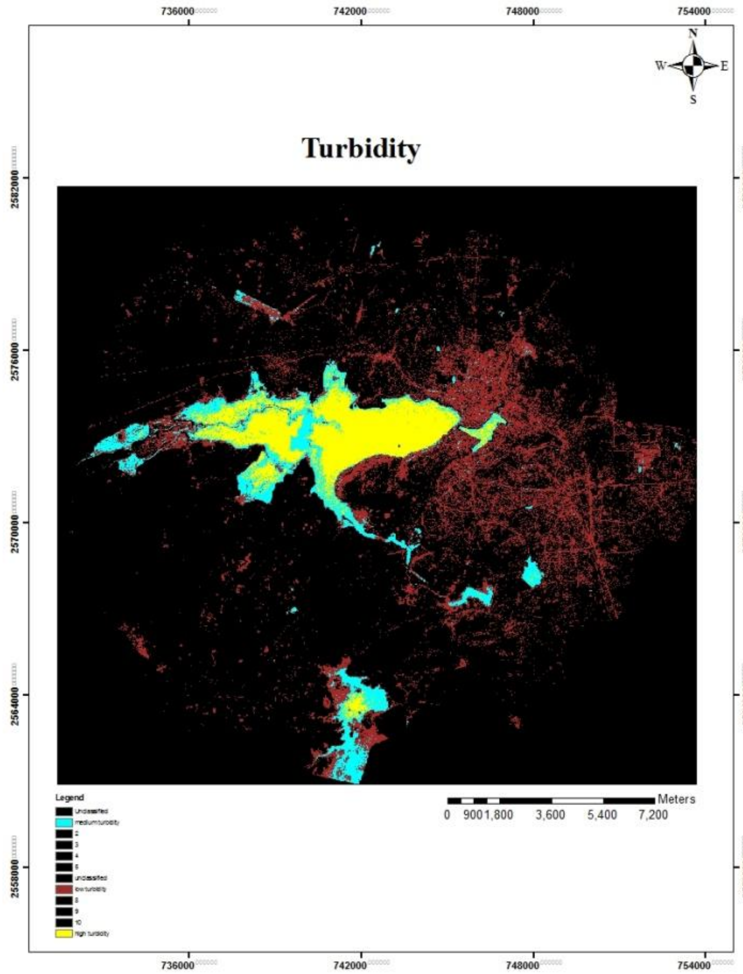

Figure 4. Turbidity Pattern in Study Area

3.5. Aquatic vegetation

For the classification of aquatic vegetation the NDVI of extracted water body image is computed. Now the obtained NDVI image is interactively density sliced to obtain the threshold values for different aquatic vegetation levels. The NDVI value of less than zero i.e. negative values of NDVI is considered as nil or negligible vegetation. The positive values of NDVI are subjectively divided into three vegetation levels i.e. poor, moderate, and high vegetation coverage. Now by using these threshold values the NDVI image is recoded and thus an image classified into 4 aquatic vegetation classes is obtained, which is shown in figure No. (5) and the area covered by all three aquatic vegetation levels is shown in table No. (5).

Used recode values are:
Nil/negligible coverage: 1
Poor vegetation: 2
Moderate vegetation: 3
High vegetation: 4

Table 5. Area of Aquatic Vegetation in Study Area

Sr. No.	Class Name	Area (Hectare)
1	Negligible Aquatic Vegetation	26565.2
2	Poor Aquatic Vegetation	2789.37
3	Moderate Aquatic Vegetation	762.401
4	High Aquatic Vegetation	40.104

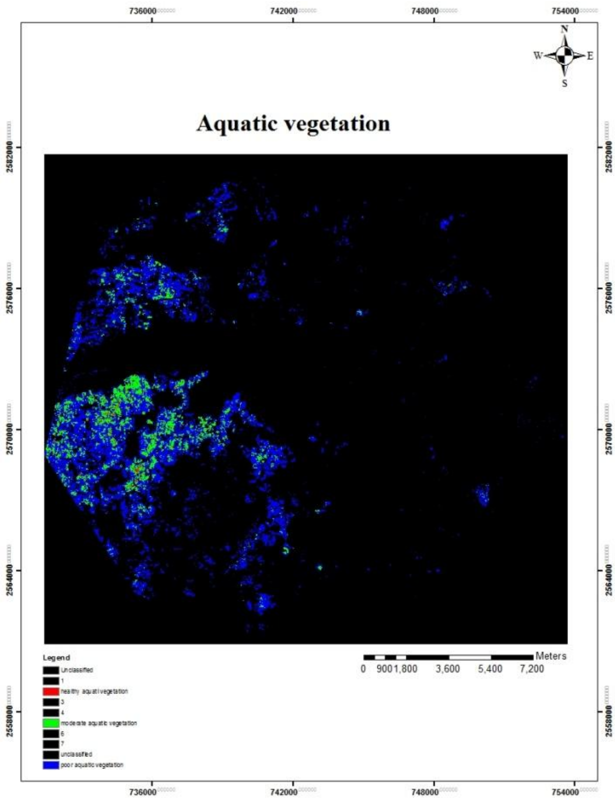

Figure 5. Aquatic Vegetation Observed in Study Area

3.6. Integration of wetlands on the basis of turbidity and aquatic vegetation

The turbidity classified image (having coded values 10, 20, 30) obtained and the aquatic vegetation classified image (coded 1, 2, 3, 4) are then added using arithmetic operator. The resulting image obtained has 12 classes which show the four vegetation classes amongst the three turbidity levels. Now the image is again recoded by giving new value to each class. The recoded values used are: coded 20, 21, 22, 23, 25, 26, 27, 28, 30, 31, 32, and 33. The turbidity and aquatic vegetation classified image is shown in figure No. (6) and table No. (6) shows area of each class.

Classification codes for aquatic vegetation and turbidity classes:

Low turbidity and no vegetation 20
Low turbidity and poor vegetation 21

Low turbidity and moderate vegetation	22
Low turbidity and high vegetation	23
Medium turbidity and no vegetation	25
Medium turbidity and poor vegetation	26
Medium turbidity and moderate vegetation	27
Medium turbidity and high vegetation	28
High turbidity and no vegetation	30
High turbidity and poor vegetation	31
High turbidity and moderate vegetation	32
High turbidity and high vegetation	33

Table 6. Area of Aquatic Vegetation and Turbidity in Study Area

Sr. No.	Class Name	Area (Hectare)
1	Low turbidity and no vegetation	1534.89
2	Low turbidity and poor vegetation	0
3	Low turbidity and moderate vegetation	0
4	Low turbidity and high vegetation	0
5	Medium turbidity and no vegetation	0
6	Medium turbidity and poor vegetation	7.4844
7	Medium turbidity and moderate vegetation	40.8564
8	Medium turbidity and high vegetation	757.447
9	High turbidity and no vegetation	0
10	High turbidity and poor vegetation	1271.86
11	High turbidity and moderate vegetation	106.24
12	High turbidity and high vegetation	6792.98

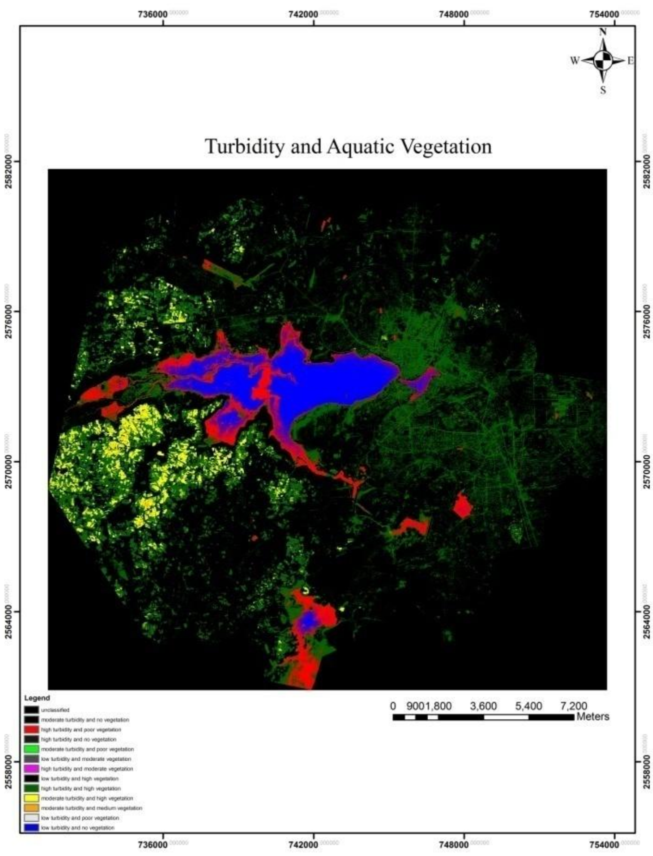

Figure 6. Combined Map of Turbidity and Aquatic Vegetation

3.7. Integration of land use classification with turbidity and aquatic vegetation

The classified and recoded land use map image is then combined to the recoded aquatic vegetation and turbidity image obtained to obtain a final land use classification image containing six land use classes and 12 classes in the wetland. Now the combined image of turbidity and aquatic vegetation is then further recoded. The output obtained is shown below in figure No. (7).

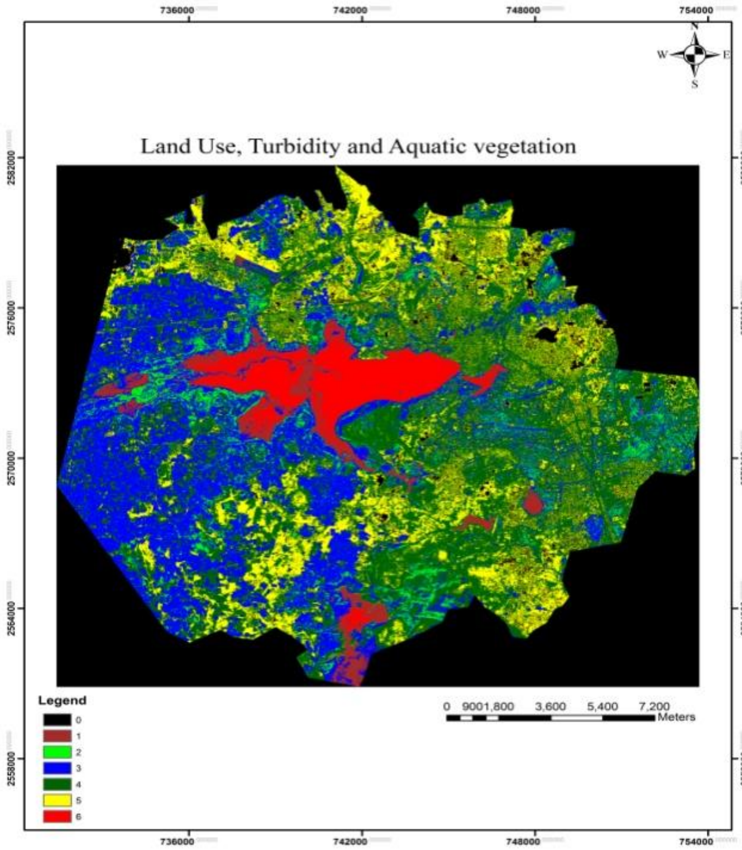

Figure 7. Integrated of Land Use, Turbidity and Aquatic Vegetation

4. CONCLUSION

From the study it can be concluded that the wetlands are majorly been effected due to absence of reliable and updated information and data on extent of wetlands, and also their conservation values and socioeconomic impotance has greatly hampered. Remote sensing data in combination with Geographic Information System (GIS) methods have been found to be effective tools for wetland conservation and management. Because by using digital remote sensing data for wetland mapping and analysis, information at any scale of all wetlands will be available according to the management and conservation requirements. The development of the remote sensing technology makes us obtain very abundant information of wetlands, especially with the appearance of high resolution satellite imagery which extends the visual field of the wetlands. Multiple GIS layers can easily be applied for zoning potential wetland restoration/ enhancement sites using GIS packages such as ArcGIS. The zonation map prepared proves to be a greater efficacy for wetland ecologists and geologists.

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